IFPRI

FOOD POLICY STATEMENT

NUMBER 39, OCTOBER 2002

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INNOVATION IN NATURAL RESOURCE MANAGEMENT:

THE ROLE OF PROPERTY RIGHTS AND COLLECTIVE ACTION IN DEVELOPING COUNTRIES

EDITED BY RUTH MEINZEN-DICK, ANNA KNOX, FRANK PLACE, AND BRENT SWALLOW

Degradation of natural resources is a global problem that threatens the livelihoods of millions of poor people. Innovation by research centers, development organizations, and farmers themselves has produced many promising technologies and practices for making agriculture and natural resource management more sustainable. Most of these technologies, however, require investment by farmers, both individually on their own farms and collectively by groups or communities. The book, *Innovation in Natural Resource Management: The Role of Property Rights and Collective Action in Developing Countries,* edited by Ruth Meinzen-Dick, Anna Knox, Frank Place, and Brent Swallow, examines the factors that affect whether and how farmers apply sustainable agricultural technologies and natural resource management practices, giving special attention to the role of property rights and collective action.

The volume begins with a conceptual framework showing how property rights influence incentives to adopt innovations that have long time horizons, and how collective action is necessary for technologies or practices that operate on a socio-spatial scale above the individual farm. A chapter on methodology discusses how the concepts of tenure security and technology adoption can be put in practice in empirical studies that are relevant to policymakers and practitioners. Case studies from Africa, Asia, and Latin America then show the complex ways in which these institutions affect the adoption of a wide range of practices, from agroforestry techniques to rangeland management and from livestock feeding practices to integrated pest management.

Property Rights and Long-term Investment

Although the effects of property rights on agricultural investment have long been debated, the evidence has been fragmented, owing in part to the poorly understood complexities of the rights of individuals and groups to land, water, and trees. Understanding the links between property rights and innovation requires looking beyond "ownership" as defined by government title. For private, common, or public property, there can be many different bundles of rights to use, manage, or transfer the resource to others. The household may not always be the relevant level to examine property rights: in Malawi, different rights held by men and women affect incentives for forestry and agroforestry, whereas in Syria, rights of tribal communities play a key role in rangeland management.

Tenure security—the extent of people's rights and how confident they are that their rights will be respected over time—affects people's long-term investments in technologies for managing their resources. The case studies in the book describe different tenure systems and examine their effects on investment and productivity. Evidence shows how tenure arrangements can be shaped by market forces (as in cattle feed access in coastal Kenya) and proximity to urban areas (as in land inheritance patterns in Malawi). Because tenure systems are dynamic they usually respond to population and commercialization forces to accommodate new technology that is beneficial to the community. Not all members of the community, however, will benefit equally. Where men of certain groups have primary rights, women and tenants who have weaker, derived rights may not benefit as much and may have different incentives. Tenure implications may also be embedded in the technology itself, as is the case where cashew nut trees are used as evidence for land tenure in Mozambique, and this situation may actually deter new investment. Finally, government intervention in tenure policy may have positive or negative impacts on tenure security.

Property rights do not derive from state law alone; customary law and even local norms may be even more important sources. But if local institutions erode, customary property rights may also weaken. Indeed, cases from Haiti and Syria argue that state regulations formalizing tenure have reduced tenure security by weakening the social institutions that underpinned customary property rights systems, without replacing them with effective state institutions. In Ethiopia, state institutions were "effective" but only in enforcing policies that restricted individual and community rights.

Collective Action for Landscape-level Innovation

Many natural resource management practices cannot be effective if adopted by a single farmer but require coordination across farms or even communities. The cases of ant control in Colombia and cattle treatment for tsetse fly control in Ethiopia demonstrate the need for collective action in pest management, as well as some of the practical difficulties in getting people to work together, even where there is a clear common good. The case of crop-livestock conflicts in Sri Lanka shows that achieving balanced resource management is even harder where different user groups are highly fragmented and have conflicting interests.

Like property rights, collective action is dynamic, changing in response to internal and external forces, including policies, projects, and the availability of innovations. In Syria, for example, some customary tribal institutions are effective in regulating rangelands, whereas others have eroded. In Kenya, the availability of new technologies for intensifying cattle feeding has led to farmer innovation in the institutions governing fodder access, as well as in the application of the technologies themselves. The results of participatory research on ant control in Colombia and tsetse control in Ethiopia were shaped by collective action, which in turn depended upon the pre-existing cohesiveness of the communities and the practical difficulties and transaction costs of cooperating. On the other hand, a study from Honduras found that although external government organizations stimulate individual farmers to adopt conservation practices, they appear to displace local collective action for natural resource management.

The importance of collective action goes beyond adoption of particular agricultural technologies. Policies devolving the management of irrigation systems, forests, fisheries, and watershed resources from the state to user groups are based on the assumption that local communities will act together to control resource use. If that cooperation does not materialize, then devolution will not lead to sustainable management. The cases in this book are instructive because they analyze factors affecting the degree and type of collective action that emerges or takes place. Factors that can limit cooperation include ethnic heterogeneity, power differences, distance between farmers or to market, and rapid population growth or changes. Special attention may be required under these conditions.

Conclusions

Simplistic policy prescriptions that call for giving title as a way to stimulate investment can be misleading, because there is more to tenure security than just statutory title and more factors influencing investment than just tenure security. Development practitioners also increasingly recognize the need for collective action for adoption of many technologies and natural resource management practices, but sustained local involvement requires more than just establishing organizations on paper. Promoting sustainable natural resource management requires an understanding of the interaction between local and external institutions and must build on local strengths. This volume provides both methodological tools and empirical findings to show how such an understanding can be developed and how it can serve as the basis for adoption of sustainable resource management technologies to improve productivity, equity, and the environment.

SP-PRCA WORKING PAPER NO. 1

PROPERTY RIGHTS, COLLECTIVE ACTION AND TECHNOLOGIES FOR NATURAL RESOURCE MANAGEMENT: A CONCEPTUAL FRAMEWORK

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IFPRI

October 1998

ABSTRACT

This paper explores how institutions of property rights and collective action play a particularly important role in the application of technologies for agriculture and natural resource management. Those technologies with long time frames tend to require tenure security to provide sufficient incentives to adopt, while those that operate on a large spatial scale will require collective action to coordinate, either across individual private property or in common property regimes. In contrast to many crop technologies like high-yielding variety seeds or fertilizers, natural resource management technologies like agroforestry, watershed management, irrigation, or fisheries tend to embody greater and more varying temporal and spatial dimensions. Whereas the literature addressing constraints and enabling factors for rural technology adoption have largely focused on their direct effects on crop technologies, the conceptual framework presented here shows how property rights and collective action interact with many other constraints to technology development (such as wealth, information, risk, or labor availability). The paper further explores how the structure of property rights and collective action shape the efficiency, equity and environmental sustainability of technological outcomes, thereby enriching our understanding of different technologies' contributions to poverty alleviation.

CONTENTS

PROPERTY RIGHTS, COLLECTIVE ACTION AND TECHNOLOGIES FOR NATURAL RESOURCE MANAGEMENT: A CONCEPTUAL FRAMEWORK

Anna Knox McCulloch, Ruth Meinzen-Dick, and Peter Hazell[*]

1. INTRODUCTION

The technologies people use play a fundamental role in shaping the efficiency, equity, and environmental sustainability of natural resource management. This has been the reason for substantial investments in research to improve agricultural technologies, from new crop varieties to natural resource management practices. However, improved agricultural and natural resource technologies are of little value unless they are judged to be appropriate by farmers and subsequently adopted. There are many factors constraining farmers' technology choices, but the lack of secure property rights has been commonly identified as an important barrier to adoption, particularly for longer-term investments in things like tree crops and improvements to natural resources. For technologies and natural resource management practices that require that farmers make joint decisions and cooperate in their implementation, inadequate and ineffective institutions for managing collective activity can be a constraint to adoption. Property rights and collective action (PRCA) are also important in determining who benefits from productivity increases (equity), both directly by determining who can reap the benefits of improvements in factor productivity, and indirectly through their effects on land markets, access to credit and the like.

This paper seeks to examine an extensive and growing literature on the links

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between PRCA and farmers' decisions about use of new technologies, including how property rights and collective action interact with other factors to either constrain or enable adoption. It further explores how PRCA condition the way technological changes translate into productivity increases, reductions in poverty, and environmental outcomes. Technology is used generally in this paper to include natural resource management practices as well as production processes and methods.

The following section of this paper reviews evidence on the major influences on technology choices, including the direct effects of PRCA. Following that, we develop a framework for understanding how property rights and collective action institutions[1] influence even the other constraints on technology choices, such as information, risk, or credit. While building on existing research, this framework highlights gaps in our present understanding, and can provide a basis for framing future empirical research. The next section deals with the effects of technologies on institutional change in PRCA, followed by a discussion of the impact on productivity, poverty and the environment. We conclude by examining how an understanding of these relationships can better inform policy decisions about the design of agricultural research and development, and reforms to PRCA institutions to enhance the use and impact of improved technologies.

2. FACTORS INFLUENCING TECHNOLOGY CHOICES

The Green Revolution brought forth technologies which led to substantial productivity increases. However, the crop varieties, agrochemicals, and irrigation technologies in the Green Revolution package were not evenly adopted by all types of farmers. Questions of why differences remained between regions, and even between farms within an area, sparked a large body of theoretical and empirical literature on factors

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[1] Institutions are defined as "the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction (North 1990:3)." Following this definition, both property rights and regularized collective action can be considered institutions.

which constrain and those which enable technology adoption. Given the orientation of the Green Revolution toward high-yielding variety (HYV) seed and use of improved inorganic fertilizers, emphasis was laid narrowly on constraints to crop production technology, rather than natural resource management (NRM). Nevertheless, these factors and the logic which identifies them as constraints provide a foundation for understanding constraints on other types of technologies, including the use of improved natural resource management practices, and their interaction with property rights and collective action. This section provides a brief overview of what those factors are and the rationale underscoring their effect on the adoption of different technologies, particularly new technologies introduced to increase production or improve the condition of the natural resources.[2]

INFRASTRUCTURE AND INFORMATION

Access is a critical dimension of technology choices. Unless the appropriate physical, economic, and information infrastructure is in place, farmers may be unable to acquire technological inputs or market their output. Whereas roads, electricity, water supplies, availability of improved seeds and other key inputs, and access to market outlets may be obvious considerations for whether a technology is adopted or not, less obvious may be barriers to the diffusion of information. Farmers must know about the availability of new technologies, and this knowledge must extend to knowledge about the returns from adoption, which in a risky world requires judgements about alternative possible outcomes of yields and profits. Full information about profitability and risk is rarely available for new technologies, simply because they are new. Consequently, farmers' perceptions of risk may dominate the adoption decision in the early years, particularly if the early years prove to be unfavorable.

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[2] Although in much of the literature, the term 'technology adoption' has referred to new or 'improved' technologies developed by national or international research stations or introduced through technologies transfer programs, in this paper 'adoption' also includes those technologies or practices where farmers themselves have played a considerable role in technology innovation.

If farmers form their risk perceptions in a rational way, then with the passage of enough time, their perceptions will tend to move from subjective to objective risk assessments based on knowledge of the interactions between technologies and their environment (O'Mara 1983). But in the early years, farmers may have exaggerated perceptions of the risks involved with new technology, making them prefer those with which they have more experience. Effective extension services can accelerate the spread of knowledge about the profitability and risks associated with new technologies. Farmers are also quite efficient in learning from each other, and at experimenting on their own farms.

ENVIRONMENTAL AND PRICE RISK

Farmers are generally averse to risk, although there is considerable variation in their individual behavioral patterns (Anderson, Dillon, and Hardaker 1977). If a new technology is clearly superior to an established technology in the sense that the return will be greater no matter what happens to weather, prices, etc., then risk aversion is not likely to deter farmers from using it (Anderson 1974). But if the new technology is not superior under all possible eventualities, then differences in risk attitudes can play a role, even when perceptions about the riskiness of the new technology are correct.

If farmers are risk averse, then they should be more reluctant to adopt risky new technologies even when these are more profitable on average, but more receptive to risk-reducing technologies such as irrigation or more stable crop varieties. Surprisingly, the empirical evidence on the importance of risk in technology choices is not conclusive (Hazell and Anderson 1984). Much seems to depend on household livelihood strategies, which are conditioned by wealth and whether farmers have efficient options for reducing their exposure to risk, and/or to coping with losses when they arise (Chambers and Leach 1989; Scherr 1995). Risk reducing options may include income and crop diversification, inter-cropping, and plot scattering; risk coping strategies may include use of savings or credit, storage, family support networks, and asset markets. Where these options are available, the amount of additional risk associated with alternative crop technologies or production techniques may be too small for risk to play an important role in these decisions. Risk is doubtless more important though when efficient risk management options are limited, as may be the case with many small scale farmers, or when farmers have to choose among "lumpy" technologies (Feder 1982; Zeller, et al. 1997; Bell 1972), such as the purchase of machines or livestock, or sizeable investments in resource improvements such as irrigation, terraces, or drainage.

WEALTH AND CREDIT

Wealth expands a household's options to acquire and use technologies, especially those that require the outlay of considerable resources. Lack of wealth need not be a constraint to technology adoption for other low asset households, provided financial markets are available to provide necessary financing arrangements. However, a sizeable body of literature points to the lack of access to credit and savings services for farmers in many rural areas, limiting their ability to purchase needed technological inputs (Lipton 1976; Jehangir 1998; Bhalla 1979; Wills 1972; Feder, Just, and Zilberman 1982; Feder 1980; Subbarao 1979; Hazell and Anderson 1984).

Whereas transaction costs of lending play a role in making small loans in more remote areas unviable, the credit that is available is often biased against small farmers and women because of their lack of collateral and perceived higher default risk. In response to this, many countries implemented subsidized agricultural credit programs, often tied to purchases of new technology. While these approaches were helpful to the uptake of Green Revolution technologies, most of these programs proved financially unsustainable, and often failed to reach small farmers and women. The contraction of subsidized and publicly funded credit schemes in recent years has led to new approaches to rural finance, including development and strengthening of local institutions for micro credit and mobilization of rural savings. Zeller et al. (1997) provide some recent evidence that these approaches can facilitate purchases of new technology, especially amongst small farmers.

LABOR

Labor bottlenecks can also be a significant constraint to the use of some kinds of technologies (Delgado and McIntire 1982; Feder, Just, and Zilberman 1982; Kirk 1988; Harriss 1972; Helleiner 1975). High yielding crop varieties not only add to total labor requirements, but they often exacerbate seasonal peaks in labor requirements. Peaks typically occur at planting, weeding and harvest times. If the new varieties have a shorter growing season, and permit additional multiple cropping, there may be consequent overlapping of the harvesting and planting of successive crops with very sharp increases in seasonal labor requirements. Unless local labor markets are elastic, increases in demand for labor raises seasonal wage rates which can quickly dampen the profitability of new technologies, particularly for farms which cannot get by with family labor alone. Even when wage rates do not rise, supervision costs make hired labor relatively more expensive than family labor because work effort, and therefore labor productivity, tends to be lower for the former. Changing to new techniques may then depend on complimentary and expensive investment in farm mechanization, which can be a particular hurdle for small farms because of the lumpiness of the required investment and the need for a minimum farm size to spread the cost. Efficient machinery rental markets can help neutralize these constraints, but transaction costs and excess demand in peak periods can still work against small farms. Even when family labor is not constraining for small farms, women's available labor supply may be quite limited due to many competing demands for their labor, thereby leaving them little time to manage new technologies.

Investments in improving natural resources (for example, construction of terraces, irrigation, water catchment areas, drainage, and regular composting) can be particularly labor demanding, and may be too expensive to undertake in communities with limited access to labor. However, if many of these investments are carried out in the off-season where they do not compete directly with labor for agriculture, opportunities costs for labor may be lower. The literature on induced innovation hypotheses argues that many of these labor intensive investments will only be undertaken when population density reaches critical levels and land becomes scarce relative to labor (Boserup 1981; Hayami and

Ruttan 1985). Commercialization of agriculture can have a similar affect, raising the value of land and hence also increasing the returns to investments that improve its productivity.

PRICE POLICY

The profitability of new technologies is affected by input and output prices, both of which are often influenced by government policies in developing countries. As such, policies that discriminate against agriculture have worked against the uptake of capital or cash-intensive technologies, although more recent devaluation and market liberalization policies have in many cases improved relative prices for traded agricultural goods and, therefore, induced adoption of technologies associated with them. However, these changes have also been associated with increased price volatility for agricultural produce and the removal of many input subsidies, such as credit, fertilizers, and irrigation water, so the net effect on farm level profitability can be quite mixed.

Another price related issue is that as more and more farmers adopt a yield improving technology, the increase in aggregate output can act to depress the market price (Alston and Martin 1992; Bhagwati 1958; Carter 1985). This effect will be greater the more inelastic the demand curve of the international market. If the new technology is clearly superior and acts to reduce average costs per unit of output by a greater margin than it reduces prices, then it may still be attractive.

OTHER CONDITIONING FACTORS

Technologies may be unsuitable beyond the bounds of certain physical, socioeconomic, cultural and political environments. Agroecological conditions have precluded the use of HYV varieties in areas with low rainfall (and insufficient irrigation facilities), unfavorable microclimates, and poor soils (Perrin and Winkelmann 1976; Gerhart 1975; Freebairn 1995). Likewise, use of ox-plow cultivation or grazing technologies is constrained in areas with very hilly terrain, or in tsetse infested areas (Kumar 1994; Erenstein and Cadena 1997). However, evaluating the appropriateness of a technology or package of technologies goes well beyond its technical characteristics.

Even when these attributes appear promising, the 'social bias' of a technology arising from institutions and power structures can preclude adoption or the positive outcomes expected from its adoption (Grabowski 1990).

In some regions of Africa and Asia, cultural restrictions prevent women from planting trees such that they are unable to participate in many agroforestry technologies (Neef and Heidhues 1994; Fortmann and Rocheleau 1985). Similarly, legal restrictions may impede use of certain technologies. Given that many such restrictions are linked to property rights, discussion of them will be reserved for a later section.

PROPERTY RIGHTS

Property rights can be defined as "*the capacity to call upon the collective to stand behind one s claim to a benefit stream* (Bromley 1991:15, emphasis in original)." As such, they are recognized as an important factor shaping the use of different technologies. If people do not have the confidence that they will benefit from investments in technologies, they are less likely to adopt the technologies. Although there is a wide variety of property rights arrangements, several aspects have received particular attention in the literature on technology adoption and natural resource management, notably the effects of landlord-tenant relationships (completeness of rights), and tenure security.

Empirical studies of landlord-tenant arrangements on incentives to adopt yield-enhancing technologies have argued that the expected gains accrued from implementing a particular technology act as disincentives to adopt, either by the tenants or the landlords themselves due to increased risk born by the tenant and the potential for weakening the lucrative patron-client relationship from the perspective of the landlord (Bahduri 1973; Scandizzo 1979). Other literature argues that these arrangements are not constraints themselves, but that other reasons, such as poor terms of trade and information assymetries, prevail (de Janvry 1979; Ghose and Saith 1976). Grabowski (1990) maintains that the high cost of negotiating tenancy and fixed-rent contracts will induce landlords to adopt mechanized agricultural processes in the face of technological change while Bardhan (1979) finds a difference in technology's impact on tenure arrangements, depending on whether it is labor-intensive or land-augmenting.

Most of the literature linking property rights with technology adoption has focused on the role of tenure security in shaping farmers' decisions to invest in agriculture, with empirical studies demonstrating mixed conclusions concerning its importance (Bruce 1993; Roth, Cochrane, and Kisamba-Mugerwa 1993; Place and Hazell 1993; Roth, Wiebe, and Lawry 1992; Barrows and Roth). Where tenure security is defined in terms of bundles of transfer rights or possession of title, the correlation between security and investment tends to be weaker. Nevertheless, substantial theoretical literature advocates privatization of land based on the premise that farmers' incentives to invest in technologies is inhibited by weak tenure security arising from indigenous property rights institutions and by lack of land titles hindering their capacity to obtain credit to make investments (Demsetz 1967; Johnson 1972; Feder and Noronha 1987). Since then, however, a body of empirical evidence has emerged which casts considerable doubt on the linkage between land title and agricultural investment, indicating that land titling is unlikely to induce enhanced tenure security (Besley 1995; Place and Hazell 1993).

How tenure security is defined has played a significant role in shaping policy outcomes. The Swynnerton Plan (1954) emerging out of colonial Kenya equated tenure security with ownership and title to land as practiced by Western countries. Indeed, much of the policy prescriptions for Africa and other developing countries that emerged in the next two decades followed suit in arguing for the need to replace community-based land tenure institutions with freehold tenure backed by formal titles (Harrison 1987; Dorner 1972; Feder et al. 1988; Feder and Onchan 1987). Subsequent research has revealed that title and privatization of land ownership are not always necessary to ensure tenure security and in fact may in some cases weaken it (Bruce 1993; Place and Hazell 1993; Shipton 1988; Roth, Unruh, and Barrows 1994). This result stems from the strength and effectiveness of indigenous property rights institutions that still exist in much of Africa, often superceding national land laws in the eyes of local people. For example, in Benin, Manyong and Houndekon (1997) found that although plots were not formally registered, divided inheritance, purchasing, and gift modes of acquisition provided enough long-term security to encourage the adoption of soil-improving technology. Likewise, regression results obtained by Ngaido et al (1997) showed that farmers planted improved varieties more on rented land than on owned fields, contrary to expected outcomes. To understand possible rationales for these outcomes, it is useful to explore some of the definitions of tenure security which have emerged in the recent literature.

Definitions provided by Place, Roth, and Hazell (1994) and Roth, Wiebe, and Lawry (1993) stress that the necessary components of tenure security include excludability, duration, assurance and robustness. Excludability allows those with rights to exclude those without rights to a particular factor such as land. Duration refers to the temporal extent of one's rights. To have secure tenure, one must possess a sufficient time horizon to reap the benefits of one's investments. An institutional framework capable of enforcing an individual's rights to land provides the assurance component, while robustness refers to the number and strength of the bundle of rights an individual possesses.

Indigenous property rights institutions have often proven effective in recognizing and enforcing secure property rights for community members, and where these institutions persist, a title does little to strengthen the land rights of community members (Ensminger 1997). In contrast to the conventional wisdom, Smucker, White, and Bannister (1997) report that in Haiti local tenure systems are a source of protection against the insecurity that comes from involvement with formal state tenure systems, which often bring a threat of urban elites taking land. Where indigenous local systems have broken down (either because of internal factors or external threats to the security of tenure, such as outsiders attempting to claim land), registration or land titling may be needed. This may also be true where commercialization has advanced to the point where efficient credit and land markets are needed in which non-community members become important agents (Bruce 1993; Cohen 1980; Noronha 1985). Yet, even where there is demand for land titles, this may stem largely from the ability to reinforce the exclusion and duration elements of security. Recent empirical research from Brazil has shown that it is these factors emanating from possession of land titles which have implications for tree investment and conservation, whereas the ability to sell land with a formal title appears to have little bearing on these decisions (Walker and Wood 1998).

In examining property rights, it is useful to employ the perspective of legal pluralism, recognizing that there is not just one legal system that applies nor a simple division between *de jure* (statutory) and *de facto* (locally practiced) rules, but rather that there are overlapping legal and normative frameworks related to property rights.[3] Not only statutory laws, but also customary and religious laws, and even unwritten local norms may *all* address the rights and responsibilities related to natural resources. Users and potential users can base their claims on the resources on one or another of these legal frameworks, and the overlap and even inconsistencies give scope for negotiation and evolution of property rights. This implies that it is not enough to look only at official statutes, nor at "customary law" in isolation, and that changes in government laws alone do not necessarily change property rights at the local level. This is aptly illustrated in the study by Rae et al. (1997) which attests to the endurance of Bedouin herding institutions in Syria despite a series of shifts in government policy since the 1950s. It further implies that to understand property rights in practice we need to begin not with the formal laws as defined by any system--be it state, religious, or "customary" law, but to begin with individuals, and look at what property rights and other institutions affect them.

Some confusion in empirical findings stems from lack of clarity regarding the scale at which property rights are measured: whether at the plot, farm, or community level. To assess the incentives of individuals or the adoption of technologies that may vary from plot to plot, it is essential to look at the property rights of individual plots, and who they are controlled by. This is especially important where a household may have plots under different types of tenure, and for assessing the effect of gender differences within households, especially in regions like much of sub-Saharan Africa where women and men have separate plots and separate responsibilities for production (Lastarria-Cornhiel 1997). In other cases, the full set of property rights held by a household may indicate the types of livelihood strategies the members can employ, for example, enabling them to try out new technologies on some types of holdings because they have other land to meet subsistence needs (for an example of analysis at different levels, see Quisumbing et al. 1998).

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[3] Legal pluralism is a central concept in the legal anthropological literature. For more information, see Griffiths (1986); Merry (1988); and Spiertz and Wiber, eds. (1996).

Concepts of tenure security have largely been confined to individually or household controlled property rather than common property, which is controlled by one or more groups of individuals or communities. To define tenure security for the users of a common property resource, three dimensions need to be considered. First, does the group or community have secure ownership rights over the collectively managed resource (in the same sense as defined above for individually controlled resources)? Second, is there security of membership in the group to ensure that an individual will have continued use rights to the resource over time? Third, is there an effective local institution to manage and regulate the use of the resource, to assure members that if they abide by the rules, others will also? Many common properties are under increasing pressure today and are degenerating to open access areas. One major reason is population expansion exerting increased competition for resources and producing a growing number of people with group membership claims. Breakdowns in common property management also occur when the ownership rights of the community are challenged by outsiders, including in some cases the state (for example, nationalization of rangelands and forests), and in response to market forces, policy interventions, and other institutional and technological forces which undermine the institutions which have managed the resource (Bromley and Cernea 1989; Jodha 1992; Richards 1997).

COLLECTIVE ACTION

As we move from agricultural technologies that can be employed on individual farms to natural resource management techniques that operate at the landscape level, collective action becomes particularly relevant. The Oxford Dictionary of Sociology (Marshall 1998) defines collective action as: "action taken by a group (either directly or on its behalf through an organisation) in pursuit of members' perceived shared interests." Collective action is most visible in community-level efforts to build and maintain local infrastructure for natural resource management. This is seen clearly in farmer-managed irrigation systems (Coward 1986; Leach 1961; Mahendrarajah 1981; Yoder 1994). White and Runge (1994 and 1995) show that people in Haiti often contribute labor for watershed management programs out of a sense of solidarity and reciprocity even if they do not directly benefit economically from land improvements. Drijver, van Wetten, and de Grout (1995) present evidence from the floodplains regions of Lake Chad of village participation in digging canals and constructing protected fish spawning areas, which are owned by groups of villagers. Groups take annual turns refraining from fishing in their spawning area in order to enable increased spawning and augment the fishing population, a sacrifice which is rewarded by a guaranteed percentage of the subsequent communal catch.

Just as the term “property rights” encompasses a number of aspects, so also collective action covers a range of activities. In addition to joint investment in purchase, construction, or maintenance of technologies, such actions as decision-making and implementation of rules to exploit (or refrain from exploiting) a resource; representing the group to outsiders; and mechanisms for sharing information and other resources are especially relevant for agriculture and natural resource management techniques.

A growing body of research (for example, Baland and Platteau 1996; Nugent 1993; Oakerson 1992; Ostrom 1990, 1994; and Rasmussen and Meinzen-Dick 1995; Runge 1986; Uphoff 1986; Wade 1988; White and Runge 1995) outlines conditions for creating and effectively sustaining collective action for managing common property resources. A resource that is to be managed or improved collectively should be accessible to group members to facilitate control and exclusion of outsiders, and small enough for a group to effectively govern (for example, river basins and oceans are possible exceptions). It helps too if use by one member has limited effect on the availability of the resource to other members (low ‘subtractability’). Greater social cohesion within the group is facilitated by a smaller number of users, by homogeneity of members in terms of shared values and economic dependence on the resource, and if the net benefits from group membership are substantial and equitably distributed. Birner and Gunaweera’s study of *chena* farmers in Sri Lanka attributed their lack of organizational capacity to their large numbers, socio-cultural heterogeneity, lack of access to infrastructure and communication facilities, and aversion to risk (Birner and Gunaweera 1998).

Institutional design is also important. Ostrom (1994) has identified seven design principles for effective local organizations for common property management: (i) there must be a clear definition of the members and the boundaries of the resource to be managed or improved; (ii) there should be a clear set of rules and obligations that are adapted to local conditions; (iii) members should collectively be able to modify those rules to changing circumstances; (iv) there should be adequate monitoring systems in place, with (v) enforceable sanctions, preferably graduated to match the seriousness and context of the offense; (vi) effective mechanisms for conflict resolution; and (vii) the organization, if not empowered or recognized by government authorities, should at least not be challenged or undermined by those authorities.

Where these conditions are not met and collective action needed for resource management is lacking, one of the first questions to ask is why? Are there sufficient incentives for people to participate? The motivation depends not only on quantifiable economic costs and benefits, but also on factors such as time involved and social tensions or gratification from participation. Where there are sufficient incentives but governance mechanisms are lacking, local leadership and/or external community organizers can play an instrumental role in developing local mechanisms (Ensminger 1992). This can be seen as reducing the transaction costs of organizing. But to be sustainable over time, these governance mechanisms need to be institutionalized, that is, not dependent on the actions of a single person.

Lack of boundedness of the resource is more complex. Clear boundaries are important in monitoring and enforcing, and in making sure that those who participate in collective action (either by contributing or refraining from taking too much) will be the ones who benefit from improvements. However, in some cases somewhat “fuzzy” boundaries may be preferred, especially in highly variable contexts, where people recognize that they may need to tap others’ resources under crisis conditions (for example, drought), and are therefore willing to allow others to use their resources under similar conditions (Cleaver 1998; McCarthy forthcoming).

LINKAGES BETWEEN PROPERTY RIGHTS AND COLLECTIVE ACTION

In many cases, property rights and collective action are interrelated, especially in natural resource management. This is most clearly seen in common property regimes, which require both clearly defined property rights for the group, and a relatively high degree of collective action within the group. Shared property rights can also reinforce collective action among a group, whereas privatization of a resource or government claims of "ownership" can erode local management institutions (Wade 1988; Coward 1986; Bromley and Cernea 1989). But even private property regimes require collective action to uphold private rights, and managing resources (with or without joint ownership rights) often requires coordination between individuals and households, especially for practices that operate at the landscape level. In their study of land tenure and deforestation in Brazil, Walker and Wood (1998) demonstrate that mutual cooperation to prevent the spread of fire contagions among privately held land holdings constitutes an important element of tenure security and thereby affects investment incentives and environmental protection outcomes.

When assessing the effect of property rights and collective action on technology adoption, it is useful to consider the spatial and temporal dimensions of a particular technology. Irrigation technology or integrated pest management (IPM) technology, for example, require substantial space to operate effectively, and hence are facilitated by collective action to coordinate their adoption (see Swallow et al. 1997b; Ravnborg, de la Cruz, and Guerrero 1998). Likewise the property regimes most appropriate for their management need to take into account this spatial scale. Quiggan (1993) points to joint ownership of harvesting equipment by small farmers as an example of efficiency gains from employing a common property technology to private property resources, which would otherwise impose spatial limitations on adoption.

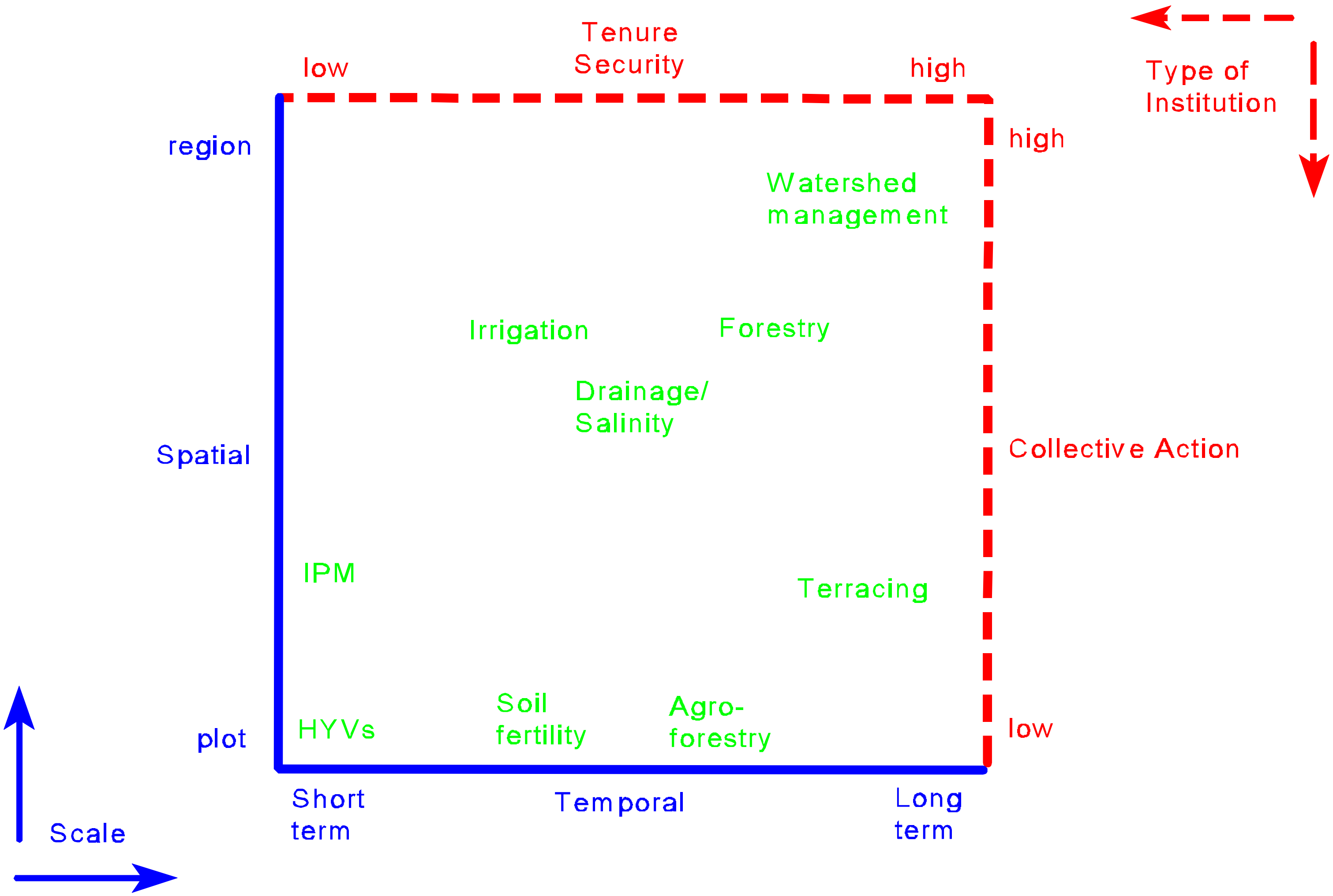
Because management of common property resources is apt to demand collective action responses to function effectively, the spatial dimensions of a resource and the spatial effects of technologies applied to those resources will also be indicative of whether collective action constitutes a potentially effective management strategy. Every thing else equal, the larger the space occupied by the resource, the more numerous the people dependent on its benefits, and the broader the spatial effects of the technologies applied to it, then the greater the incidence of inter-agent externalities whereby one person's use of a technology has either positive or negative effects on others which are not negotiated through the market. Under these circumstances, the potential for collective action strategies to promote adoption of large-scale technologies and natural resource management practices is generally greater. Collective action institutions may not only facilitate joint resource management, but also include inter-community dialog and conflict resolution. This is not to say that the association, monitoring and enforcement costs of collective action do not increase with space, but that the coordination costs and efficiency losses of managing large scale resources privately will, up to a certain level or size, often overwhelm other costs, making collective action an economically superior alternative, at least in terms of social costs and benefits. Once a threshold size is reached in terms of the transaction costs of sustaining collective action, a role for the state may be warranted. Besides collective action, other means exist for resolving inter-agent externalities, such as tradeable permits, regulations, taxes, and subsidies.

The temporal dimensions of a technology carry implications for tenure security. If property rights, whether individualized or communal, do not offer the resource user sufficient duration to reap the benefits of investment in a particular technology, adoption will not be forthcoming. Here the relationship between timing of costs and the timing and duration of benefits is especially relevant. In cases where technologies require long time horizons to generate returns on investment, tenure security needs to be addressed before meaningful uptake of technologies can be expected. For example, Fortmann, Antinori and Nabane's 1997 study of tenure security and gender differences in tree planting in Zimbabwe found that where women have less security of duration of tenure they are less likely to plant trees.

Figure 1 places several technologies within a spectrum of their relative spatial versus temporal scale. HYV technologies, given their scale neutrality and seasonal nature, are placed at the lower end of the spatial and temporal spectrum. IPM requires a high degree of spatial coordination but with a short-run turnaround. By contrast, terracing technology may be very localized yet investment is continuous and long-term (as demonstrated in Al-Sanabani, Aw-Hassan and Bamatraf's 1997 study from Yemen). Watershed management, irrigation systems, and salinity control require both longer time horizons and coordination among farmers. Finally, basin management incorporates such vast spatial scale that it even extends beyond the realm of strictly local collective action as a feasible option due to the enormity of the transaction costs incurred. Here state intervention or co-management arrangements involving the state and local institutions may offer the best solution.

In applying this framework, it is most useful if the spatial scale is seen relative to normal farm sizes within a given area. A technology serving 100 hectares could be internalized and adopted within a single farm in some areas, or require coordination of hundreds of farmers in other areas. Lynam (1994) notes that moving from agricultural to natural resource management technologies generally expands both the temporal and spatial scale of research and adoption; even technologies which are put into practice at the farm level require widespread adoption to become effective (as exemplified in IITA's program for biological control of the cassava mealybug).

Figure 1 Property rights, collective action, and sustainable agriculture/NRM practices



Note: Location of specific technologies is approximate, for illustrative purposes.

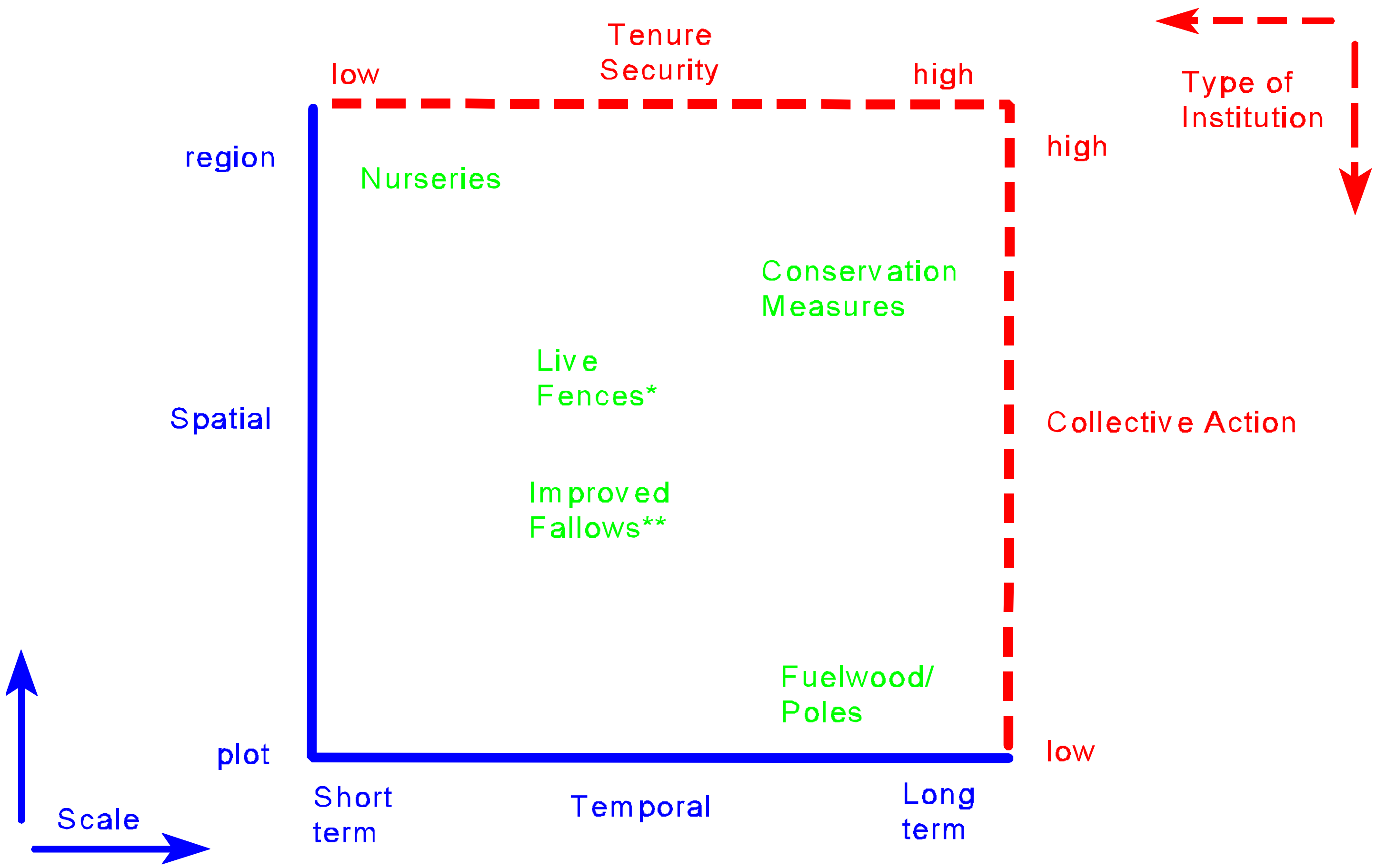
Several of the technologies specified in Figure 1 could be broken down into subgroups to more accurately reflect their spatial and temporal characteristics. The "irrigation" category should distinguish between tubewells serving a single farmer on a few hectares and a large canal system serving thousands of hectares. Within the agroforestry category (see Figure 1A), community nurseries will tend to require much greater degrees of collective action to sustain them while security-enhancing property rights are less important given the short time necessary to derive benefits from the technology. By contrast, agroforestry aimed at production of fuelwood or poles requires an extended duration for production, yet the practice is more individualized and requires much less, if any, coordination beyond the household level. Similarly, while comprehensive watershed management often has a large spatial scale and long time horizon, specific components such as contour plowing can be applied on smaller areas with shorter-term pay-offs.

Viewing technologies in this framework allows more precise identification of whether property rights or (lack of) collective action are likely to be constraining or enabling factors in technology choices. It can also provide guidance for the development and dissemination of technologies that are appropriate for the institutional context. For example, technologies that operate on a landscape scale may be more appropriate where traditions of cooperation are strong while those that require an extended duration to produce benefits may realize greater success where tenures are long-term and reasonably secure, at least for those resources linked to the technology being applied. Conversely, areas where many farmers have insecure tenure call for technologies that have significant short-term returns.

3. INDIRECT EFFECTS ON TECHNOLOGY ADOPTION

The previous section has specified a number of factors which the literature has identified as having a direct impact on technology choices. Figure 2 provides a conceptual mapping of these direct effects. Here the constraints are grouped into four

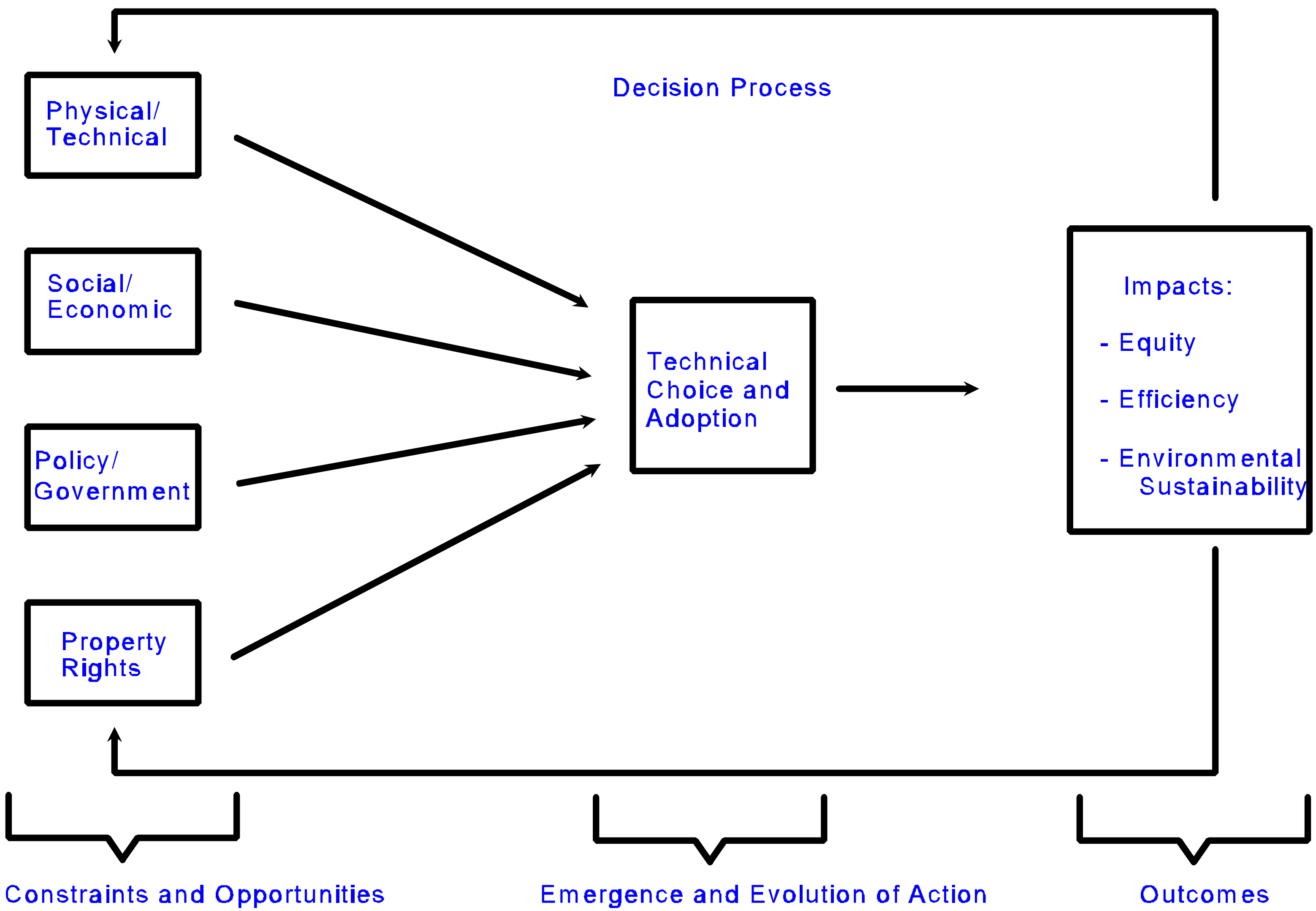
Figure 1A Property rights, collective action, and agroforestry technologies



Note: Location of specific technologies is approximate, for illustrative purposes.

* Requires changes in herding practices if fallow crop species is palatable to livestock.
** May require changes in herding practices if fallow crop species is palatable to livestock.

Figure 2 Conceptual framework: Direct effects on technology adoption



categories: *physical/technical factors* such as agroclimatic conditions (including risk) or infrastructure, *social and economic factors* including human capital (information), economic risk, social networks, wealth, credit availability, labor patterns, and social norms; *policy and government factors* such as pricing policies or legislation regarding resource use, and *property rights and collective action institutions*. In econometric terms, they can be viewed as a series of explanatory variables with technology adoption (specified as a binary or continuous variable) as the dependent variable:

$$I = f(x_1, \ldots x_n, PR, CA) \qquad (1)$$

where

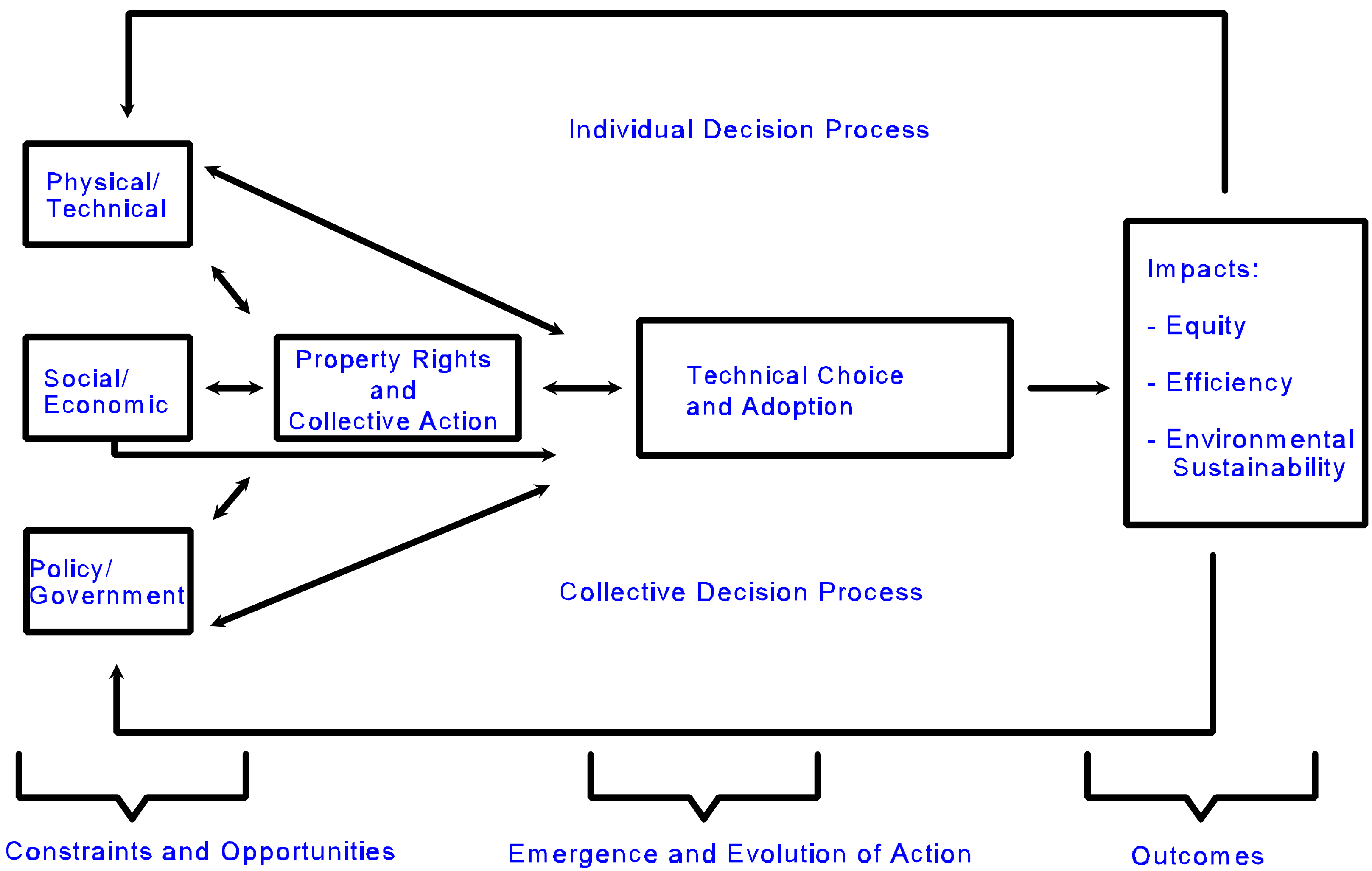
I	=	technology adoption, whether individual or collective
x_i	=	conditioning factors affecting technology adoption, such as risk, access to credit, prices, labor bottlenecks, and access to information and inputs.
PR	=	property rights measured according to the bundles of rights and the various criteria for tenure security.
CA	=	A measure of collective action.

However, this model is too simplistic in assuming that each of the explanatory variables is independent of each other. In reality, many of the explanatory variables are themselves conditioned, at least in part, by the prevailing property rights and collective action systems, and these are not considered in the model in Figure 2. A more realistic model which shows the dependence of many (for simplicity, all) of the conventional explanatory variables on PRCA is outlined in Figure 3 and demonstrated by the following relationships:

$$x_i = f(z, PR, CA); \ \ i = 1 \text{ to } n \qquad (2)$$

$$I = f(x_1 \ldots x_n, PR, CA) \qquad (3)$$

Figure 3 Conceptual framework: Indirect effects on technology adoption via property rights and collective action



Substituting (2) into (3) gives the reduced form relation:

$$I = f\ (z, PR, CA) \qquad (4)$$

where

z = exogenously generated conditioning factors, such as household and site-specific characteristics.

Figure 3 and the above model illustrates how traditional constraints act on and are acted on by property rights and collective action to influence the decision to adopt. There is a two-way mapping between traditional constraints and PRCA, which subsequently influences choice of technology. An example of the impact of traditional constraints on PRCA might be if population pressures stimulate the emergence of more privatized forms of land tenure, which may in turn reorient technological choices toward smaller-scale technologies that can be better managed by families and individuals. Pender and Scherr (1998) test the effect of population growth and other socioeconomic variables on the likelihood of local organizations and collective action in Honduras, and relate these to intensification through coffee, horticulture, forestry, basic grains, or other enterprises. In the reverse case where PRCA shapes other constraints, forcible sedentarization of pastoral populations may expose them to greater environmental and food security risks, causing them to uptake crop technologies and reduce their stock numbers.

Similarly, technologies and their adoption can stimulate institutional change as in the case where introduction of integrated pest management technologies have fostered increased levels of community and inter-community organization (Ravnborg, de la Cruz, and Guerrero 1998) or in the case of agroforestry technologies strengthening tenure security. The equations below demonstrate not only technologies' impact on institutions, but also how exogenous and endogenous factors, including other institutions, act as causal elements for shaping property rights and collective action.

$$PR = f\ (y_i, CA, I)$$
$$CA = f\ (y_i, PR, I) \qquad (5)$$

where

y_i = exogenous factors like population growth, community- and region-specific characteristics, and national laws and policies.

The final mapping in Figures 2 and 3 is directed toward the outcomes of efficiency, equity and environmental sustainability, and suggests that PRCA can be important in determining these outcomes. We shall consider these linkages in Section 5. These factors then feed back on the environmental and institutional conditions, for example, through population growth or changes in the physical condition of the resource. With the framework of Figure 3 in mind, this section will explore some of the important inter-dependencies that have emerged in the literature between PRCA and other determinants of adoption.[4]

INFRASTRUCTURE AND INFORMATION

Property rights are intrinsically linked to the distribution of technological inputs and information. At the community level, extension services have often favored those who control the greatest quantity of resources, that is, the wealthy. At the intrahousehold level, the norm in most patrilineal societies is for male heads of household to either own or have primary rights over land and other natural resources, even when they are not the primary users of the resource. Although this does not necessarily imply that they can easily exercise the right to deprive other family or community members of use rights over the resources they control, it does tip the balance of technology and information access in their favor. One sees a recurring pattern where extension services have largely targeted male heads of household, mainly because they were seen as the ones who controlled the land (Agarwal 1994; Fortmann and Rocheleau 1985; Lastarria-Cornheil 1997).

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[4] Conducting research on all of these factors is conceptually complex, and requires drawing on different disciplines. Ensminger (1992) notes that much of the new institutional economics examines the impact of property rights and other institutions, but treats the institutions themselves as exogenously determined. Anthropologists have done more research on processes of change in institutions themselves. Ensminger advocates not making all factors endogenous at the same time, but rather to shift back and forth, looking at different aspects of these relationships to get the full picture.

Property rights extend not only to the resources to which technologies are applied, but also to the technologies themselves. Adoption is highly dependent on access to technologies and information, and on control (that is, property rights) over a technology in order to implement it. Furthermore, property rights over technology will determine its marketability and the terms of exchange for either the physical inputs or the technical information. Intellectual property rights to technology is rapidly becoming a prominent issue in the policy arenas of many developing countries today and has fundamental implications for access to technologies and information at both macro and micro levels. In particular, as the private sector assumes a growing share of agricultural research, the rights of farmers to access certain technologies may become increasingly restricted.

Collective action, in its capacity to build social capital[5] and foster empowerment, may act to strengthen the bargaining power of disadvantaged community interest groups (Agarwal 1994; Kurien 1995). This occurs through a process of building common objectives which identify the group and of magnifying the voice of individuals via the collective. If it succeeds in altering the distribution of local power and voice, collective action has the potential for realigning the distribution of technologies and resources to enable access to technologies and information (Sarin and Khanna 1993; Agarwal 1994; Chen 1983; Meinzen-Dick et al. 1997).

Likewise, formation of networks among community members can facilitate access to information by reducing the cost of acquiring it. Networks and other forms of collective action may also enable coordination of technology adoption efforts, whether they be individual or collective. For example, a communally managed seed bank may be established to facilitate individual tree planting, but also provide a forum for information sharing about the technology or other matters. Swallow et al. (1997b) show how the spread of information through *kabeles* (cooperatives) and interaction among neighbors facilitate the study of adoption of tsetse control measures in Ethiopia. The development

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[5] Putnam (1993) defines social capital as "features of social organization, such as networks, norms, and trust, that facilitate coordination and cooperation for mutual benefit."

of agricultural cooperatives in many countries is based on the premise that collective action for marketing of inputs and outputs can substantially reduce costs, and make it feasible for farmers to use hybrid seeds, agrochemicals, or produce new crops. Although collective action may serve to diminish both technology acquisition and management costs, it will not necessarily make adoption profitable.

ENVIRONMENTAL AND PRICE RISK

Farmers' ability to manage risk efficiently can be affected by prevailing property rights and collective action institutions. For example, plot scattering, which takes advantage of micro-climate variations and reduces the possibilities that a farmer's full range of crops will be lost to pest or weather problems, must either be institutionalized through land inheritance systems, or requires active land markets so that farmers can optimally diversify their holdings through land swaps, purchases or leases. Land markets, in turn, depend on the presence of secure property rights. Plot scattering also requires that government does not prohibit fragmentation as often occurs based on the belief that land consolidation is necessarily more efficient.

Access to common property resources (CPRs) frequently functions as a buffer against risk. During drought periods, for example, agricultural households often resort more to CPRs to meet their subsistence needs, particularly for fuelwood and food (Jodha 1992). Pastoral and agro-pastoral populations occupying arid and semi-arid regions rely on herd mobility on communal rangelands to mitigate their risk exposure, engaging in opportunistic grazing (Behnke 1994; Galaty 1994; Swallow 1994). Collective action among herders not only establishes the membership, rules and enforcement of common property, it also enables risk sharing and diversification and inspires mechanisms for collective self-help (Mearns 1996; Thompson and Wilson 1994; Waller and Sobania 1994).

The bundle of property rights held by an individual bears significantly on their capacity to manage risk. In many parts of West Africa, women and 'stranger' farmers originating from outside the community are restricted from planting and owning trees since doing so would confer to them greater land rights (Berry 1988; Fortmann 1988; Rocheleau and Edmunds 1997). Inevitably, this limits their adoption of agroforestry and reforestation practices as well as other tree technologies which could diminish their exposure to risk (Neef and Heidhues 1994; Rocheleau 1988).

The literature on the links between property rights and risk management has tended to focus on the production side. Here collective action can also play a role, for example, in the sharing of germ plasm or pooling of labor. But collective action can also play a critical role in smoothing consumption in the face of uncertain and variable production. Support networks and reciprocity norms are frequently present in low-wealth rural communities to cope with these hazards, particularly given insufficient or complete lack of insurance markets. Sharing of output or other resources, and even participation in collective action can be seen as an investment in social capital, which can prove invaluable for the survival of the poor in the face of risk.

The spatial characteristics of risk are important for understanding the adoption or non-adoption of different technologies and for designing improved technologies which match the preferences of low-wealth individuals to mitigate risk. Idiosyncratic risks affect the individual or household. Illness, fires or job loss are some examples. Covariate risks, by contrast, are associated with environmental disasters or economic downturns which take their toll on large groups, communities or even the entire country.

Different forms of collective action and social capital may be needed depending on whether risks are idiosyncratic or covariate. In the latter case, collective action networks may need to involve a larger number of participants and be more heterogeneous so that the impact of the risk on individuals is differentiated. However, large groups and heterogeneity may introduce coordination problems and conflict, diminishing the potential success of collective action (Mearns 1996; Quiggan 1993; Olson 1971; Nugent 1993; Lawry 1990; Hansmann 1988 and 1990; Baland and Platteau 1996; Tang 1992). In contrast, collective action designed to confront idiosyncratic risk can be coordinated with an informal set of reciprocity rules or norms in a small community setting or even among a few neighbors, hence it is more likely to be an effective strategy.

WEALTH

In agrarian societies, wealth is intricately linked to property rights over natural resources, and this has a strong effect on people's options with regard to technology. In Pakistan, for example, farmers owning more land are wealthier, and are more likely to install tubewells; the control over groundwater which tubewells provide further increases their wealth (Meinzen-Dick 1996).

The bundle of one's property rights and the security of those rights combined with one's level of assets, income, and food security affect the degree to which one discounts possible future gains. Those who possess a higher quantity and quality of endowments will place a higher future value on the medium- and long-run benefits produced by investment in technologies. This is because they are less constrained by food insecurity and risks which undermine the ability to meet basic needs as compared to low-wealth actors. Social structures and power distributions furthermore bias technologies and the flow of technical information in favor of the wealthy, shaping adoption outcomes accordingly (Grabowski 1990).

By serving as a risk sharing device, collective action can alleviate food insecurities and other survival risks borne disproportionately by the poor to lower the degree of future discounting and therefore constraints on technology adoption. However, because collective action implies the exclusion of non-participants, negative equity outcomes emerging from collective action strategies are possible. Even among participants in collective action, equity is not guaranteed. Women, for instance, may be accorded less voice in the decision-making process while still being accountable for labor contributions, or being otherwise affected by the new management practices (Ahluwalia 1997; Athukorala and Zwarteveen 1994; Mayoux 1993; Sarin 1995). Nevertheless, collective action frequently becomes a means of realigning the distribution of gains from a resource by facilitating the adoption of more advanced technologies that require "lumpy" investments. For example, in Pakistan and Bangladesh, groups of small scale farmers or even landless people or women obtain rights to groundwater through collective purchases and management of wells and pumps, which provide for the water needs of members or other farmers in the community (Meinzen-Dick 1996; Wood and Palmer Jones 1990; van Koppen and Mahmud 1995*)*. By applying collective action to enhance resource access, wealth acts as less of a constraint to obtaining rights to water resources and adopting water technologies.

CREDIT

One of the primary arguments made in favor of privatization of land tenure is that farmers need title to their land so that they can offer it as collateral for credit. For farmers who tend to have little or no collateral, it is hypothesized that privatization will permit them access to financial markets and increase the supply of credit available to them (Feder and Noronha 1987). As a result, agricultural investment and technology adoption is expected to follow.

However, formal financial institutions remain a rarity in many rural settings, particularly for the purposes of agricultural lending (Roth, Cochrane and Kisamba-Mugerwa 1993; Place and Hazell 1993). In fact, it is questionable how important a constraint formal collateral actually is relative to the overwhelming transaction costs involved in rural lending. Once means are found to reduce the transaction costs of lending, other forms of collateral may prove more appropriate, or even more effective, for reducing the risks of lending to low-wealth borrowers. The many examples of informal financial institutions undertaking successful group lending schemes which employ joint liability mechanisms attests to this (Adams and Fitchett 1992; Berger and Buvinic 1989; Bhole and Bhavani 1995; Chen 1989; Zeller 1996). These programs may be seen as substituting collective action (group formation and backing) for conventional property rights as a form of collateral. Implementing more progressive models of financial service provision may therefore accelerate the adoption of NRM technologies.

Some of the most noted forms of collective action in the literature center on the dynamics of credit and savings groups, which act to lower transaction costs of financial services and establish mutual accountability for repayment. Such groups provide a forum for building assets and self-reliance via savings programs as well as opportunities via credit for purchasing technologies and inputs to develop and maintain technologies. Group credit may also make larger scale, expensive technologies more feasible to acquire and operate if the costs of acquisition are shared by members and subsequently the use and maintenance of the technology (Agarwal 1994). Documenting the decollectivization of Mongolian pastoralism, Mearns (1996) notes that herders engage in jointly purchasing lumpy technologies which tend to be beyond the capacity of individual households to acquire. By investing and acting collectively, the costs associated with a particular technology are also spread out amongst the group members, lowering individual risk exposure and thereby potentially facilitating adoption.

Finally, credit groups may play a role in strengthening social capital formation and producing network externalities[6] so as to enhance opportunities for collective action in natural resource management and technology adoption. If groups are already formed around a common purpose and share a common set of norms and values, this reduces the information and coordination costs of their organizing around another purpose having already established a history of coordination and trust (Baland and Platteau 1996; Wade 1988; Nugent 1993; Mearns 1996; North 1990). In his analysis of irrigation in India, Coward (1986) illustrates how local investment and the creation of joint property rights to irrigation facilities forms the social basis of collective action for the ongoing management of irrigation works by community members.

LABOR

Within the households of most rural societies, property rights fail to correspond closely to labor responsibilities. A oft-cited statistic on the status of African women states that they perform around two-thirds of all the hours spent on agricultural-related work and

[6] In this case, 'network externalities' implies that the more people which have access to credit or participate in credit groups, the greater the probability of each individual having access. Therefore, the utility an individual receives in terms of access to credit is enhanced the more other people also have access.

own only 1 percent of the property (FAO 1985).[7] Carney and Watts (1991) demonstrate how the benefits arising from the employment of a technology were presumed to be below the opportunity costs facing those individuals exerting their labor, resulting in the withdrawal of women's labor. However, in some cultures women may need to contribute labor to their husbands' plots in order to get access to plots for their own production (Berry 1988; van Koppen forthcoming; Carney 1992; Meinzen-Dick et al. 1997). The introduction of new technology (for example, irrigation) can shift these labor demands and responsibilities. Von Braun and Webb (1989) attribute declines in women's labor productivity in a Gambian setting to their lesser access to labor-saving and yield enhancing technologies and shifting labor responsibilities away from agricultural production. Berry (1988) and Quisumbing et al. (1998) explore how the spread of cocoa as a commercial crop in Western Ghana led to men demanding a greater share of women's labor to farm cocoa crops owned by men. In some cases this has led to men giving women a stronger claim over land in compensation for the added labor burden (also see Okali 1983). This can be expected to have positive results for technology adoption by women.

Even when transaction costs are incorporated into the economic equation, institutions and political powers may foster sub-optimal outcomes, such as the inefficient distribution of labor, as a means of preserving the interests of the dominant group, be it gender, ethnic, class-based or a combination of these (von Braun and Webb 1989; Grabowski 1990; Folbre 1997). In the Gambia, for example, elite men used a tree planting program as a means of reclaiming land that had been given to women, who had been using the land for high-value horticultural produce (Schroeder 1993). In another example, irrigation project officials and local elite men in Burkina Faso acted to take land and water rights away from women who had been cultivating rice, and reallocate them as "family" plots, controlled by men. The result was a decline in productivity, as well as increased work burdens for women. In later schemes, local men insisted that women be included in decision-making on plot allocation, with better outcomes (van Koppen forthcoming).

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[7] Given the pervasiveness of community-based land tenure in Africa, one assumes that the term, 'own' refers to holding primary use rights to land.

Collective action can be employed as a means to exert control over individuals' own labor. In her study of a contract farming irrigation scheme in the Gambia intended to target women, Carney (1988) describes how women's property rights to land for rice cultivation were undermined by men. In several communities, women jointly responded by withdrawing their labor from rice cultivation, thereby undermining the successful adoption of contract farming technology. Collective action and reciprocity arrangements may also be employed as a means to overcome labor shortages faced by individual households, particularly in cash-scarce economies, thereby facilitating the use of more labor-intensive technologies (Kirk 1988; White and Runge 1995).

OTHER CONDITIONING FACTORS

Besides property rights institutions, other statutory laws and formal and informal community rules, norms, or ideas can act to expand or constrain people's choices with regard to technology. Erenstein and Cadena (1997) partially attribute the adoption of conservation tillage practices to state agricultural policies, including a law prohibiting the burning of crop residues. In South Asia, taboos forbid women to use ploughs, restricting agricultural productivity and reinforcing women's dependence on men (Agarwal 1994). Nevertheless, property rights institutions are pervasive in their scope; they frequently shape and reinforce other rules, both legal and normative. Property rights vested in the state provide the means by which laws are enacted which forbid the cutting of trees, which can then discourage cultivation of crops (Freudenberger 1994).

Although on the surface cultural norms which hinder technology adoption may appear to have equity, efficiency or environmental drawbacks, it is important to understand their more profound implications and not to write them off as being irrational. In many African rural societies, the capacity to perpetuate a cohesive community and lessen exposure to risk is rooted in kinship and marital practices, which have implications for the distribution of property rights (see Eyzaguirre 1988). In patrilineal societies, when men and women marry, women often move to their husbands' community and acquire secondary use rights to land without retaining rights to land in their birthright community.

Likewise, the practice of having multiple wives means that male household heads periodically must redistribute land to accommodate newcomers as well as children. Altering the principles and property regimes which facilitate a cohesive community and the practice of polygamy may constitute increased exposure to environmental risk and diminished social security for women, at least in the short term. From an institutional economics perspective, the discounted transaction costs of change exceed the discounted benefits of the technology.

SUMMARY

Understanding the use of different technologies beyond the realm of crop technologies to include technologies appropriate for natural resource management requires a deeper appreciation of the spatial and temporal externalities embodied in various technologies, as well as the role played by property rights and collective action in facilitating or impeding adoption. As yet, little empirical research has been carried out documenting factors influencing technology choices applied to common property resources and how traditionally identified constraints interact with various property rights regimes to either weaken or assist in expanding the use of resource-enhancing technologies. Similarly, collective action, by internalizing the externalities produced by spatially dispersed resources and by lowering transaction costs of institutional change, may be instrumental in facilitating technological change in the NRM context.

Despite their important implications, it is important not to view property rights and collective action as a panacea for identifying constraints or enabling factors for adoption of NRM technologies. Rather, other constraining factors that are not influenced by PRCA abound. For instance, lack of market infrastructure and human capital constraints may hinder the use of mechanized wells for improved livestock management, given the inability to acquire spare parts and lack of indigenous knowledge to repair the wells. Property rights may constitute a separate issue constraining adoption in this context, being relatively independent of other constraints.

Because so many things tend to be related to property rights, it is easy to confound the effects of property rights with the effects of other related variables. For example, Adesina, Nkamleu, and Mbila (1997) found that, after controlling for other factors such as fuel and fodder scarcity, secure land rights were not a significant factor in adoption of alley farming in Cameroon (though secure tree tenure was). Similarly, Gavian and Ehui (forthcoming) found that in Ethiopia, land with less secure tenure had lower total factor productivity, but this was not due to farmers applying less inputs; rather, it was low quality of inputs or low skill in applying them that limited productivity. By modifying the existing property rights structure or facilitating collective action responses, more fundamental barriers can be overlooked while more problems may be created than solved. Instead of focusing on property rights or collective action in isolation, the purpose in introducing the PRCA framework to evaluate technology choices is to stimulate greater appreciation for how these issues manifest themselves in people's decisions about which technologies to employ, and the process of technology change itself.

4. TECHNOLOGY AND PRCA: A TWO-WAY MAPPING

Thus far, we have focused our discussion mainly on factors which have an impact on technology choices. However, technological change is a fundamental element of institutional change and, as shown in Figure 3, has feedback effects on the structure of property rights, collective action and other socioeconomic constructs. For example, Unruh (1998) shows that past adoption of cashew agroforestry in Mozambique has now become a major source of evidence used to secure land claims, and Kimberly Swallow's (1997) study of new cattle feeding technologies in Kenya changed the rules of access to a variety of feed sources, affecting both property rights and collective action. Otsuka et al. (1998) demonstrate how changes in physical and economic conditions such as the introduction of cocoa production, population growth, and scarcity of natural forests in Ghana has led to changes in the types of property rights found within communities; the property rights found within the community in turn set the options available to the household; and household allocation decisions affect the rights available to individuals. In effect, the framework displayed in Figure 3 is dynamic, driven by endogenous forces that operate at different levels.

The new institutional economics provides especially relevant analysis of the impact of technology on institutions. North (1992) argues that societies can only take advantage of technologies if they are able to restructure the institutions shaping their choice sets to provide incentives for increasing productivity and technology adoption. With increased specialization and impersonalization of markets, the number and scope of transactions grows as monitoring and enforcement of contracts becomes more difficult. In response to a widening in the overall costs of transacting, technologies and institutions need to adapt in order to reduce the cost of individual transactions.

North (1995) asserts that most decisions are made within the existing institutional framework, but the need to alter contracts puts pressure on rules and norms causing them to be modified. Incentives for modification, in turn, arise out of individuals' perceptions that they will benefit from restructuring exchanges. Such perceptions may stem from exogenous factors or, more importantly, a process of learning. The rate of learning determines the speed of economic change while the kind of learning guides its direction. North argues that the latter is rooted in the mental constructs of individuals and the incentive structures embodied in the institutional framework.

Putting this framework into a collective action context, we can assume that groups which share common environments and experiences are more likely to form similar mental constructs, which will shape their learning processes and perceptions. Presumably, this will foster a similar set of modifications which would be reinforced by communication within the group. Through a process of consensus-building and collective mapping out of strategies for altering contracts and norms, interest groups may consolidate their power so as to be better positioned than individuals to drive a process of institutional change. Whether collective action is initiated and ultimately succeeds depends crucially on the transaction costs it imposes over time.

In the case of collective action for the purpose of managing common property resources, costs are associated with design of the use rules, coordination of efforts, enforcement of rules and prevention of free-riding behavior, and the private and social costs resulting from exclusion of non-members. However, when weighed against the private and social costs of privatizing natural resources which embody widespread externalities, collective management exercised within common property regimes may have substantial efficiency and equity advantages over systems of individual management of private property. Under these circumstances, technologies which are designed for coordinated implementation by multiple users in a common property setting will prove to be most appropriate and the best candidates for adoption.

The choice of NRM technologies will inevitably shape the institutions underlying property rights and collective action. Technologies embodying substantial spatial externalities such as irrigation are likely to induce demand for common property regimes and collective action given the gains to be realized from coordinated efforts. However, if incentives for adoption are not built into PRCA institutions, information asymmetries are profound, and transaction costs of coordination and enforcement are not reduced, then technology adoption will not succeed and unsustainable outcomes may prevail. Using North's language (1992), the 'adaptive efficiency' of a society or community is the critical variable in ascertaining the potential for technical and institutional change.

Technologies with temporal externalities whereby the benefits of the technology are reaped at some future point in time carry implications for enhancing tenure security. Ploughing and planting barley establishes a claim on communal rangelands under the informal tenure system prevailing in large parts of North Africa and West Asia (Ngaido 1997a). However, such cultivation practices on fragile rangelands often lead to soil erosion, implying that existing property rights institutions can foster perverse outcomes in the face of competition and scarcity.

Planting trees may also establish or strengthen a claim on land. While this may be seen as a positive effect in terms of halting environmental degradation, promoting tree planting without understanding the interaction with tenure can lead to problems. The example in Section 3 of a tree planting program in the Gambia undermining women's productivity and power illustrates this (Schroeder 1993). The result was negative both in terms of efficiency and gender equality. Furthermore, if technologies are to be employed by women and other less enfranchised groups, the institutions which govern their rights to use a technology and capture the returns on their investment must be in place. In societies where women cannot plant trees because it is seen to strengthen their claim to land, agroforestry technology will only alter cultural norms if its benefits to women and to the community as a whole outweigh the costs faced by women seeking changes and the costs perceived by society of modifying the status quo.

Even though expectations of increased tenure security may encourage tree planting, incentives for tree management may not be present as suggested by Otsuka et al. (1998) in their study of land and tree tenure institutions in Western Ghana. Here farmers sought increased tenure security through extensive tree planting, thereby strengthening individual land rights. However, improvements in cocoa yields, a sign of better tree management, were not observed outcomes of having established stronger claims to land.

More generally, technologies that increase the value of a resource may induce privatization, enclosure, and the exclusion of some customary uses. Yet, the gains to some households and individuals from such institutional change are frequently offset by losses to others. Empirical studies have revealed a negative correlation between household income and reliance on CPRs for subsistence purposes (Jodha 1986 and 1992; Hopkins, Scherr, and Gruhn 1994). Women especially depend on resources from common property and "interstitial spaces" of private property (for example, hedgerows, reed beds) to provide for their family's needs (Maggs and Hoddinott 1997; Agarwal 1994; Rocheleau 1988; Rocheleau and Edmunds 1997), or for their own tenure security where private property does not guarantee them access in the case of widowhood or divorce (Fortmann, Antinori, and Nabane 1997). Well-defined and secure property rights to CPRs are therefore highly important for the poor, and women who are poor in particular. Effective poverty alleviation strategies need to support common property regimes which enhance production of CPRs over the long-term and ensure fair distribution to more marginalized interest groups.

5. IMPLICATIONS FOR EFFICIENCY, EQUITY AND ENVIRONMENTAL SUSTAINABILITY

Adoption of new technologies is not an end in itself, either for agricultural researchers, policy-makers, or people who employ them in farming or managing natural resources. Rather, the outcome of technological change should be evaluated in terms of the contribution to broader goals of sustainable development. Growth, poverty alleviation, and environmental sustainability form a "critical triangle" for development (Vosti and Reardon 1997). Although there may be trade-offs between these three objectives, all are necessary and interlinked.

The way these play out in practice is strongly influenced by the nature of property rights and degree of collective action. Tenure security may elicit higher productivity and more efficient outcomes by ensuring only those who invest reap the benefits from doing so and that the right to do so is guaranteed for a long enough period in the eyes of the producer (Bruce 1993). Likewise, arguments stemming from as far back as colonial Africa maintain that tenure security provides the necessary incentive for producers to conserve resources by assuring them the future benefits (Lloyd 1977). However, the degree of tenure security within a community or among communities is not necessarily uniform. Wealth, power, and status are factors in determining one's tenure security and thus shape equity and environmental outcomes. Collective action becomes a critical component of tenure security in common property regimes, and a means of coordinating resource management across private holdings.

PROPERTY RIGHTS AND TECHNOLOGY ADOPTION

The effect on increasing productivity is a basic aspect considered in efficiency-oriented technology development. However, simplistic analyses of efficiency can lead to distortions. Many customary tenure regimes permit different users to exploit different "niches." Examples include pastoralists and cultivators on the same land; irrigation, fishing, and domestic use of water; or timber, firewood, and minor forest products (Swallow et al. 1997a). Technologies that increase the production of one of those components at the expense of other outputs do not necessarily improve efficiency. For example, introducing new tree species or forest management practices may maximize production of logs, but sacrifice kindling and minor forest products critical to the livelihoods of local residents (Meinzen-Dick et al. 1997).

Privatization of common property and land under communal tenure tends to lead to loss of multiple user rights in favor of more concentrated resource holding by a less diverse set of interests (Jodha 1992; Swallow et al. 1997a; Rocheleau and Edmunds 1997). The logic underpinning the privatization of tenure in Kenya during the 1950s rested on the belief that more entrepreneurial and supposedly more efficient farmers would acquire land from less efficient farmers (Swynnerton 1954). Subsequent research has linked conversion to freehold tenure to rising loss of access to land and other resources and large-scale land acquisitions by wealthy producers, government officials and speculators, with dubious gains for efficiency (Jodha 1992; Shipton 1988; Hitchcock 1980). Where the purchases are by large scale producers and speculators who are interested in short-term profits and have little stake in the long-term productivity of the land, soil fertility and other natural resources may be depleted (Jodha 1988 and 1992; Chambers et al. 1989; Arnold and Stewart 1989; Gupta 1987).

Examination of efficiency outcomes of new technology also need to include considerations of risk and transaction costs. Targeting wealthy households often shows the most rapid adoption and apparent productivity gains because farmers with large holdings will have a greater capacity to adopt mechanized and other capital intensive technologies which lend themselves to enhanced efficiency outcomes, particularly in labor-scarce environments. Households with low wealth face greater constraints and will likely place a higher value on stability of earnings and therefore be more risk averse than a more affluent household. The incorporation of transaction costs and risk considerations in efficiency calculations shows the rationality of the livelihood strategies employed by the poor, and the factors that need to be considered in understanding technology choices. This appreciation broadens the scope of technologies deemed to be efficiency improving so that they are less biased toward ‘wealthy’ concepts of efficiency.

Concerns over the equity outcomes of introducing new technologies have received considerable attention in the wake of the Green Revolution. Unless land holdings are distributed relatively evenly, improving the productivity of wealthier farmers by making technology available which are unsuitable for small scale farmers or those with less secure tenure exacerbates inequalities. Determining the temporal and spatial scale of technologies as in Figure 1, and relating this to the local distribution of tenure provides an indicator of where this is likely to be problematic. For example, the scale neutrality and short-term benefits of HYVs meant that small farm size and tenancy were not constraining (though risk aversion and credit constraints often limited adoption by small farmers, at least initially -- see Hazell and Ramasamy 1991). By contrast, tubewells or tractors are "lumpy" investments that require a longer time horizon and larger service area to be profitable, and hence are more likely to be purchased by larger farmers or groups of small farmers with long-term rights to resources (Meinzen-Dick 1996; Binswanger 1978). The fact that scale-neutral technologies (for example, new varieties) often require investments in large-scale technologies (for example, irrigation) to be effective can also undermine adoption of seemingly equity-enhancing innovations.

Although common property regimes do not guarantee equitable outcomes among their members, they do accommodate multiple users beyond the household level and are therefore better equipped than private property to spread benefits more evenly. However, recent research has cautioned against assuming common property regimes and collective action embody impartial sharing rules and equal distribution of power (Agrawal and Gibson 1997). In his research on communally owned land in Portugal, Brouwer (1992) maintains that mechanisms of social redistribution and security shape equity outcomes of resource exploitation, rather than property rights themselves. Although users have equal rights to the resource, ability to exploit the resources is conditioned by one's access to private means of production.

Equity considerations do not only apply between households, but also to gender differences in access to and control over technology and resources. Although it cannot be said that male dominance in many societies stems from their monopoly on property rights, ownership of property enhances the status and bargaining power of individuals within both the household and community (Agarwal 1994, 1997; Meinzen-Dick et al. 1997; Folbre 1997). Greater control over resources tends to enhance men's influence over community power structures and wield political leverage with government officials and others responsible for technology distribution as well as infrastructure and market development. The same is true for the wealthier strata of society (Kurien 1995; Grabowski 1990). Technologies and their supporting infrastructure will therefore mainly reflect the interests of men who control the most substantial resources unless a sufficient degree of collective action emerges capable of reshaping political outcomes so that government and other suppliers of technology and infrastructure intervene with policies to override these biases.

COLLECTIVE ACTION AND TECHNOLOGY ADOPTION

As discussed in Section 4, various technologies will be more efficiently employed with collective adoption after material and transaction costs are assessed, whereas others will be more amenable to individual adoption. Alternatively, collective action may influence technological choices based on their anticipated impact on efficiency, equity and environmental sustainability.

Used as an advocacy or political tool, collective action can be used by marginalized interests groups to challenge property rights institutions, existing political and cultural institutions, and technology adoption. Agarwal (1994) reports how women's groups in Bihar, India succeeded in getting land titles assigned to women in their own right as part of a broader peasant land reform struggle. In another example, organization by artisinal fishermen in Kerala, India led to restoration of their coastal common property rights, state financial assistance and eventually a season ban on trawling by commercial fishermen (Kurien 1995).

Collective action can be used to prevent the use of certain technologies, as seen in Katon, Pomeroy, and Salamanca's (1997) study of a fishers' organization in the Philippines preventing the use of beach seine nets, dynamite, and strong poisons for fishing. In other cases it can serve to modify the features of a particular technology or its mode of adoption. In both the Philippines case and the case of the artisinal fishermen in India (Kurien 1995), local groups constructed artificial reefs as a means to lure more fish and increase their food supply. Harvesting technologies thus shifted from extractive practices to artificial reefs which not only benefitted small scale fishermen, but also enhance the productivity of coastal resources. Greater integrated community participation in decision-making about the design, implementation and adaptation of technologies may not only ensure that new technology does not disproportionately and inefficiently increase the workload of marginalized groups, but actually functions to reduce overall labor inputs.

LINKAGES AND TRADEOFFS BETWEEN THE COMPONENTS OF THE CRITICAL TRIANGLE

Inequities may also carry environmental implications. For instance, use of pesticide technology by large farmers may generate negative externalities for small farmers if they do not have access to it, especially if the chemicals eliminate predators who would otherwise keep the pest in check. Inadequate access to land and technology by the poor can lead to over-exploitation and degradation of resources. Conversely, where indigenous property systems have broken down so that members no longer have an assurance that they will benefit from investments or long-term management practices, individualization of resources can contribute to adoption of more sustainable resource management practices (Bruce 1993).

Objectives of efficiency, equity and environmental sustainability frequently involve tradeoffs, particularly in the short run. Efficiency maximization involves selection, whether it is managers, labor, capital or land. Some inputs will lose relative to others, and this leads to inequitable outcomes. Even within input categories, substitutions are made. In the U.S., efficiency-enhancing technology improvements combined with certain macroeconomic factors have increased the demand of skilled labor at the expense of unskilled labor (Krugman and Lawrence 1993).

Efficiency and environmental goals are often at odds as well. Efficiency measures tend to assess only the private financial costs of inputs and neglect social and environmental costs. Privatization of such resources as rangelands and fisheries has been advocated as a measure to control stocking rates and improve resource productivity so as to enhance profitability (Cheung 1970; Picardi 1974; Johnson 1972; Foss 1960; Demsetz 1967). However, one sees in Africa where failure to account for environmental variability and fragility has resulted in overgrazing, soil erosion, and other forms of environmental degradation on many privatized ranches and areas appropriated by sedentarization schemes (Keya 1991; Hogg 1987; Gilles and Jamtgaard 1981). Likewise, poverty alleviation strategies may initially rely on extensification techniques which lead to resource degradation.

However, the tradeoffs are perhaps overstated. In the case of natural resource management techniques such as agroforestry, environmental degradation can raise the perceived value of products and conservation of the resource base to where it becomes worthwhile to invest in new technologies (Scherr 1995). Also, when efficiency criteria are placed in a dynamic framework, the value of a resource over time is captured and conservation often emerges as the optimal strategy. When transaction costs and risk considerations are incorporated into efficiency calculations, the livelihood strategies employed by the poor can be understood as economically rational. Likewise, when productivity measures include the value of non-traded goods and services which poor households (and especially women within those households) obtain for their livelihood and security, an equitable distribution of resources, or technologies that favor the disadvantaged, may be seen as highly productive. Appreciation of less tangible economic and social dynamics broadens the scope of technologies deemed to be efficiency improving so that they are less biased toward concepts of efficiency which consider only physical inputs. Thus, recognition and attention to the complexity of measuring efficiency is necessary to prevent the poor from being left behind or hurt by technologies and to narrowing equity gaps.

Tradeoffs may also become less relevant in the long-term. Compatibility between efficiency, equity, and environmental outcomes can arise over time with the development of more land intensive and conservation-oriented technologies that either evolve or are designed to be both accessible and affordable to poor farmers and herders (Vosti and Reardon 1997).

6. POLICY IMPLICATIONS AND AREAS FOR RESEARCH

Despite the growing body of theoretical and empirical studies of how property rights and collective action institutions can constrain or facilitate the adoption of agricultural and natural resource management technologies, the effects of these institutions has often been understated because most of these studies have looked only at the direct effects (or has been overstated because they have been confounded with the effect of other factors.) This paper has proposed a conceptual framework for analyzing the factors affecting technology choice which not only includes the direct effects, but also indirect effects as they are filtered through changes in property rights and collective action institutions (Figure 3). In doing so, it seeks to provide a new approach for framing empirical research which specifies and tests these indirect effects.

Whereas the literature has taken account of the effect of property rights on the technology adoption process, empirical research on the importance of collective action on application of NRM technologies remains largely underresearched. Likewise, empirical research is lacking on assessing the impact of technology on an array of adoption constraints and opportunities, including PRCA. New institutional economics has produced much theory, but notably little in the way of actually measuring technology's role in the evolution of institutions. Shifting to the tail end of the conceptual framework, there is a need for both theoretical and empirical research to enrich our understanding of the interaction between technological choice and efficiency, equity and environmental sustainability. This component is especially critical for illuminating improved strategies aimed at poverty alleviation, the overarching goal of much national and international research on technologies for natural resource management.

Testing these relationships empirically is a serious methodological challenge, given the number of factors involved. Moreover, because institutional change is path dependent, the answers from one site will not necessarily apply more broadly. However, detailed analyses of the interrelationships between technological and institutional change are nevertheless needed to understand the dynamic processes if technologies are to be adopted, and to improve the productivity, equity, and sustainability of resource management.

Institutions do not always need to adapt to technology. Even the existing base of knowledge of property rights and collective action provides guidance for developing technologies that fit the institutional, as well as the physical environment. Assessing the degree of tenure security and collective action in a location can be used as a starting point for developing techniques with an appropriate scale and time horizon, as indicated in Figure 1.

On the policy side, strengthening local institutions of property rights and collective action increases the probability that people will use many of the new technologies for resource management. However, no single instrument provides the key to understanding and influencing people's use of different technologies. This paper has illustrated some of the complexities in the linkages between property rights, collective action, and technology choices. Because of the many interrelationships, and the number of site-specific factors involved, it is not straightforward to prescribe a certain type of property regime as "most appropriate" for a particular technology or resource management practice. But even if it were, identifying policy tools to develop such property rights is far from straightforward. Simply passing laws specifying the rights and responsibilities of individuals, groups, or government agencies is not enough. Laws alone do not create property rights unless there are institutions to monitor and enforce those rights. If we recognize the importance of legal pluralism, we see that local law derived from a number of sources may have equal or greater influence on actual behavior. Thus, the evolution of property rights must be understood as a process of institutional change, in which resource users themselves play an active role. While this certainly limits the ability of outside "experts" or policy-makers to shape property rights, it also recognizes that local users themselves have greater knowledge of their specific physical, socioeconomic, and institutional context.

Similarly, collective action cannot be externally dictated (unless there is considerable coercion). However, there are policies that have been shown to be effective in fostering local organizations for voluntary resource management activities. Employing a cadre of institutional organizers is one approach that has been effective, especially in the irrigation sector (Korten and Siy 1988; Manor, Patamatamkul, and Olin 1990). In Namibia, an organizing partnership of communities, NGOs and the Ministry of Tourism and the Environment enables the integration of GIS and participatory mapping for establishing institutions to jointly manage wildlife resources (Tagg, Holme, and Kooiman 1996). These organizers, who may work for an NGO, university, or government agency, spend time in the communities, discussing what needs to be done, developing consensus, and encouraging local participation in both direct activities and in decision-making about the structure of collective action. While this approach can be time-consuming and somewhat expensive in terms of organizers' salaries and field expenses, it is often a relatively small portion of total development project costs, and has shown high returns in terms of uptake and sustainability of resource management practices (Bagadion and Korten 1991; Meinzen-Dick, Reidinger, and Manzardo 1995). The use of organizers can be thought of as subsidizing initial leadership development and as an investment in the institutional infrastructure required for sustainable resource management.

Finally, property rights over natural resources can provide an important policy tool for strengthening collective action in their management. Just as individuals are unlikely to invest in soil fertility, terracing, or tree planting unless they have secure tenure, communities cannot be expected to invest in managing long-term practices if they have no long-term rights to the resource. Yet many governments have been unwilling to transfer rights to water, irrigation infrastructure, rangelands, or forests when they devolve management responsibility to user groups. The issues of community rights and ways of creating new common property resources (in place of government ownership) are emerging as critical issues in devolution programs (Svendsen 1997).

REFERENCES

Adams, D. W. and D. A. Fitchett. 1992. *Informal finance in low-income countries.* Boulder, Colo.: Westview Press.

Adesina, A., J. Chianu, and D. Mbila. 1997. Property rights and alley farming technology adoption in West and Central Africa. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Agarwal, B. 1994. *A field of one s own: Gender and land rights in South Asia*. Cambridge, U.K.: Cambridge University Press.

Agarwal, B. 1997. Environmental action, gender equity and women's participation. *Development and Change* 28 (1): 1-44.

Agrawal, A. and C. Gibson. 1997. Community, resources and development. Beyond enchantment and disenchantment. Indiana University, Bloomington, In. Mimeo.

Ahluwalia, M. 1997. Representing communities: The case of a community-based watershed management project in Rajasthan, India. *IDS Bulletin* 28 (4): 23-35.

Al-Sanabani, M., A. Aw-Hassan, and A. R. Bamatraf. 1997. The impact of land tenure on mountain terrace maintenance in Yemen. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Alston, J. M. and W. Martin. 1992. Global and domestic impacts of technological change in agriculture: A developing country perspective. Department of Agricultural Economics, University of California and International Trade Division, World Bank, Washington, D.C. Mimeo.

Anderson, J. R. 1974. Risk efficiency in the interpretation of agricultural production research. *Review of Marketing and Agricultural Economics* 42 (3): 131-184.

Anderson, J. R., J. L. Dillon, and J. B. Hardaker. 1977. *Agricultural decision analysis.* Ames, Ia.: Iowa State University Press.

Arnold, J. E. M. and W. Stewart. 1989. Common property resource management in India: A desk review. Report for the Asian Environment and Social Affairs Division and the India Agriculture Division. Washington, D.C. World Bank.

Athukorala, K. and M. Zwarteveen. 1994. Participatory management: Who participates? *Economic Review* 20 (6): 22-25.

Bagadion, B. U. and F. F. Korten. 1991. Developing irrigators' organizations: A learning process approach. In *Putting people first: Sociological variables in rural development*, 2nd edition, ed. M. M. Cernea. Washington, D.C.: World Bank.

Bahduri, A. 1973. A study in agricultural backwardness under semi-feudalism. *Economic Journal* 83: 120-137.

Baland, J-M. and J-P. Platteau. 1996. *Halting degradation of natural resources: Is there a role for rural communities?* Oxford, U.K.: Clarendon Press.

Bardhan, P. K. 1979. Agricultural development and land tenancy in a peasant economy: A theoretical and empirical analysis. *American Journal of Agricultural Economics* 61: 48-56.

Barrows, R. and M. Roth. 1990. Land tenure and investment in African agriculture: Theory and evidence. *Journal of Modern African Studies* 28: 265-297.

Behnke, R. H. 1994. Natural resource management in pastoral Africa. *Development Policy Review* 12: 5-27.

Bell, C. 1972. The acquisition of agricultural technology: Its determinants and effects. *Journal of Development Studies* 9 (1): 123-159.

Berger, M. and M. Buvinic. 1989. *Women s ventures: Assistance to the informal sector in Latin America*. West Hartford, Conn.: Kumarian Press.

Berry, S. 1988. Property rights and rural resource management: The case study of tree crops in West Africa. *Cahiers des Sciences Humaines* 24 (1): 3-16.

Besley, T. 1995. Property rights and investment incentives: Theory and evidence from Ghana. *Journal of Political Economy* 103 (5): 903-937.

Bhagwati, J. 1958. Immiserizing growth: A geometrical note. *Review of Economic Studies* 25: 201-205.

Bhalla, S. S. 1979. Farm and technical change in Indian agriculture. In *Agrarian structure and productivity in developing countries*, ed. R. Berry and W. Cline, Baltimore, Md.: Johns Hopkins University Press.

Bhatia, B. 1992. Lush fields and parched throats: The political economy of groundwater in Gujarat. *Economic and Political Weekly* 27 (51-2): A-142-170.

Bhole, L. M. and R.V. Bhavani. 1995. Grameen Bank of Bangladesh: A model for financing rural development. *International Journal of Development Banking* 13: 35-46.

Binswanger, H. 1978. *The economics of tractors in South Asia: An analytical review*. New York: Agricultural Development Council and International Crops Research Institute for the Semi-Arid Tropics.

Birner, R. and H. Gunaweera. 1998. Between market failure, policy failure, and "community failure": Property rights, crop-livestock conflicts, and the adoption of sustainable land use practices in the dry zone of Sri Lanka. Institute of Rural Development, University of Gottingen. Mimeo.

Boserup, E. 1981. *Population and technological change*. Chicago, Il.: University of Chicago Press.

Bromley, D. W. 1991. *Environment and economy: Property rights and public policy.* Cambridge, Mass.: Basil Blackwell, Inc.

Bromley, D. W. and M. M. Cernea. 1989. *The management of common property natural resources: Some conceptual and operational fallacies*. World Bank Discussion Paper 57. Washington, D.C.: The World Bank.

Brouwer, R. 1992. Common goods and private profits: Traditional and modern communal land management in Portugal. Paper presented at the Inequality and the Commons conference of the International Association of Common Property, Washington, D.C., September 17-20.

Bruce, J. 1993. Do indigenous tenure systems constrain agricultural development? In *Land in African Agrarian Systems*, ed. T. J. Bassett and D. E. Crummey. Madison, WI: University of Wisconsin Press.

Carney, J. 1988. Struggles over crop rights and labour within contract farming households in a Gambian irrigated rice project. *Journal of Peasant Studies* 15 (3): 334-349.

Carney, J. 1992. *Contract farming and female rice growers in the Gambia*. Network Paper 15. London: Overseas Development Institute.

Carney, Judith and Michael Watts. 1991. Disciplining women? Rice, mechanization, and the evolution of Mandinka gender relations in Senegambia. *Journal of Women in Culture and Society* 69 (4): 349-365.

Carter, C. A. 1985. Agricultural research in international trade: In *Economics of Agricultural Research in Canada*, ed. K. K. Klein and W. H. Furtan, Calgary: The University of Calgary Press.

Chambers, R. and M. Leach. 1989. Trees as savings and security for the rural poor. *World Development* 17 (3): 329-342.

Chambers, R., N. C. Saxena, and T. Shah. 1989. *To the hands of the poor: Water and trees*. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Chen, M. A. 1983. *A quiet revolution: Women in transition in rural Bangladesh*. Cambridge, Mass.: Schenkman Publishing House.

Chen, M. 1989. The working women's forum: Organizing for credit and change in Madras, India. In *Seeds: Supporting women s work in the Third World*, ed. A. Leonard. New York: The Feminist Press.

Cheung, S. N. S. 1970. The structure of a contract and the theory of a non-exclusive resource. *Journal of Law and Economics* 13: 49-70.

Cleaver, F. 1998. Incentives and informal institutions: Gender and the management of water. *Agriculture and Human Values* (forthcoming).

Cohen, J. 1980. Land tenure and rural development in Africa. In *Agricultural development in Africa*, ed. R. Bates and M. Lofchie. New York: Praeger.

Coward, E. W., Jr. 1986. Direct or indirect alternatives for irrigation investment and the creation of property. In *Irrigation investment, technology and management strategies for development*, ed. K. W. Easter. Boulder, Colo.: Westview Press.

de Janvry, A. 1979. Comment. In *Economics and the design of small farmer technology*, ed. A. Valdez, G. Scobie, and J. Dillon. Ames, Ia.: Iowa State University Press.

Delgado, C. and J. McIntire. 1982. Constraints on oxen cultivation in the Sahel. *American Journal of Agricultural Economics* 64: 188-196 (May).

Demsetz, H. 1967. Toward a theory of property rights. *American Economic Review* 57: 347-59.

Dorner, P. 1972. *Land reform and economic development*. Kingsport: Kingsport Press.

Drijver, C. A., J. C. J. van Wetten, and W. T. de Groot. 1995. Working with nature: Local fishery management on the Logone floodplain in Chad and Cameroon. In *Local resource management in Africa*, ed. J. P. M. van den Breemer, C. A. Drijver and L.B. Venema.. West Sussex, U.K.: John Wiley and Sons, Ltd.

Ensminger, J. 1992. *Making a market: The institutional transformation of an African society.* Cambridge, U.K.: Cambridge University Press.

Ensminger, J. 1997. Changing property rights: Reconciling formal and informal rights to land in Africa. In *The frontiers of the new institutional economics,* ed. J. N. Drobak and J. V. C. Nye. San Diego, Calif.: Academic Press.

Erenstein, O. and P. Cadena Iniguez. 1997. *The adoption of conservation tillage in a hillside maize production system in Motozintla, Chiapas*. NRG Paper 97-01. Mexico D.F.: Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT).

Eyzaguirre, P. B. 1988. Competing systems of land tenure in an African plantation economy. In *Land and Society in Contemporary Africa*, ed. R.E. Downs and S. P. Reynas. Hanover, N.H.: University Press of New England.

FAO (Food and Agricultural Organization of the United Nations). 1985. *Women and developing agriculture*. Women in Agriculture Series No. 1. Rome: FAO.

Feder, G. 1980. Farm size, risk aversion and the adoption of new technology under uncertainty. *Oxford Economic Papers* 32 (2): 263-283.

Feder, G. and R. Noronha. 1987. Land rights, systems and agricultural development in sub-Saharan Africa. *World Bank Research Observer* 2 (2): 143-169.

Feder, G. and T. Onchan. 1987. Land ownership security and farm investment in Thailand. *American Journal of Agricultural Economics* 69 (2): 311-320.

Feder, G., T. Onchan, Y. Chalamwong, and C. Hongladaron. 1988. *Land policies and farm productivity in Thailand*. Baltimore, Md.: Johns Hopkins University Press.

Feder, G., R. E. Just, and D. Zilberman. 1982. *Adoption of agricultural innovations in developing countries*. World Bank Staff Working Paper No. 542. Washington, D.C.: World Bank.

Folbre, N. 1997. Gender coalitions: Extrafamily influences on intrafamily inequality. In *Intrahousehold resource allocation in developing countries: Models, methods, and policy*, ed. L. Haddad, J. Hoddinott, and H. Alderman. Baltimore and London: Johns Hopkins University Press.

Fortmann, L. and D. Rocheleau. 1985. Women and agroforestry: Four myths and three case studies. *Agroforestry Systems* 2: 253-272.

Fortmann, L. and J. Bruce. 1988. *Whose trees? Proprietary dimensions of forestry.* Boulder, Colo.: Westview Press.

Fortmann, L. 1988. The tree tenure factor in agroforestry with particular reference to Africa. In *Whose trees? Proprietary dimensions of forestry*, ed. L. Fortmann and J. W. Bruce. Boulder, Colo.: Westview Press

Fortmann, L., C. Antinori, and N. Nabane. 1997. Fruits of their labors: Gender, property rights, and tree planting in two Zimbabwe villages. *Rural Sociology* 62 (3): 295-314.

Foss, P.O. 1960. *Politics and grass: The administration of grazing on the public domain*. Seattle, Wash.: University of Washington Press.

Freebairn, D. K. 1995. Did the Green Revolution concentrate incomes? A quantitative study of research reports. *World Development* 23 (2): 265-279.

Freudenberger, M. 1994. *Tenure and natural resources in the Gambia: Summary of research findings*. Land Tenure Center Research Paper. Madison, Wisc.: University of Wisconsin.

Galaty, J. G. 1994. Rangeland tenure and pastoralism in Africa. In *African pastoralist systems: An integrated approach*, ed. E. Fratkin, K. A. Galvin, and E. Abella Roth. Boulder, Colo.: Lynne Rienner Publishers.

Gavian, S. and S. Ehui. Forthcoming. Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia. *Agricultural Economics*.

Gerhart, J. 1975. *The diffusion of hybrid maize in West Kenya*. Mexico D.F.: CIMMYT.

Ghose, A. K. and A. Saith. 1976. Indebtedness, tenancy and the adoption of new technology in semi-feudal agriculture. *World Development* 4 (April): 305-320.

Gilles, J. L. and K. Jamtgaard. 1981. Overgrazing pastoral areas: The commons reconsidered. *Sociologica Rurales* 21 (2): 129-41.

Grabowski, R. 1990. Agriculture, mechanization and land tenure. *The Journal of Development Studies* 27 (1): 43-53.

Griffiths, J. 1986. What is legal pluralism? *Journal of Legal Pluralism* 24: 1-55.

Gupta, A. K. 1987. Why poor people do not cooperate? A study of traditional forms of cooperation and implications for modern organisations. In *Policies and Practices of Social Research*, ed. G. C. Wanger. London: Allen and Unwin.

Hansmann, H. 1988. Ownership of the firm. *Journal of Law, Economics and Organization* 4 (2): 267-304.

Hansmann, H. 1990. The viability of worker ownership. An economic perspective on the political structure of the firm. In *The firm as a nexus of treaties*, ed. M Aoki, B. Gustaffson, and O. E. Williams. London: SAGE Publications.

Harrisson, P. 1987. *The greening of Africa*. London: Paladin Grafton Books.

Harriss, B. 1972. Innovation adoption in Indian agriculture—the high yielding variety program. *Modern Asian Studies* 6.

Haugerud, A. 1983. The consequences of land tenure reform among smallholders in the Kenya Highlands. *Rural Africana* 15-16: 65-89.

Hayami, Y. and V. W. Ruttan. 1985. *Agricultural development: An international perspective.* Baltimore, Md.: Johns Hopkins University Press.

Hazell, P. B. R. and J. R. Anderson. 1984. Public policy toward technical change in agriculture. *Greek Economic Review* 6 (3): 453-482.

Hazell, P. B. R. and C. Ramasamy. 1991. *The Green Revolution reconsidered: The impact of high-yielding rice varieties in South India*. Baltimore, Md.: Johns Hopkins University Press.

Helleiner, G. K. 1975. Smallholder decision making: Tropical African evidence. In *Agriculture in development theory*, ed. L.G. Reynolds. New Haven, Ct.: Yale University Press.

Hitchcock, R. K. 1980. Tradition, social justice and land reform in Central Botswana. *Journal of African Law* 24 (1): 1-34.

Hogg, R. 1987. Settlement, pastoralism and the commons: The ideology and practice of irrigation development in Northern Kenya. In *Conservation in Africa: People, policies and practice*, ed. David Anderson and Richard Grove. New York: Cambridge University Press.

Hopkins, J., S. J. Scherr, and P. Gruhn. 1994. Food security and the commons: Evidence from Niger. International Food Policy Research Institute (IFPRI), Washington, D.C. Mimeo.

Jehangir, Waqar. 1998. Property rights and salinity management (lessons learned from the Rechna Doab, Punjab, Pakistan. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Jodha, N. S. 1986. Common property resources and the rural poor in dry regions of India. *Economic and Political Weekly* 21: 1169-1181.

Jodhan, N. S. 1988. Institutional aspects of range resource management in the arid zone of India. Paper presented at the Third International Rangeland Congress, November 7-11, New Delhi, India.

Jodha, N. S. 1992. *Common property resources: A missing dimension of development strategies*. World Bank Discussion Paper 169. Washington, D.C.: World Bank.

Johnson, O. E. G. 1972. Economic analysis, the legal framework and land tenure systems. *Journal of Law and Economics* 15: 259-76.

Katon, B. M., R. S. Pomeroy, and A. Salamanca. 1997. The marine conservation project for San Salvador: A case study of fisheries co-management in the Philippines. Paper presented at Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Keya, G. A. 1991. Alternative policies and models for arid and semi-arid lands in Kenya. In *When the grass is gone: Development intervention in African arid lands*, ed. P.T.W. Baxter. Uppsala: The Scandanavian Institute of African Studies.

Kirk, M. 1988. Technological innovations and changes in agrarian structures: The diffusion of animal traction in Cameroon and Togo. *Quarterly Journal of International Agriculture* 27 (1): 52-63.

Korten, F. F. and R. Y. Siy, Jr. 1988. *Transforming a bureaucracy: The experience of the Philippine National Irrigation Administration*. West Hartford, Connecticut: Kumarian.

Krugman, P. and R. Lawrence. 1993. *Trade, jobs and wages*. Working Paper No. 4478. Cambridge, Mass.: National Bureau of Economic Research.

Kumar, S. K. 1994. *Adoption of hybrid maize in Zambia: Effects on gender roles, food consumption, and nutrition*. Research Report 100. Washington, D.C.: IFPRI.

Kurien, J. 1995. Collective action for common property resource rejuvination: The case of people's artificial reefs in Kerala State, India. *Human Organization* 54 (2): 160-168.

Lastarria-Cornheil, S. 1997. Impact of privatization on gender and property rights in Africa. *World Development* 25 (8): 1317-1333.

Lawry, S. W. 1990. Tenure policy toward common property natural resources in sub-Saharan Africa. *Natural Resource Journal* 30: 403-421.

Leach, R. 1961. *Pul Elya, a village in Ceylon: A study of land tenure and kinship*. Cambridge, U.K.: Cambridge University Press.

Lipton, M. 1976. Agricultural finance and rural credit in poor countries. *World Development* 4: 543-554.

Lloyd, W.F. 1977. On the checks to population. In *Managing the commons.* ed. G. Hardin and J. Baden. San Francisco, Calif.: W.H. Freeman & Co.: 8-15.

Lynam, J. 1994. Sustainable growth in agricultural production: The links between production, resources and research. In *Opportunities, use, and transfer of systems research methods in agriculture to developing countries: Proceedings of an International Workshop on Systems Research Methods in Agriculture in Developing Countries*, ed. P. Goldsworthy and F. Penning de Vries. November 22-24, 1993, ISNAR, The Hague. Dordrecht; Boston: Kluwer Academic Publishers.

Maggs, P. and J. Hoddinott. 1997. The impact of change in common property resource management on intra-household allocation. FCND Discussion Paper No. 34. IFPRI, Washington, D.C.

Mahendraraja, S. 1981. *Water resource optimisation in small dams in Sri Lanka*. Canberra, Australia: Australian National University.

Manor, S., S. Patamatamkul, and M. Olin, eds. 1990. *Role of social organizers in assisting farmer managed irrigation systems*. Proceedings of a regional workshop held at Khonkaen, Thailand from 15 to 29 May, 1989. Colombo, Sri Lanka: International Irrigation Management Institute.

Manyong, V. M. and A.V. Houndekon. 1997. Land tenurial systems and the adoption of mucuna planted fallows in the derived savannas of West Africa. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Marshall, G. 1998. *A dictionary of sociology.* New York, N.Y.: Oxford University Press.

Mayoux, L. 1993. Integration is not enough: Gender inequality and empowerment in Nicaraguan agricultural co-operatives. *Development Policy Review* 11 (1): 67-89.

McCarthy, N. Forthcoming. An economic analysis of the effects of production risk on the use and management of common-pool rangelands. EPTD Discussion Paper. IFPRI, Washington, D.C.

Meinzen-Dick, R. S. 1996. *Groundwater markets in Pakistan: Participation and productivity.* Research Report 105. Washington, D.C.: IFPRI.

Meinzen-Dick, R. S., L. R. Brown, H. Sims Feldstein, and A. R. Quisumbing. 1997. Gender, property rights, and natural resources. *World Development* 25 (8) 1303-1315.

Meinzen-Dick, R. S., L. A. Jackson, and T. A. White. 1996. Conceptual framework: System-wide program on property rights and collective action. IFPRI, Washington, D.C.. Mimeo.

Meinzen-Dick, R., R. Reidinger, and A. Manzardo. 1995. *Irrigation.* Participation Sourcebook Technical Paper. Washington, D.C.: World Bank.

Mearns, R. 1996. Community, collective action and common grazing: The case of post-socialist Mongolia. *The Journal of Development Studies* 32 (3): 297-339.

Merry, S. E. 1988. Legal pluralism. *Law and Society Review* 22 (5): 809-896.

Murgai, R. 1997. Localized and imperfect reciprocity—an analysis of the limitations to village-level risk sharing. University of California, Berkeley. Mimeo.

Neef, A. and F. Heidhues. 1994. The role of land tenure in agroforestry: Lessons from Benin. *Agroforestry Systems* 27: 145-161.

Ngaido, T. 1997. Property rights and natural resource management in the low-rainfall areas. Paper presented at the International Conference on Agricultural Growth, Sustainable Resource Management and Poverty Alleviation in the Low Rainfall Areas of West Asia and North Africa, September 2-6, Amman, Jordan.

Ngaido, T., K. Nesheiwat, Q. Mamdouh, Y. Sweidan, Abir Minla Hassan, S. Nassar, A. Khnefiss, T. Nordblom, and P. Hazell. 1997. Adoption of improved varieties: Do property rights constrain farmers' strategies in low-rainfall areas of Jordon and Syria? Paper presented at Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Noronha, R. 1985. *A review of the literature on land tenure systems in sub-Saharan Africa*. Report No. ARU 43, Agriculture and Rural Development Department. Washington, D.C.: The World Bank.

North, D. 1990. *Institutions, institutional change and economic performance*. Cambridge, U.K.: Cambridge University Press.

North, D. 1992. Institutions, idealogy, and economic performance. *Cato Journal* 11 (3): 477-488.

North, D. 1995. The Adam Smith address: Economic theory in a dynamic economic world. *Business Economics* 30 (1): 7-12.

Nugent, J. B. 1993. Between state, markets and households: A neoinstitutional analysis of local organizations and institutions. *World Development* 21 (4): 623-632.

Oakerson, R. J. 1992. Analyzing the commons: A framework. In *Making the commons work: Theory, practice and policy*, ed. D. W. Bromley. San Francisco, Calif.: Institute for Contemporary Studies Press.

Okali, C. 1983. *Cocoa and kinship in Ghana: The matrilineal Akan*. London: Routledge and Kegan Paul.

Olson, M. 1971. *The logic of collective action*. Cambridge, Mass.: Harvard University Press.

O'Mara, G. 1983. The microeconomics of technique adoption by smallholding Mexican farmers. In *The book of CHAC: Programming studies for Mexican agriculture*, p.p. 250-289, ed. R. D. Morton and L. Solis. Baltimore, Md.: Johns Hopkins University Press.

Ostrom, E. 1990. *Governing the Commons: the Evolution of Institutions for Collective Action*. Cambridge, U.K.: Cambridge University Press.

Ostrom, E. 1994. *Neither market nor state: Governance of common-pool resources in the twenty-first century*. IFPRI Lecture No. 2. Washington, D.C.: IFPRI.

Otsuka, K., J. B. Aidoo, T. Tachibana, and A. R. Quisumbing. 1998. Causes and consequences of changing land tenure institutions in Western Ghana. Paper presented at the International Workshop on Land Tenure and the Management of Land and Trees: Community and Household Case Studies from Asia and Africa, 1-3 July 1998, Tokyo Metropolitan University, Tokyo, Japan.

Pender, J. and S. J. Scherr. 1998. Organizational development and natural resource management: Evidence from Central Honduras. IFPRI, Washington, D.C. Mimeo.

Perrin, R. and D. Winkelman. 1976. Impediments to technical progress on small versus large farms. *American Journal of Agricultural Economics* 58 (5): 888-894.

Picardi, A.C. 1974. A systems analysis of pastoralism in the West African Sahel. In *Framework for evaluating long-term strategies for the development of the Sahel-Sudan region*, Annex 5. Cambridge, Mass.: Center for Policy Alternatives, MIT.

Place, F. and P. Hazell. 1993. Productivity effects of indigenous land tenure systems in sub-Saharan Africa. *American Journal of Agricultural Economics* 75 (1): 10-19.

Place, F., M. Roth, and P. Hazell. 1994. Land tenure security and agricultural performance in Africa: Overview of research methodology. In *Searching for land tenure security in Africa*, ed. J. W. Bruce and S. Migot-Adholla. Washington, D.C.: The World Bank.

Putnam, R. D. 1993. The prosperous community: Social capital and public life. *The American Prospect* 13: 35-42.

Quiggan, J. 1993. Common property, equality and development. *World Development* 21 (7): 1123-1138.

Quisumbing, A. R., E. Payongayong, J. B. Aidoo, and K. Otsuka. 1998. Women's land rights in the transition to individualized ownership: Implications for tree resource management in Western Ghana. IFPRI, Washington, D.C. Mimeo.

Rae, J., G. Arab, T. Ngaido, G. Gintzburger, K. Jani, and T. Nordblom. 1997. Property rights and technology adoption in rangeland management, Syria. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Rasmussen, L. and R. S. Meinzen-Dick. 1995. Local organizations for natural resource management: Lessons from theoretical and empirical literature. EPTD Discussion Paper No. 11. IFPRI, Washington, D.C.

Ravnborg, H. M., A. M. de la Cruz, and M. del Pilar Guerrero. 1998. Collective action in ant control. Centro Internacional de Agricultura Tropical, Cali, Colombia. Draft Mimeo.

Richards, M. 1997. Common property resource institutions and forest management in Latin America. *Development and Change* 28: 95-117.

Rocheleau, D. 1988. Women, trees and tenure: Implications for agroforestry. In *Whose trees? Proprietary dimensions of forestry,* ed. L. Fortmann and J. W. Bruce. Boulder, Colo.: Westview Press.

Rocheleau, D. and D. Edmunds. 1997. Women, men and trees: Gender, power and property in forest and agrarian landscapes. *World Development* 25 (8): 1351-1371.

Roth, M., J. A. Cochrane, and W. Kisamba Mugerwa. 1993. *Tenure security, credit use and farm investment in the Rujumbura pilot land registration scheme, Rukungiri District, Uganda.* Land Tenure Center Research Paper 112. Madison, WI: University of Wisconsin.

Roth, M., Jon Unruh, and R. Barrows. 1994. Land registration, tenure security, credit use, and investment in the Shebelle region of Somalia. In *Searching for land tenure security in Africa,* ed. J. W. Bruce and S. E. Migot-Adholla. Dubuque, Ia.: Kendall/Hunt.

Roth, M., K. Wiebe, and S. Lawry. 1992. Land tenure and agrarian structure: Implications for technology adoption. In *Proceedings of a workshop on social science research and the CRSPs*, June 9-11, University of Kentucky, Lexington, Ky. Washington, D.C.: USAID.

Runge, C. F. 1986. Common property and collective action in economic development. *World Development* 14 (5): 623-635.

Sakurai, T. 1995. Equity and sustainable management of common-pool resources: The case of grazing land in the West Africa semi-arid tropics. Department of Agricultural Economics, Michigan State University, East Lansing. Mimeo.

Sarin, M. 1995. Regenerating India's forests: Reconciling gender equity with joint forest management. *IDS Bulletin* 26 (1): 83-91.

Sarin, M. and R. Khanna. 1993. Women organize for wasteland development: A case study of SARTHI in Gujarat. In *Women and wasteland development in India*, ed. Andra M. Singh and Neera Burra. New Delhi: Sage Publications.

Scandizzo, P. L. 1979. Implications of sharecropping for technology design in Northeast Brazil. In *Economics and the design of small-farmer technology*. ed. A. Valdez, G. Scobie, and J. Dillon. Ames, Ia.: Iowa State University Press.

Scherr, S. J. 1995. Economic factors in farmer adoption of agroforestry: Patterns observed in western Kenya. *World Development* 23 (5): 787-804.

Schroeder, R. 1993. Shady practice: Gender and political ecology of resource stabilization in Gambian garden/orchards. *Economic Geography* 69 (4): 349-365.

Shipton, P. 1988. The Kenyan land tenure reform: Misunderstandings in the public creation of private property. In *Land and society in contemporary Africa*, ed. R.E. Downs and S. P. Reynas. Hanover, N.H.: University Press of New England.

Smucker, G., T. A. White, and M. Bannister. 1997. Land tenure and the adoption of agricultural technology in rural Haiti. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Spiertz, J. and M.G. Wiber, eds. 1996. *The role of law in natural resource management*. The Hague: VUGA.

Subbarao, K. 1979. *Institutional credit, uncertainty and adoption of HYV technology: A comparison of East Uttar Pradesh with West Uttar Pradesh*. Delhi, India: Institute of Economic Growth.

Svendsen, M. 1997. Second generation issues of privatized irrigation. In *Water, economics, management and demand*, ed. M. Kay, T. Franks, and L. Smith. London: E & FN Spon.

Swallow, B. 1994. *The role of mobility within the risk management strategies of pastoralists and agro-pastoralists*. London: International Institute for Environment and Development.

Swallow, B., R. Meinzen-Dick, T. Williams, and T. A. White. 1997a. Multiple functions of common property regimes. EPTD Workshop Summary Paper No. 4. IFPRI, Washington, D.C.

Swallow, B., J. Wangila, N. Tesfaemichael, O. Okello, and R.l Kruska. 1997b. Assessing collective action using spatial household data. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria,

Swallow, K. 1997. Action sectors used to access cattle feeds during the intensification of cattle production: A case study of a village in Kenya’s coast province. Paper presented at the Workshop on Property Rights, Collective Action, and Technology Adoption, ICARDA, November 22-25, Aleppo, Syria.

Swynnerton, R. J. M. 1954. *A plan to intensify the development of African agriculture in Kenya.* Nairobi: Government Printer.

Tagg, J., D. Holme, and A. Kooiman. 1996. Communities and government jointly managing wildlife in Namibia: Geographic information systems (GIS) as a monitoring and communication tool. Paper presented at the Voices from the Commons conference of the International Association of Common Property, June 5-8, Berkeley, Calif.

Tang, S. Y. 1992. *Institutions and collective action: Self- governance in irrigation*. San Francisco, Calif.: Institute of Contemporary Studies Press.

Thompson, G. D. and P. N. Wilson. 1994. Common property as an institutional response to environmental variability. *Contemporary Economic Policy* 12 : 10-21.

Unruh, J. 1998. Land conflict resolution and adoption of natural resource management technologies in Mozambique. Indiana University, Bloomington. Mimeo.

Uphoff, N. 1986. *Improving international irrigation management with farmer participation: Getting the process right.* Boulder, Colo.: Westview Press.

van Koppen, B. Forthcoming. Gendered water and land rights in construction: Rice valley improvement in Burkina Faso. In *Negotiating water rights*, ed. B. Bruns and R. Meinzen-Dick. New Delhi: Sage.

van Koppen, B. and S. Mahmud. 1995. *Woman and water-pumps in Bangladesh: The impacts of participation in irrigation groups on women s status*. Wageningen, The Netherlands: Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University.

von Braun, J. and P. J. R. Webb. 1989. The impact of new crop technology on the agricultural division of labor in a West African setting. *Economic Development and Cultural Change* 37: 513-534.

Vosti, S. A. and T. Reardon. 1997. Introduction: The critical triangle of links among sustainability, growth, and poverty alleviation. In *Sustainability, growth, and poverty alleviation: A policy and agroecological perspective*. Baltimore, Md.: Johns Hopkins University Press.

Vosti, S. A. and T. Reardon, eds. 1997. *Sustainability, growth, and poverty alleviation: A policy and agroecological perspective*. Baltimore, Md.: Johns Hopkins University Press.

Wade, R. 1988. *Village republics*. Cambridge, U.K.: Cambridge University Press.

Walker, R. and C. Wood. 1998. Conserving the tropical resource base: Do we title land or organize community? Florida State University, Tallahassee and University of Florida, Gainesville. Draft Mimeo.

Waller, R. and N. W. Sobania. 1994. Pastoralism in historical perspective. In *African pastoralist systems: An integrated approach*, ed. E. Fratkin, K. A. Galvin, and E. Abella Roth. Boulder, Colo.: Lynne Rienner Publishers.

White, T. A., L. A. Jackson, and R. Meinzen-Dick. 1996. Conceptual framework: System-wide program on property rights and collective action. IFPRI, Washington, D.C. Mimeo.

White, T. A. and C. Ford Runge. 1994. Common property and collective action. Lessons from cooperative watershed management in Haiti. *Economic Development and Cultural Change* 43: pp. 1-41.

White, Thomas A. and C. Ford Runge. 1995. The emergence and evolution of collective action: Lessons from watershed management in Haiti. *World Development*: 23 (10):1683-1698.

Wills, I. R. 1972. Projection effects of modern inputs on agricultural income and employment in a C.D. Block, U.P., India. *American Journal of Agricultural Economics* 54: 452-460.

Wood, G. D. and R. Palmer-Jones. 1990. *The water sellers: A cooperative venture by the rural poor*. West Hartford, Conn.: Kumarian Press.

Yoder, R. 1994. *Locally Managed irrigation systems: Essential Tasks and implications for assistance, management transfer and turnover programs*. Colombo, Sri Lanka: International Irrigation Management Institute.

Zeller, M., G. Schrieder, J. von Braun, and F. Heidhues. 1997. *Rural finance for food security for the poor: Implications for research and policy.* Food Policy Review No. 4. Washington, D.C.: IFPRI.

Zeller, M. 1996. Determinants of repayment performance in credit groups: The role of program design, intra-group risk pooling, and social cohesion in Madagascar. FCND Discussion Paper No. 13. IFPRI, Washington, D.C.

CAPRi WORKING PAPER NO. 2

ASSESSING THE RELATIONSHIPS BETWEEN PROPERTY RIGHTS AND TECHNOLOGY ADOPTION IN SMALLHOLDER AGRICULTURE: A REVIEW OF ISSUES AND EMPIRICAL METHODS

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IFPRI

May 2000

CAPRi Working Papers contain preliminary material and research results, and are circulated prior to a full peer review in order to stimulate discussion and critical comment. It is expected that most Working Papers will eventually be published in some other form, and that their content may also be revised.

ACKNOWLEDGEMENTS

The authors of this paper have many intellectual debts. Frank Place and Brent Swallow have learned about property rights and technology adoption over the last ten years by working with more colleagues than can be listed here. Their collective contributions to our understanding of the issues addressed in this paper are greatly appreciated. The need for this particular paper was identified at the CAPRI workshop on "Property Rights, Collective Action and Technology Adoption" that was hosted by ICRARDA in Aleppo, Syria in November 1997. Many of the key issues listed in this paper were identified during the plenary and working group sessions held in Aleppo. We received constructive comments on earlier drafts of the paper from Peter Hazell, Keijiro Otsuka and Jean-Marie Baland. Ruth Meinzen-Dick and Anna Knox provided helpful comments and ideas throughout the paper's considerable gestation period.

ABSTRACT

Studies of the relationships between property rights and technology adoption are complicated in several respects. First, there are challenges involved in defining and measuring property rights and tenure security. Second, there are several different valid purposes for undertaking such studies and each purpose may require a different approach. Third, there are a number of difficult theoretical and empirical issues involved in such studies, particularly in defining technology, identifying key dimensions of property rights, and accounting for the endogeneous determination of property rights.

Through a synthesis and evaluation of previous studies, this paper identifies key issues and develops guidelines for conducting research on the relationships between property rights and technology adoption in smallholder agriculture. It seeks to benefit researchers and policy makers wishing to undertake or interpret empirical research. The topics addressed in the paper are: definition of scope and terms; key issues pertaining to the relationships between technology adoption and property rights variables; data collection and measurement issues; and analyses and interpretation of findings. The primary target groups for this paper are researchers and policy analysts.

CONTENTS

ASSESSING THE RELATIONSHIPS BETWEEN PROPERTY RIGHTS AND TECHNOLOGY ADOPTION IN SMALLHOLDER AGRICULTURE: A REVIEW OF ISSUES AND EMPIRICAL METHODS

Frank Place and Brent Swallow

1. OBJECTIVES AND RATIONALE

The overall objective of this paper is to provide researchers and policy analysts with a better understanding of the key issues and guidelines for conducting research on the relationships between property rights and technology adoption in smallholder agriculture. The primary target group for this paper is composed of researchers who have advanced training in micro-economic theory and statistics, but are not specialists in property rights per se. An important secondary target group are policy analysts who review empirical studies and draw lessons for policy design.

The study of property rights and technology is complicated in several respects. First, there are challenges involved in defining and measuring property rights and tenure security. There now is general agreement that tenure security is related to a number of rights over land and other resources that may or may not be vested in individuals. But there is no general agreement about how rights should be measured, aggregated, or otherwise manipulated to derive quantifiable measures of tenure security.

Second, researchers can have several different reasons for undertaking a study of the relationship between property rights and technology adoption. Each reason may have different implications for methodology. Perhaps the most common reasons are:

1) providing input into discussions of property rights policy;
2) defining recommendation domains for existing technologies or those under development;

3) identifying traits that will make new technology attractive to farmers;

4) assessing the impacts of technology on objectives such as production and poverty alleviation; and

5) identifying groups (e.g. women) that may not be able to adopt a technology because of the property rights institutions.

Objective (1) suggests the need for a good dialog between researchers and policy makers (local or national) to ensure that the study will have a positive impact on the policy formulation process. The other objectives imply closer collaboration with applied researchers, development institutions, and farmers themselves.

Approaches to definition of property rights variables and modeling the causes and consequences of property rights also differ across the five objectives. For objective (1), the results must have policy relevance. That is, the analysis must involve variables that policy makers understand and can influence through the policy instruments under their control. A clear structural model in which the effects of the policy variable(s) can be distinguished from other variables is required. This structural model also needs to show the linkages between property rights and the other important outcome variables. Policy makers are likely to be interested in the effects of property rights on technology adoption, productivity, sustainability, equity and income. To fully address objectives (4) and (5) the researcher also needs a structural model that isolates the impacts of individual variables. On the other hand, a cost-effective predictive model is needed to achieve objectives (2) and (3). The research, extension and development agencies that use the research outputs will be most interested in identifying and measuring the variables that can guide them in targeting new technologies. In that case, they may be most interested in proxy variables that are easy to measure.

The third challenge is that there are a number of difficult theoretical and empirical issues involved in such analyses. Some of the major issues are:

6) defining the technology, including the spatial and temporal dimensions of the costs, benefits, and scale of adoption;
7) identifying the dimensions of property rights that have the greatest effects on technology adoption;
8) selecting the appropriate level or levels of observation and analysis—plot, individual, farm, community;
9) reducing potential biases in sampling;
10) accounting for the endogenous determination of property rights;
11) controlling for the confounding effects of property rights with other explanatory variables correlated with property rights; and
12) making appropriate interpretations of the empirical results.

As a result of these complicating factors, there have been several different approaches to empirical testing of the links between property rights and technology adoption. Through a synthesis and evaluation of previous studies, this paper seeks to benefit those who wish to undertake or interpret empirical research in the future. This paper does not develop a particular structural model of the relationship between property rights and technology adoption. Instead, it draws upon models that have been recently developed by analysts such as Feder and Feeny (1993) and Sjaastad and Bromley (1997).

The remainder of the paper is as follows. Section 2 briefly delineates the boundaries within which this review is organized. Section 3 reviews key issues pertaining to modelling and conceptualizing technology adoption and property rights variables and the relationships between them. Section 4 discusses specific data collection and measurement issues arising from Section 3. Section 5 addresses some key aspects associated with analyses and interpretation of findings. Finally, Section 6 is a re-emphasis of the major issues and points raised in the paper.

2. SCOPE AND DEFINITIONS

To enable this review to be tractable and thus useful, we have deliberately put some boundaries around different dimensions of the review.

TECHNOLOGIES

This paper will focus on the intensity of adoption and management of technologies by individuals for use on agricultural land. Agricultural land includes home gardens, fields, fallow lands and grazing lands. Collective adoption of technologies is not considered here.

PROPERTY RIGHTS

Property rights considered here are the rights of individuals to benefit streams produced from agricultural land (including all natural resources on the land). We review literature relating to both customary and formal (e.g. statutory legal) tenure systems that affect smallholder farmers. This includes the situations of legal pluralism in which customary and statutory legal systems overlap.

TOPICAL SCOPE

The review concentrates on methods for empirical analysis rather than theoretical modelling. Attention is given, however, to the links between theory and empirical analysis.

GEOGRAPHIC SCOPE

The methods reviewed should be relevant to smallholder agriculture in developing countries, especially where there is insecure social and legal support for customary and formal rights.

3. MODELLING AND HYPOTHESES

It is noted above that the type of structural model that is developed to guide an empirical study depends upon the purpose of the study. Some of the questions that need to be considered when developing a structural model are:

- What characteristics of a technology suggest a relationship with property rights?
- What aspects of technology adoption and use are most important to model and test?
- What dimensions of property rights are important in the adoption decision?
- How are property rights expected to affect technology adoption?
- How is technology adoption hypothesized to affect property rights?
- Are property rights variables correlated with other variables that affect adoption?

- What are the most important social-spatial scales for the problem at hand?
- What characteristics of a technology indicate a relationship with property rights?

The nature of the technology or investment will affect the hypothesized relationships between technology adoption and property rights. Technologies whose cost and benefit streams are of very short duration will be less affected by property rights than those whose benefit streams are lengthier. Thus, a land manager who faces a high probability of losing her rights to land may still use fertilizer on her crops. Other types of investments, though of a longer-term nature, may be undertaken if the costs of investment are very low. This may be the case with the direct sowing of a small number of trees. For many other types of investment, such as terracing, fencing, water harvesting, windbreaks, and medium term fallowing, property rights are expected to have greater effects on incentives. The extent of those effects will depend on the degree of insecurity. However, the effect of insecure tenure is not necessarily pervasive. High expected profits can overcome the negative incentives that result from insecure property rights.

The type of technology also affects whether or not it may have an impact on property rights. Tree planting is widely cited as an investment that confers strong land rights to individuals (Fortmann and Bruce 1988; Suyanto et al. 1999; Snyder 1996; Baland et al. 1999). Fallowing, on the other hand, is a type of land investment that may weaken land rights. This may be because land that is left uncultivated can be perceived as excess to household needs and thus become subject to claims by other extended family members (Place and Otsuka 1998). Investments in water wells and pumps may confer a high degree of exclusivity over the water resource. Investments in fruit trees, however, may be subject to a myriad of secondary use rights by community members. Many other types of investments may have little effect on property rights, particularly those with short duration.

WHAT ASPECTS OF ADOPTION ARE IMPORTANT TO MODEL AND TEST?

A few remarks about what constitutes “technology” and “adoption” are appropriate at this point. Technology is often used broadly to encompass both physical/biological structures or objects as well as management practices. Most often, researchers are interested in the adoption of specific technology components (e.g. fertilizer) or integrated technological packages (e.g. high yielding crop variety with fertilizer). However, it may be more important to study the traits or functions of these technologies. For example, rather than analyzing the adoption of all types of improved maize varieties or a particular variety, a study could be designed to examine the adoption of all short duration maize varieties. Similarly, one might wish to study the adoption of trees, not by species, but by grouping together all species that farmers use to enhance soil fertility. Grouping criteria will depend on one’s hypothesis about what function of a particular technology constitutes the underlying rationale for adoption.

Generally, it is difficult to identify exactly when a technology has been adopted. Researchers instead often record current use of the technology. This may be unsatisfactory for new technology where farmers may be merely experimenting or in areas where projects have had strong influence and possibly have provided incentives for farmers to use particular technologies. Informal discussions and qualitative research can identify whether these issues are important in the study area. If so, additional questions could be added to formal surveys to distinguish among different types of users of technology (see Section 4).

Technology adoption is often measured by a single binary variable: the technology is present or absent on a farm at a particular time. A binary variable may be adequate for assessing farmer investment in, for example, traditional water wells. There are five special characteristics of traditional water wells that lend themselves to this present/absent measurement. First, traditional wells are very familiar to farmers and thus farmers are relatively certain about the associated payoffs and risks. This implies that farmers are willing to make full rather than partial investments. Second, farmers are usually not given any external incentive to make an investment in a traditional well so that one can assume it is demand driven. Third, traditional wells are indivisible. A farmer cannot choose to invest in half a well. Fourth, traditional wells do not normally require complementary inputs in order to be functional and thus are independent of constraints associated with other technologies. Lastly, once they have been built, wells exist for a long time, compared to technologies like crop varieties that come and go.

However, researchers are usually interested in technologies that differ from traditional water wells in one or more of those four characteristics. First, researchers are often interested in technologies that are under development or have been recently made available to farmers. In those cases, it may be important to explore the farmers' knowledge and information about the technology. Does the farmer have accurate information about the technology? Are there systematic biases in the information systems that limit access to information by certain types of farmers (e.g. women, migrants, minority ethnic groups)? Decision-tree modelling may be appropriate for separating the effects of information from the effects of property rights (Gladwin et al. 1997).

Second, new technologies are often made available to farmers in less developed countries through some type of adaptive research, extension or development project. In that case, it is important to consider the amount of discretion that the farmer exercises over the investment. Erroneous and misleading results can result from studies that confuse adoption with acquiescence to the wishes of researchers or extension workers. There are also farmers who test or use a technology solely because they may desire to copy other villagers or to obtain intangible benefits such as prestige from visits by researchers. If possible, it is preferable to restrict studies of adoption behavior to farmers who do not have direct contact with such projects. If not, then researchers should endeavor to account for this potential effect in the analysis.

Third, it is often necessary to quantify the intensity of technology adoption beyond simple presence or absence of the technology on farm. In this, there usually are tradeoffs between the benefits and costs of more refined measurement of the intensity of technology adoption. For example, the adoption of trees can be measured by the number of trees per farm, the density of trees per hectare, the number of particular species or types of trees per hectare, or the standing biomass of trees per hectare, among others. Where investments are divisible and relatively easy to make (like trees), a binary assessment of adoption may fail to detect important variation in technology adoption. In this case, some type of further narrowing of the technology (say to certain species of trees) or quantification would be essential.

Fourth, farmers often adopt components of technology packages in a stepwise manner, with some components necessarily pre-dating others. In that case the absence of a technology at a particular time may be unrelated to farmer plans to adopt the technology at a future time. Equally, the absence of a technology at a particular time does not mean that the farmer has never used the technology. Again, decision tree modeling may be appropriate for understanding farmers' strategies vis-à-vis the technology. Based on this, the collection of historical data is valuable and may be warranted in some cases such as when there are clear relationships between technologies, or links between farming systems and technologies, or links between household life cycle and technology traits. If indeed the duration were more relevant than current presence of a technology, this would suggest the use of survival or hazard models that deal explicitly with temporal issues. In addition, complementary relationships between technologies would suggest the use of models that account for these relationships (e.g. multi-nomial logits).

WHAT DIMENSIONS OF PROPERTY RIGHTS AFFECT ADOPTION?

The literature suggests that the three important dimensions of property rights are exclusivity, security and transferability. The exclusivity dimension refers to the way that relationships among potential right holders are defined. Under open access, no one has rights or duties. Under common property, rights are defined to coexist for an identified group, with other groups or individuals having duties to respect those rights. Under communal property, rights of ownership are vested in groups, but rights of usufruct and limited rights of transfer may reside with individual households. Under private property, individuals or households may enjoy rights to the exclusion of others. However, private property does not necessarily imply a high degree of exclusion. In Africa, it is common for people to have secondary rights to the livestock feed, firewood and water produced on private land.

Place et al. (1994) describe key components of tenure security to be freedom from interference from outside sources, continuous use, and ability to reap the benefits of labor and capital invested in the resource. Embedded in this description are three dimensions of land rights: breadth, duration, and assurance. Breadth refers to the types of rights held. Generally the more rights held the more secure those rights. Households with rights to alienate land or to make long-term improvements on land would be considered to be more secure than those with only use rights to land. However, there often are certain rights, such as the right to bequeath, that are critical to motivate long-term investment. Some rights may be indicative of larger bundles of rights. For example, someone who holds the right to sell may automatically hold the right to rent out. Duration refers to the length of time over which the individual/group may enjoy specific rights. Assurance refers to the ability of individuals to exercise their rights. Despite adequate breadth and duration of rights, assurance may be lacking where overlapping rights exist or where there is weak enforcement of rights.

Transferability refers to the ability of the right holder to transfer rights over the resource to others. Primary examples of this include the ability to select heirs and bequeath land, the ability to rent or lease land or trees to others temporarily, and the ability to dispose (alienate) an asset. Transferability is valuable by increasing the ability to raise cash through sale or rental of the property (also through credit) and by allowing farmers to endow heirs with key assets.

HOW ARE PROPERTY RIGHTS HYPOTHESIZED TO AFFECT TECHNOLOGY ADOPTION?

It is generally accepted that, at least in sub-Saharan Africa, there are both direct and feedback relationships between property rights and technology adoption. First, the property rights that govern the use of a particular plot of land will affect farmers' adoption and use of technology on that land. Second, the adoption and use of technology has feedback effects on property rights. Some of these feedbacks occur within a prevailing property rights institution. Others put pressure on the property rights institution to change. This sub-section is concerned with the direct effects of property rights on technology adoption. The following sub-section is concerned with the feedback effects.

Exclusivity

Property rights that are generally regarded as being 'private' may confer rights to individuals, nuclear families or lineages. Private property rights may also be encumbered by secondary rights or public restrictions. It is generally hypothesized that the degree of exclusivity has a positive effect on the incentive to produce, invest and adopt technology. The greater the exclusivity, the greater is the incentive to adopt technologies that are fixed to the land. Thus, for example, institutionalized seasonal grazing of farm land (lack of exclusivity) may discourage certain types of investment such as the planting of perennial crops. However, free grazing livestock may well encourage investment in fencing and adoption of non-palatable plants and trees. Also, Baland and Platteau (1996) suggest that there may be circumstances in which less exclusive land rights may help people to pool the risks associated with new innovations or technologies.

Security

Feder and Feeny (1993) distinguish different possible effects of insecure property rights on technology adoption. First, rights of short duration provide a direct disincentive for farmers' to undertake investments in land. Relatedly, when the breadth or assurance of rights are inadequate, local rules may not protect an individual's claim to benefits from investments. This has often been noted in the case of women, who lack rights to undertake long-term investments (Kerkhof and May 1988, McLain 1992; Place 1995; Mugo 1999; for trees). Whether breadth or assurance is hypothesized to be linked to technology adoption depends upon the specific technology/property rights context such as the payback period of the technology. Second, insecure property rights will increase the relative price of long-term assets to land and thus reduce the capital intensity of farming.

Transferability

The transferability of land rights, including rental, bequest, temporary and permanent gift, and sale, may affect technology adoption in three ways. First, restrictions on transferability may reduce the incentives of current residents to adopt technologies likely to generate benefits beyond their likely tenure. For example, if an elderly man cannot pass a piece of land to his heirs, then he is likely to exploit existing trees rather than plant new trees. In this case there is a clear interaction between property rights and life cycle of the household. Second, restrictions on transferability are likely to reduce the market exchange of land and thus may affect the efficiency of land allocation. Households with most incentive to undertake investments on certain land types will thus have limited access to that land. As a consequence, it might be expected that land that is purchased might receive more investment than others. At a community level, one would expect a greater level of technology adoption in communities where rights to sell land were more prevalent. Third, restrictions on transferability will reduce the possible use of land as collateral. In theory, land is the most important collateral asset in rural areas. However, it is only valuable to potential lenders to the extent that it can be sold by lenders to third parties, in case of default. In many parts of Sub-Saharan Africa, it is difficult to sell land, particularly to people from outside the community. As noted above, the importance of specific transfer rights in a given area depends on whether such rights are exercised.

HOW IS TECHNOLOGY ADOPTION HYPOTHESIZED TO AFFECT PROPERTY RIGHTS?

There are two possible types of feedback effects between technology adoption and property rights. First, an existing property rights institution may provide a farmer with different types of property rights to a particular plot of land (in terms of exclusivity, security and transferability) depending upon their investment in that plot. For example, qualitative studies have documented the ability of certain investments, such as in land clearing and tree planting, to enhance tenure security (e.g. Snyder 1996; Quisumbing et al. 1999). The expectation of more secure property rights may thus stimulate farmers to undertake certain investments (see for Uganda, Place and Otsuka 1999 and Baland et al. 1999; for Burkina Faso see Braselle et al. 1998). More research is needed to assess the temporal duration of this effect and to assess the aspects of tenure security that can be expected to change following such investments.

Second, the adoption of certain types of technology may result in pressure on property rights institutions to change. For example, recognition of investment in trees has induced changes in tenure rules in Uganda and Zambia. In Eastern Zambia the adoption of improved fallows by a few thousand farmers prompted the Paramount Chief to pass a new bylaw to that prohibits free grazing of livestock (personal communication with Chief, October 1998). In Kabale, Uganda, secondary grazing rights continue, but there are now strict fines for damage to young trees planted by households. The introduction of certain technologies can also modify rights of women over resources. For instance, women who were not allowed to plant timber and pole trees by their husbands were allowed to plant trees for soil fertility in Uganda, as these were considered to be different types of trees (personal communication, Two Wings Agroforestry Group 1996).

If property rights variables are likely to be treated as dependent variables, then one must try to identify variables that would influence changes or differences in observed values and plan for the collection of those data. Furthermore, if property rights and technology variables influence each other, then it is important to construct an appropriate structural model to account for these relationships. This can be complicated by multiple scale considerations. For example, property rights institutions may prevail at the level of a community or ethnic group whereas technology adoption may be an individual decision. This may call for the integration of community and household level studies. Whether at multiple or single scales, multiple-equation systems should be specified. In a simultaneous system, one must identify, measure, and include variables that can help to identify the equations. Often, this comes down to identifying an explanatory variable that explains only one of the dependent variables. These will be re-examined in Section 4.

ARE PROPERTY RIGHTS VARIABLES CORRELATED WITH OTHER VARIABLES THAT AFFECT ADOPTION?

There are strong theoretical reasons to believe that some property rights variables are correlated with other variables that may be directly related to technology adoption. At an individual level, women and men may differ systematically with respect to the ways they can acquire rights to land and the subsequent rights they enjoy to this land. For instance, women may tend to rely more on temporary land acquisitions and therefore have less secure rights to land than men. In this case, a tenure variable related to acquisition or land rights may capture other gender-differentiated impacts. Other variables that may be related to property rights variables at the plot or household level might be wealth (e.g. wealthier household may have stronger rights to land), soil fertility (purchased parcels may be of better quality), and distance from house to parcel (closer parcels may be more secure). At the community level, there may be systematic relationships between property rights and population pressure and distance to market. Theory suggests that individualization of land rights strengthens under greater population pressure and proximity to developing markets by virtue of heightened competition for land and higher returns brought on by better access to markets. The presence of such correlations suggests more complicated structural models with multiple equations. This means that strategies for sampling and data collection will have to be modified accordingly.

If multicollinearity is anticipated, then it is important to explore theoretically the relationships between property rights and other explanatory variables. Otherwise, misspecification of the model can lead to erroneous conclusions about the importance of individual variables. For example, it may be that the effect of gender on technology is transmitted entirely through indirect effects on farm size and tenure security. If this is the case, then the inclusion of gender, farm size, and tenure security in a single equation model would show gender to be insignificant. But if a structural model was well thought out, the effect of gender might emerge as significant in a reduced form regression. Adjusting the original model will likely imply the collection of additional variables that might be used to help identify equations of a more complex model. All these concerns are lessened, however, if the objective is only a predictive model. In this case, identifying inexpensive variables associated with adoption takes priority over teasing out the causal relationships among individual variables.

ARE THERE DIMENSIONS OF THE PROBLEM THAT ARE RESOLVED AT DIFFERENT SOCIAL-SPATIAL SCALES (PLOT, INDIVIDUAL, FARM, COMMUNITY)?

With respect to social and spatial scales, two dimensions are important. The first pertains to the right holder(s) and the second to the resource unit. Right holders could be individuals, households, pastoralists, user groups, communities, and the like. Resource units could be individual trees, wells, and various land units such as forests, pastures, agricultural parcels, or fields within parcels. There is no single unit(s) of observation that is best nor even appropriate to address all tenure issues. The best unit(s) of observation will vary according to the particular issue under study. Most of the empirical studies dealing with property rights and technology adoption use households or individual household members as key right holders and land parcels or fields as the main resource for which property rights are examined.

How can one best select the appropriate units? Perhaps it is best to indicate the types of cases where the standard practice of using the household right holder/land parcel resource combination may not be the most appropriate. One is the issue of how rights of women may affect technology adoption. Using the household as the key right holder unit will only be able to compare the cases of female-headed and male-headed households. Obtaining information for all male and female adults within a household is most effective to look at intra-household distinctions (see Golan 1994; Mugo 1999). Moreover, women's rights over land may not identical across the entire farm. Women may enjoy more secure rights over specific plots of land than others. These subtleties must be understood prior to the analysis of the more complex tenure issues. Other cases requiring special attention to unit of observation are: trees may have to be differentiated according to species or function; higher level tenure variables that are uniform for many households within a defined area; where there is significant fragmentation of landholdings; resources that are shared by households.

Though these cases suggest that there may be a superior strategy for selecting units of observation, it should be stressed that conducting analyses at multiple units of observation can yield different insights into the property rights-technology adoption relationships. In some cases, the use of a single observational unit may lead to erroneous conclusions. For example, a farm level analysis could mask many important relationships taking place on different land parcels or fields where rights may differ. On the other hand, focusing only on the smaller units can sometimes lose sight of the broader implications of tenure on household level decision-making. For instance, many studies have found negative relationships between rented parcels and investment in technology using household-parcel level analyses. However, this may obscure effects such as the effect renting land might have on enabling households to make longer term plans on their owned parcels. Therefore, one should always consider whether the units of observation selected would lead to unambiguous answers to the key questions being studied.

The most common right holder studied in property rights studies is that of the household. These studies begin with the assumption that most decisions concerning agricultural investment and technology adoption are made at the household level, normally by the head of household. Following from this, property rights over a specific resource are treated as uniform for the household, bearing the property rights of the household head. These approaches are well accepted in the literature and therefore are generally well founded to study certain issues. For example, focusing on the rights of the household head in a study of the effect of the right to sell land on technology adoption is quite sensible. Sales cannot be initiated by other members of the household or community. In such studies, the most common resource units are farms or plots. It is now well recognized that in many rural settings, households may acquire more than one plot of land using different methods of acquisition. Furthermore, rights of a particular household member over these plots could differ. Therefore, it is now routine to collect property rights information at plot level.

Studies at the individual (i.e. household member) level are intended primarily to look at the implications of gender on technology adoption. One of the key differences between males and females is in their control and access to resources and the benefits streams they produce. Thus, a key feature of these studies is to look at gender differences in methods of land acquisition, rights to land, and then to relate these to resource management in general, and technology adoption in particular. Studies that account for individual difference also often are cognizant of the possibility for finding different property rights arrangements across plots. For instance, wives may have more control over decisions in one plot than on the rest of the farm and property rights studies may focus on the question of whether this asymmetry leads to difference in technology adoption.

Studies at the community level are rare. This is due in large part to the observation that agricultural land is managed directly by smaller units and as such the smaller units are more pure observational units. But another reason may be related to measurement problems: how can one accurately measure technology adoption at the community level? What property rights variables are appropriate at the community level and which can be measured? But increasingly, the power of such studies is being recognized (Pender et al. 1998; Suyanto et al. 1999; Baland et al. 1999; Place and Otsuka, 2000;). Community level studies are ideal for examining property rights aspects that tend not to vary over smaller units or areas. Those that may be linked to ethnicity, such as grazing practices, land acquisition methods, and the rights of women, may be quite variable across communities, but vary little within communities. Community level studies enable researchers to study wider areas for less financial cost. The drawback is in the compromises that must be made in terms of precision of data. Moving to higher levels of aggregation brings even more difficulties in conceptualizing meaningful technology adoption and property rights variables. Often the aggregation of very diverse intra-national variation in these variables renders a national level analysis weak. However, some innovative work has taken place at the national level, at least in formulating property rights variables (e.g. Deacon 1994).

4. DATA COLLECTION AND MEASUREMENT

In collecting data, some iteration between individual and group interviews and between qualitative and quantitative research techniques is usually appropriate. Qualitative techniques are used to identify priority issues for study, determine the population to be considered in the study, identify variables for stratifying the population, identify local definitions of property rights, determine the sensitivity of the questions, and interpret quantitative results. Quantitative techniques (including quantification through participatory techniques) are used to validate qualitative results, statistically test hypotheses, estimate elasticities and prioritize policy and action steps.

POPULATION AND SAMPLING STRATEGY

Several issues need to be considered early in a study of this type. Once the specific technology(s) is defined, it is important first to define the population from which a sample may be targeted for further analysis. Then a sampling scheme must be devised. Lastly, one must decide whether the observations drawn should be georeferenced in order to be able to relate observations at different spatial locations and scales.

Population

Identifying the population on which to base a sample for a study of a property rights-technology adoption study can be challenging. It is less of a concern when the study is focused on adoption or impact of a specific technology in which case the researcher is confined to defining the population from within the feasible adoption domain (e.g. an area surrounding the points of technology dissemination). This will provide a sample of communities and households with different degrees of adoption that is necessary to examine the technology-property relationship from either direction. It is more of a difficulty for a researcher who wishes to identify representative property rights systems, as detailed information about property rights is not generally available across large areas. A further problem is that there can be peculiar property rights institutions based on ethnicity and this will affect the degree to which specific empirical results may be generalized. Nonetheless, there is a great deal of dispersed qualitative information about property rights systems and these can be exploited to assist in developing study populations. Rather than being overwhelmed with the nuances distinguishing different property rights systems, classification on specific characteristics or incentives may be more fruitful in delineating pathways for extrapolating results.

Sampling

Once the population is defined, the next step is to develop a sampling scheme. Among the first issues to address is that of unit of observation. Given that this is the focus of the above section on social-spatial scales, this discussion is postponed to the corresponding empirical section on measuring property rights at aggregate levels. Regardless of the unit of observation, when the purpose of the study is to examine factors affecting technology adoption or impact, it is essential to have a sufficient number of adopter and non-adopter outcomes in the sample. From a statistical perspective, ensuring a reasonable number of cases for each outcome improves the ability to find statistical and reliable links between factors and different outcomes by reducing standard errors and influence of outliers.

Whether the sampling procedure should be random or stratified depends on the size of intended sample and the distribution of technology. If a very large sample is planned (say over 1,000), then sufficient numbers of adopters and non-adopters might be found from a random sample, even if adoption rates are relatively low, say between 10–20 percent. More frequently, studies can only afford smaller samples in the range of 100–200 households. For technologies that are used by a large proportion of the population, a random sample of households/individuals may suffice. However, for new technologies with limited exposure, stratification of specific geographical areas, if not households themselves, may be necessary. The implication of non-random sampling is that there is over-sampling of areas where the technology has been introduced. The implications of this on interpretation and extrapolation are important and are discussed in Section 5.

Most studies of technology adoption have not stratified households on the basis of property rights variables. The first reason is that it is not always possible to obtain sufficient information on property rights with which to stratify. Second, if property rights variables are endogenous, such stratification can lead to econometric complications in terms of model misspecifications and omitted variable biases. Third, important categories of property rights will be automatically included if the sample is sufficiently large and not too narrow geographically. An indirect way to obtain a representation of different tenure arrangements would be to stratify on the basis of ethnic group and population pressure or any other variable that is available and is related to property rights variables (e.g. Place and Otsuka 1998; Baland et al. 1999). Where such techniques are inadequate and secondary data is not available, rapid censuses have been found to helpful to generate sampling frames based on tenure variables (e.g. Place and Otsuka 1998).

Georeferencing

Georeferencing is a technique to improve the ability to relate locations of study units to one another and to other phenomenon in the landscape, such as towns or roads. To the extent that aggregations of phenomenon and distances to key physical or manmade structures are important in creating incentives for behavior, analyses can be improved by using georeferencing. Georeferencing should definitely be used in community level studies, where primary data collection can be easily linked to other variables likely to differ across communities. Georeferencing may be less important for studies at lower levels (because information on other variables may be too coarse to vary at these levels), but an exception is the creation of variables of aggregation (pockets of like households, areas of similar land characteristics) or measures of dispersion (fragmentation of household plots). A cost-benefit analysis of georeferencing should be undertaken as part of the planning of the study.

MEASUREMENT OF TECHNOLOGY ADOPTION

First, we consider the identification of ‘real’ adoption. This is especially relevant to the CGIAR where there is pressure to demonstrate impact from their research. Farmers may undertake rather lengthy experimental processes before deciding whether to adopt a technology. An understanding of recent technology expansion is helpful in distinguishing testers from adopters. An adopter may be one who has expanded the level of use over a number of years. Spending some time to understand these differences is most critical for researchers unfamiliar with an area or technology.

The most common form of measuring technology adoption is through the use of a binary variable indicating its current presence or not on a particular plot. This leaves unanswered questions about how the technology found its way onto the field. Was it demand-driven or were farmers rewarded for trying it? This approach also crudely places observations into one of two categories and may result in grouping of households with quite dissimilar behavior. For instance, a household that has planted 1 tree may be treated as equal to the household that has planted 1,000 trees. A binary measure works better for larger more indivisible investments such as a well or the formation of a bench terrace. Whether simple binary measures or more quantitative assessments are made, it is important to verify that wilful investments were made. Variants on the use of binary measurements are to incorporate into criteria for adoption evidence of prior expansion or willingness to expand in the future (e.g. Manyong and Houndekon 1999).

If investment levels are well distributed, using a binary measure results in considerable loss of information. As a consequence, the statistical relationship between property rights and investment may differ fundamentally in the cases of binary and quantitative measure of investment. Likewise, it becomes more difficult to isolate the impact of property rights from other possible explanatory variables. Another concern emerges in regression analysis. First, because property rights variables are themselves often represented by discrete variables, there is a chance that regression models will not converge. This probability increases the more unbalanced are the frequencies of adoption and property rights.

When measuring technology adoption, it is often easy to scale up to higher levels. For instance, with a measure of plot level technology adoption, a similar variable can be created at a household level or a community level (given that suitable sampling methods were employed). Thus, a binary plot level variable on adoption of terraces can be aggregated to form a community variable on the percentage of plots or households with terraces.

Quantifying the level of adoption is used in some cases (see Lin 1991; Bellon and Taylor 1993; and Adesina and Zinnah 1993 for examples). Some examples of quantifying adoption would be the meters of similar types of conservation strips, meters of live fencing, and area under a particular tree crop. However, there are challenges to the quantification of adoption including the evaluation of the quality of the technological investment. A terrace bund formed by earth, vegetative strips, and stone is technically superior to that formed by earth alone. In this case, comparison of 'meters under terrace' would not provide an appropriate measure of intensity of adoption. Some investments are more easily quantified, e.g. the number of trees planted, but here too quantifying can become costly if there are many different tree species to condition upon and if within each, there were many different dates of planting. There are trade-offs between precision and cost. Certain cases suggest that further precision is more important. If property rights are expected to have very specific impacts, say on a particular type of tree rather than trees in general, then all trees cannot be grouped together. This is true in the case of timber trees in Uganda (Place 1995). On the other hand, one shouldn't undertake an exercise of mining the data to find any type of relationship. Focusing on narrow definitions rather than the bigger picture can lead to erroneous conclusions.

If duration of an investment or the date of investment is important to measure, this is usually relatively easy to collect at the plot or household levels. For some types of technologies, e.g. the use of a particular crop variety or management practice, it may become more difficult. In conducting community level surveys, finding average dates of adoption is practically impossible. Instead, one might need to settle with first dates of technology adoption, which is achievable, though average duration among those who adopt is more easily understood. A survey could thus be modified not merely to tick whether a technology is present or not, but whether it had ever been present and when. This can provide the necessary information to investigate adoption rates between two points in time (e.g. Knudsen 1991; and Fischer et al. 1996) or sequential adoption of related technologies or components (e.g. Feder 1982).

There are two additional points here. The first is that a technology that is observed may well have been inherited (especially something such as tree crops) and an understanding of what was already present on the land at the time of inheritance is very important. For example, there may be quite perverse effects where only the current stock of trees is measured. A farmer with a relatively high current level may in fact have inherited a much larger number of trees and has only reduced his density. Meanwhile another farmer with a low current number of trees could have started with none and planted all those observed. Second, if technology adoption had in fact taken place several years prior to the survey, then it may be wise to attempt to match property rights and other explanatory variables as much as possible to the conditions at the time of adoption.

MEASUREMENT OF PROPERTY RIGHTS

The concepts of exclusivity, security, and transferability are often captured empirically through various measures of rights to resources. Exclusivity has been proxied for by responses to questions on the necessity of households or individuals to seek approval or to notify particular individuals, groups, or authorities outside of the household prior to exercising a right (see Migot-Adholla et al. 1991). Excludability may also be proxied by collecting information about the extent of secondary rights to resources. This is very pertinent for community level surveys to gain an understanding of the general level of excludability of rights. The particular context of the technology-property rights issue will suggest the specific types of rights or approval mechanisms that are more appropriate.

Security has been approached in several different ways. One common way is to capture the breadth or number of rights held by individuals (Migot-Adholla et al. 1991; Besley 1995; Hayes et al. 1997; Braselle et al. 1998). Others have identified hierarchies of land rights and then measured the presence or absence of key land rights (Migot-Adholla et al. 1991; Hayes et al. 1997; Baland et al. 1999). This approach is appropriate if, from the perspective of the respondents, some rights are more important than others or if possession of more powerful rights implies possession of many less powerful rights (Schlager and Ostrom 1992). Another common approach is to use the method of acquisition or local tenure categories as a proxy for tenure security (Matlon 1994; Gavian and Fafchamps 1996; Ayuk 1997; Adesina 1999; Manyong and Houndekon 1999). Normally, purchased land is hypothesized to be most secure, rented and leased land the least secure, with other types of acquisitions lying somewhere between. Some studies have endeavored to differentiate categories that contain a large proportion of cases. For instance, Lawry and Steinbarger (1991) and Adesina (1999) distinguished between divided and undivided inheritance acquisition methods. Likewise, Place and Otsuka (1998) distinguished four different inheritance patterns among the patrilineal and matrilineal ethnic groups in Malawi. A few studies have directly asked farmers about their perceptions of the risks of losing land (e.g. Kisamba-Mugerwa and Barrows 1989). Informal discussions in the study area assist greatly in the identification of important tenure security groupings.

Transferability is almost always measured either by the right to sell land, rent land, or by the presence of land title (Feder et al. 1988). Whether these are useful variables to distinguish different degrees of transferability can be evaluated by obtaining information about the prevalence of land market transactions. For example, if few land sales take place, it is not clear that the right to sell is linked strongly to transferability per se. Information about rights to sell and rent can be obtained rather easily, but care should be taken to understand the degree to which individuals can make free and independent decisions. Often, extended families or elders must approve sales. In some societies, land must first be offered to members of one's extended family before it can be placed on the open market. The presence of land title or any other formal document (e.g. purchase agreement) is also easy to enumerate. In the case of title, because updating land registers following land transfers is often an endogenous choice of farmers, titles to land are sometimes outdated, being in the name of the previous owner, often the father. The separation between titleholder and user may not mean much in terms of tenure security, but it may have an important implication for the ability of the user to transfer land.

There are a group of variables that are often described as components of land tenure, though they are not directly linked to security or rights. These are variables that describe land holdings patterns, such as plot size, farm size, distance between homesteads and plots, and fragmentation (or scattering) of plots. For the size variables, the data collection issue for this variable is really the accuracy of farmer estimates. In areas where land surveys have been done, their knowledge is normally quite accurate. In other areas, there may be significant errors in estimation. It is advisable to collect information on total farm size and to check this with information (or direct measurements) of individual plots or fields. Distance between the homestead and specific plots is fairly easy to collect, be it in by space (e.g. kilometers) or time (e.g. minutes of walking time). Growing population pressure has led to increasing fragmentation of farm holdings in some areas. Farmers might therefore operate one or more inherited plots, one or more purchased plots, and one or more rented plots at the same time. Farm fragmentation as a variable could be measured by the number of plots or by more sophisticated measures that take into account the size of plots or the distances between them (e.g. dispersion indices can be used—see Blarel et al. 1992).

While these proxies of tenure security are important in understanding the fundamental links between property rights and technology adoption (see Haugerud 1989; Blarel et al. 1992; Carter et al. 1994; and Place and Hazell 1993), they are often not variables over which formal policy makers have direct influence. There may be additional legal property rights instruments for which an analysis might be quite important. For instance, a very relevant research issue would be the impact of the issuance of formal titles to land on investment and agricultural productivity. The impact of title has been tested by several authors (Feder et al. 1988; Roth et al. 1994; Pinckney and Kimuyu 1994; Alston et al. 1996; and Place and Migot-Adholla 1998) and reviewed by Atwood (1990). Other legal instruments that have appeared in empirical research include contracts with the state and other farmers through tenancy (Gavian and Ehui 1999).

Three issues regarding the method of data collection are of particular relevance to property rights studies. First, some types of topics or questions are believed to be quite sensitive to respondents. This should be first investigated in more informal discussions by the researchers. However, considering the wide variety of information on property rights reported in the literature, such concerns do not appear to be widely validated. Second, concepts of tenure security and rights are not so straightforward to articulate in questionnaires. For instance there may be confusion over the distinction between what rights may be exercised versus what rights are commonly exercised. This is problematic both for enumerators and respondents and researchers should prepare for considerable training on these this topic. Third, not all types of respondents are equally informed of property rights issues. Often, it is the male head of household who is best able to respond about household level rights and details of acquisition methods. In fact, if the head is a male, the wife may not be willing to divulge detailed information about property rights. On the other hand, in studies of individual household members rights, it is recommended to seek responses from the particular individuals concerned rather than accepting responses from a single respondent. The same principles apply in community studies; it is important to identify respondents with appropriate knowledge of the subject while still capturing the varied viewpoints of different stakeholders.

TIMING OF STUDY RELATIVE TO TIME PERIODS OF ADOPTION AND REALIZATION OF PAYOFFS FROM ADOPTION

The different reasons for conducting a study of property rights and technology adoption can imply different timings for the study. Organizations that wish to identify recommendation domains or desirable traits of new technology can benefit greatly from studies conducted during early stages of technology dissemination. The feedback of information from these studies can prevent wasted resources. Studies that are more geared towards influencing policy are best served by allowing technology development and transfer processes to mature for a longer period. In studying the impact of technology, there are benefits from studies implemented at different times. Early studies can identify improvements to feedback into the research process, while late studies can give better assessments of overall impact. In all cases, it is important to be sure that farmers are beyond an early testing phase.

If the study is seeking to look at the influence of technology adoption on property rights change, then a longer time frame is clearly warranted since such institutions cannot be expected to change rapidly. Moreover, it may be that only after widespread technology adoption would there be sufficient pressure on institutions to change.

Measuring the feedback of technology adoption on property rights

If technology adoption is expected to affect property rights variables, a couple of important data collection issues arise. First, it is best to be able to document a change in property rights from one point in time to another. For a plot, this might be from the time of acquisition or the period just prior to the adoption of technology, to the current period. The variable(s) selected to represent property rights must be such that they are not static (so method of plot acquisition would not be appropriate) and can be relatively easily recalled by respondents. The second issue concerns the ability to distinguish the property rights-technology adoption link from the technology adoption-property rights link. To some extent this means understanding the temporal processes involved. But there may several distinct processes. Therefore, at a statistical level, it is important to identify variables that might affect one of the links but not the other so as to be able to identify the parameters associated with the different directional relationships.

Some examples of variables and their likely impact on the property rights-technology adoption complex are:

Those affecting adoption only:

- household size, size of family labour force, certain plot biophysical
- characteristics (plot size, slope)

Those affecting property rights only:

- ethnic group, leadership & community political variables

Those affecting both:

- farm size, marital status of household, age of head, gender of head

These are not fixed nor defensible in all cases. They must be developed for the particular situation under study.

DATA COLLECTION WHEN EXPLANATORY VARIABLES ARE EXPECTED TO BE CORRELATED

When correlations between property rights and other explanatory variables are probable, then adjustments to data collection may be in order. Examples include land titles and farm size (Carter et al. 1994) and gender and mode of land acquisition (de Zeeuw 1997 and Manyong and Houndekon 1999). One of the best ways to identify the influence of the property rights variable(s) from others is through sampling strategies. The goal is to have a sufficient variation in the sample so that there are adequate numbers of cases contrary to the systematic correlations (e.g. women with strong rights or low populated areas with strong rights). It is best to deal with this through stratification.

However, a priori, it can be exorbitantly costly to design a sampling frame to achieve this. One remedy is to increase the size of the sample in order to increase the number of different interactions among the independent variables. Increasing the sample size has long been known as one of the best ways to mitigate against multicollinearity problems. If multicollinearity is recognized only at the data analysis stage another option is to do some informal, quick, and inexpensive data collection to distinguish real driving factors from symptomatic variables (e.g. to solicit expert opinion from key informants from a village). If all these methods are unavailable, then the researcher can apply some of the econometric techniques available to deal with multicollinearity such as ridge regression (Goldberger 1990).

MEASURING PROPERTY RIGHTS AT MORE AGGREGATE LEVELS OF OBSERVATION

The section reviewing measurement of property rights at the plot and household levels showed that at the purest level of specific resource and specific right holder, very detailed assessment and precise measure of property rights can be made. At higher levels, such as a community, information will be collected from spokespersons on behalf of the community leading to some fundamental differences in the quality of information. This means that the information will be subject to less detail, for example averages are reported and the rich variation in property rights systems are lost. There may also be less accuracy in reporting. Thus, some property rights arrangements could be reported to be much more important than what actually occurs in practice. Collecting reliable information at community level can be challenging. It is of course good practice to interact with individuals or groups of different characteristics to be able to assess the variety of tenure arrangements. Older people will be the key resource people for obtaining historical information. In some cases, it may be necessary to build up community level property rights variables from rapid surveys of households in order to be assured of reliable data (Suyanto et al. 1999). Participatory tools may be used to help obtain more precise property rights variables. For instance, for variables that are highly related to spatial location (e.g. extent of commons, area under broad tenure regime such as customary versus estate), respondents might be able to draw boundaries on maps allowing for more accurate assessment of the importance of different tenure arrangements. If the boundaries are subsequently stored in a GIS database, the tenure variables can be linked to a host of other information similarly stored (Place and Otsuka 2000).

5. ANALYSIS AND INTERPRETATION

This section will explore alternative statistical/econometric techniques used as well as the interpretation of the results for research and policy.

There are at least three important components of the statistical analysis:

- investigation of statistical significance of a relationship
- investigation of the importance of a relationship and its interpretation
- extrapolation of results to impact policy

These are discussed in consecutive sub-sections below.

ANALYSIS

Multivariate regression techniques are almost always preferred over simpler univariate or bivariate analyses in the statistical investigation of the property rights-technology adoption link. A major reason for this is that property rights are often associated with other plot and household characteristics so that simple comparisons of adoption under different property rights will likely bias the strength of the relationship. Technology adoption is almost always in the form of a limited dependent variable. Where it is binary, a logit or probit regression model is appropriate. Where adoption values may take many positive values (e.g. level of adoption), a tobit model is normally appropriate. If adoption is measured by proportion of area under the technology, truncated models should be used instead. Maddala (1983) provides a highly readable introduction to these cases, while other authors (e.g. Greene 1993) may provide more accessible treatments of the underlying econometrics.

Two complications to this methodological approach are the observance of multiple technologies and the endogeneity of property rights. Many studies of technology adoption find several technologies of interest. In many cases, there are clear conceptual relationships between different technologies, e.g. terracing and tree crops, zero grazing and improved fodder, and water wells and fencing. When the number of individual lined technologies is small, or if some grouping of technologies can be made, a multinomial logit regression analysis can be used. If there is a large number of technology variables, most studies have resorted to an assumption of independence between them and have used single equation models. Simultaneous models involving limited dependent variables are not yet well developed and are not used in this literature. A study by Hayes et al. (1997) though, applied a two-stage procedure to tease out the indirect effects of land rights on productivity through their effects on investment.

When property rights both affect technology adoption and are affected by technology adoption, a simultaneous equation model is appropriate. If the property rights and technology adoption variables are continuous, then the three-stage least-squares estimation method can be used. This is rarely the case, however. For limited dependent variables, single equation methods for handling endogeneity (such as two-stage least-squares) have been utilized and techniques such as bootstrapping have been employed to correct for the resulting biases in estimated standard errors of coefficients (Braselle et al. 1998; Baland et al. 1999). The treatment of simultaneous equations consisting of limited dependent variables is neither well developed in this literature nor in other applications.

An additional complication in the development of simultaneous models is that property rights and technology adoption are not always measured at the same unit of observation, a requirement in simultaneous equation models. For example, land rights may be measured at a parcel level, while adoption of livestock technologies might be a farm level variable. Similar difficulties have been noted in developing analytical methods for examining the effect of land titling (parcel level) on crop productivity (field level) or use of credit (farm level) (Place and Migot-Adholla 1998).

Notwithstanding the discussion above, there are some instances where simpler, non-econometric techniques are preferable. One is where investments show little variation in a plot or household level survey. Thus, econometric models for qualitative variables do not always work, nor are they appropriate. Sometimes simpler decision trees (diagrammatic descriptions of relationships among discrete choice variables) will be able explain a substantial proportion of the different outcomes. For example, it may be that nearly all sloped land is terraced while hardly any flat land is terraced. A simple decision tree can show the patterns of these recursive relationships more clearly and powerfully than can econometric results.

INTERPRETATION

When faced with a situation where the majority of technologies are not found to vary much, researchers may be tempted to aim their attention on those few that do lend themselves to further analysis. This is of course legitimate. However, when making conclusions, researchers must remember to re-examine the totality of investments. For instance, if property rights were found to impact on 1 or 2 types of land investments, but 5 other similar investments were found to be present on nearly all fields/farms, what is the appropriate conclusion? The role of property rights will be overstated if only those investments exhibiting variation across the observational units are considered.

Finding a statistically significant result on a property rights variable is not the end of the analysis. Evaluating the magnitude of the coefficient is the second step in ascertaining whether or not a variable has a significant impact on technology adoption. Since property rights variables will often be of a binary nature, the size of the coefficient will directly reflect the impact of observing or not observing the specific property rights variable.

Relating back to Section 1, the results should be interpreted in light of the objectives of the study. If the study is based on a stratified sample using adoption of the technology as a criterion, then this must be kept in mind when interpreting marginal impacts. For instance, the sample rate of adoption will be over-stated in such a purposeful sample and thus, so also will the marginal impact of explanatory variables.

One last point on interpretation is that it may be wise in some instances to interact property rights variables with others to improve understanding. For example, property rights impacts may manifest themselves in different ways in different circumstances. For example, rights of sale may only be important in peri-urban areas so interacting this property rights variable with another indicating peri-urban location or not can provide additional clarification as to the circumstances under which the property rights effect holds.

PROVIDING INPUT INTO POLICY DISCUSSIONS

The finding that property rights may impact on technology adoption does not necessarily suggest changes to the property rights systems. It may be much simpler and more effective to alter certain characteristics of the technologies to enhance their adoptability under existing property rights. There are other reasons to pause before making policy recommendations from such studies. While case studies may have direct policy relevance at the study site, wider policy relevance of the research depends on the ability to draw wider implications from the study. Do the conclusions hold for more aggregated spatial scales? Are the conclusions based on a comprehensive evaluation of the impacts of property rights or only on certain impacts (e.g. efficiency only or equity only)? These are critical for it must be kept in mind that there are costs associated with property rights change.

If properly done, useful recommendations can be made to policy makers who have influence at the study site(s). However, most researchers would hope that their results could have influence well beyond the boundaries of their study sites. Working against ease of extrapolation is that property rights systems are complex, influenced by varying customary practices, formal rules and institutions, and by hosts of intervention organizations, such as development agencies. Thus, types of land acquisition methods and rights over resources may be quite uniquely defined within local areas. To find basis for comparison and extrapolation, it may be necessary to find common characteristics of rights and acquisition methods. For example, what might be defined as renting may actually differ significantly from site to site. Components of the rental method of accessing land, such as the formalization of the agreement, duration, relationship between transactors, and payment and other considerations exchanged are the types of variables that can be used to reconcile types of acquisitions across sites. It may well be that one or more of these components of renting are more important for technology adoption, than the more aggregate and blunt ‘renting’ variable.

Because property rights systems are fundamental to the pursuit of economic growth, equity, and sustainability, studies that focus only on the property rights-technology adoption link are generally modest in their policy recommendations. Two aspects of policy implication analyses could be strengthened. First, it is often presumed that more incidence of a technology is better, but the links between technology adoption and the wider goals of economic growth, equity, and sustainability are not often clearly elaborated. Second, the sequencing of complementary property rights interventions or between property rights and other policy options are not usually explored. These extensions could add considerable policy value to research in this area.

6. DEALING WITH THE COMPLEXITY OF PROPERTY RIGHTS AND TECHNOLOGY ADOPTION

This review covered several conceptual and empirical aspects associated with the study of the relationships between property rights and technology adoption in smallholder agriculture. Most of the discussion stems from the most general point of the paper, that the study of property rights and their effects is very complex. There is complexity in conceptualizing the important aspects of property rights and, once defined, in measuring them. Further complications in the study of property rights and their relationships with technology adoption arise because the different reasons for undertaking such studies lead to different research methodologies. Finally, property rights are often dynamic and related to other variables, including technology adoption, so that the isolation and quantification of direct and indirect effects between property rights and other variables is complicated from an empirical point of view. This paper has briefly referenced a number of other studies that have attempted to deal with portions of this complexity. The main recommendation of this paper is that this body of research must be reviewed prior to the launching of new studies on property rights and their relationships with agricultural technology adoption.

ACKNOWLEDGEMENTS

The authors of this paper have many intellectual debts. Frank Place and Brent Swallow have learned about property rights and technology adoption over the last ten years by working with more colleagues than can be listed here. Their collective contributions to our understanding of the issues addressed in this paper are greatly appreciated. The need for this particular paper was identified at the CAPRI workshop on "Property Rights, Collective Action and Technology Adoption" that was hosted by ICRARDA in Aleppo, Syria in November 1997. Many of the key issues listed in this paper were identified during the plenary and working group sessions held in Aleppo. We received constructive comments on earlier drafts of the paper from Peter Hazell, Keijiro Otsuka and Jean-Marie Baland. Ruth Meinzen-Dick and Anna Knox provided helpful comments and ideas throughout the paper's considerable gestation period.

REFERENCES

Adesina, A. and M. Zinnah. 1993. Technology characteristics, farmers' perceptions and adoption decisions: A tobit model application in Sierra Leone. *Agricultural Economics*, 9, 297–311.

Adesina, A. 1999. Land and tree property rights, and farmers' investment in alley farming in Cameroon (this book).

Alston, L., G. Libecap, and R. Schneider. 1996. The determinants and impact of property rights: Land titles on the Brazilian frontier. *Journal of Law, Economics, and Organization* 12(1): 25–61.

Atwood, D. 1990. Land registration in Africa: The impact on agricultural production. *World Development* 18(5): 659–671.

Ayuk, E. 1997. Adoption of agroforestry technology: The case of live hedges in the central plateau of Burkina Faso. *Agricultural Systems*, 54(2): 189–206.

Baland, J.-M. and J.-P. Platteau 1996. Halting degradation of natural resources: Is there a role for rural communities? Oxford: Clarendon Press.

Baland, J-M., F. Gaspart, F. Place, and J-P. Platteau. 1999. Poverty, tenure security, and access to land in Central Uganda: The role of market and non-market processes. Namur: Centre de recherches sur l'economie developpement. Mimeo.

Bellon, M. and J.E. Taylor. 1993. "Folk" soil taxonomy and the partial adoption of new seed varieties. *Economic Development and Cultural Change* 43: 763–786.

Besley, T. 1995. Property rights and investment incentives. *Journal of Political Economy* 103: 913–37.

Blarel, B., P. Hazell, F. Place, and J. Quiggin. 1992. The economics of farm fragmentation: Evidence from Ghana and Rwanda. *World Bank Economic Review* 6(2): 233–254.

Braselle, A-S., F. Gaspart, and J-P Platteau. 1998. Land tenure security and investment incentives: Further puzzling evidence from Burkina Faso. Namur: Centre de recherches sur l'economie developpement. Mimeo.

Carter, M., K. Wiebe, and B. Blarel. 1994. Tenure security for whom? Differential effects of land policy in Kenya. In *Searching for land tenure security in Africa*, ed. Bruce, J. and S. Migot-Adholla. Dubuque: Kendall/Hunt.

de Zeeuw, F. 1997. Borrowing of land, security of tenure and sustainable land use in Burkina Faso. *Development and Change* 28: 583–595.

Deacon, R. 1994. Deforestation and the rule of law in a cross-section of countries. *Land Economics* 70: 414–430.

Feder, G. 1982. Adoption of interrelated agricultural innovations: Complementarity and the impacts of risk, scale, and credit. *American Journal of Agricultural Economics* 64: 94–101.

Feder, G. and D. Feeny 1993. The theory of land tenure and property rights. In *The economics of rural organization: Theory, practice and policy,* ed. K. Hoff, A. Braverman, and J.E. Stiglitz. Washington D.C.: World Bank.

Feder, G., T. Onchan, Y. Chalamwong, and C. Hongladaron. 1988. *Land policies and farm productivity in Thailand*. Baltimore: Johns Hopkins University Press.

Fischer, A., A. Arnold, and M. Gibbs. 1996. Information and the speed of innovation adoption. *American Journal of Agricultural Economics* 78: 1073–1081.

Fortmann, L. and J.W. Bruce. 1988. *Whose trees? Proprietary dimensions of forestry*. Boulder: Westview Press.

Gavian, S. and S. Ehui. 1999. The relative efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia (this book).

Gavian, S. and M. Fafchamps. 1996. Land tenure and allocative efficiency in Niger. *American Journal of Agricultural Economics* 78: 460–471.

Gladwin, C., K.L. Buhr, A. Goldman, C. Hiebsch, P.E. Hildebrand, G. Kidder, M. Langham, D. Lee, P. Nkedi-Kizza and D. Williams. 1997. Gender and soil fertility in Africa. In *Replenishing soil fertility in Africa*, ed. R.J. Buresh, P.A. Sanchez, and F. Calhoun. SSSA Special Publication Number 51. Madison, Wisconsin: Soil Science Society of America.

Golan, E. 1994. Land tenure reform in the peanut basin of Senegal. In *Searching for land tenure security in Africa*, ed. J. Bruce and S.E. Migot-Adholla. Dubuque: Kendall/Hunt.

Goldberger, A. 1990. *A course in econometrics*. Cambridge, MA: Harvard University Press.

Greene, W. 1993. Econometric analysis (2nd edition). New York: Macmillan Publishing Company.

Haugerud, A. 1989. Land Tenure and Agrarian Change in Kenya. *Africa* 59(1): 61–90.

Hayes, J., M. Roth, and L. Zepeda. 1997. Tenure security, investment and productivity in Gambian agriculture: A generalized probit analysis. *American Journal of Agricultural Economics* 79: 369–382.

Kerkhof, P. and V. May. 1988. Sex roles in agroforestry in Kakamega. *Appropriate Technology* 15(1).

Kisamba-Mugerwa, W. and R. Barrows. 1989. *Land tenure and agricultural development in Uganda*. Madison: Makerere Institute for Social Research and the Land Tenure Center.

Knudsen, M. 1991. Incorporating technological change in diffusion models. *American Journal of Agricultural Economics* 73: 724–733.

Lawry, W.S. and M.D. Stienbarger. 1991. *Tenure and alley farming in the humid zone of West Africa: Final report of research in Cameroon, Nigeria, and Togo*. LTC Research Paper 105. University of Wisconsin-Madison and International Livestock Centre for Africa.

Lin, J. 1991. Education and innovation adoption in agriculture: Evidence from hybrid rice in China. *American Journal of Agricultural Economics* 73: 713–723.

Maddala, G. 1983. Limited dependent and qualitative variables in econometrics. New York: Cambridge University Press.

Manyong, V. and V. Houndekon. 1999. Land tenurial systems and the adoption of *mucuna* planted fallows in the derived savannas of West Africa (this book).

Matlon, P. 1994. Indigenous land use systems and investments in soil fertility in Burkina Faso. In *Searching for land tenure security in Africa*, ed. J. Bruce and S.E. Migot-Adholla. Dubuque: Kendall/Hunt.

McLain, R. 1992. Recommendations for a new Malian forest code: Observations from the Land Tenure Centre's Study of land and tree tenure in Mali's fifth region. LTC Research Paper 109. University of Wisconsin-Madison.

Migot-Adholla, S.E., P. Hazell, B. Blarel, and F. Place. 1991. Indigenous land rights systems in Sub-Saharan Africa: A constraint on productivity? *World Bank Economic Review* 5: 155–175.

Mugo, F. 1999. The effects of fuelwood demand and supply characteristics, land factors, and gender roles on tree planting and fuelwood availability in highly populated rural areas of Kenya. Phd diss., Department of Natural Resources, Cornell University.

Quisumbing, A.R., E. Payongayong, J.B. Aidoo and K. Otsuka (1999). Women's land rights in the transition to individualized ownership: Implications for the management of tree resources in Western Ghana. FCND Discussion Paper No. 58. Washington, D.C.: International Food Policy Research Institute.

Pender, J., S.J. Scherr, and G. Durón. 1998. Pathways of development in the hillsides of Honduras: Causes and implications for agricultural production, poverty, and sustainable resource use. Plenary paper presented at the AAEA International Conference on Agricultural Intensification, Economic Development and the Environment, July 31-August 1 1998, Salt Lake City.

Pinckney, T. and P. Kimuyu. 1994. Land tenure reforms in East Africa: Good, bad or unimportant? *Journal of African Economies* 3: 1–28.

Place, F. 1995. The role of land and tree tenure on the adoption of agroforestry technologies in Zambia, Burundi, Uganda, and Malawi: A summary and synthesis. Madison: Land Tenure Center.

Place, F. and P. Hazell. 1993. Productivity effects of indigenous land tenure systems in sub-Saharan Africa. *American Journal of Agricultural Economics* 75(1): 10–19.

Place, F. and S.E. Migot-Adholla. 1998. Land registration and smallholder farms in Kenya. *Land Economics* 74(3): 360–373.

Place, F. and K. Otsuka. 1998. Land tenure systems and agricultural productivity in Uganda. Nairobi: ICRAF. Mimeo.

________. 1999. Population, and tenure, and natural resource management: The case of customary land area in Malawi. Nairobi: ICRAF. Mimeo.

________. 2000. Population pressure, land tenure, and tree resource management in Uganda. *Land Economics* (August). Forthcoming.

Place, F., M. Roth, and P. Hazell. 1994. Land tenure security and agricultural performance in Africa: Overview of research methodology. In *Searching for land tenure security in Africa*, ed. J. Bruce and S.E. Migot-Adholla. Dubuque: Kendall/Hunt.

Roth, M., J. Cochrane, and W. Kisamba-Mugerwa. 1994. Tenure security, credit use, and farm investment in the Rujumbura pilot land registration scheme, Uganda. In *Searching for land tenure security in Africa*, ed. J. Bruce and S.E. Migot-Adholla. Dubuque: Kendall/Hunt.

Schlager, E. and E. Ostrom. 1992. Property rights regimes and natural resources: A conceptual analysis. *Land Economics* 68(3): 249–262.

Sjaastad, E. and D.W. Bromley. 1997. Indigenous land rights in Sub-Saharan Africa: Appropriation, security and investment demand. *World Development* 25(4): 549–562.

Snyder, K.A. 1996. Agrarian change and land-use strategies among Iraqw farmers in Northern Tanzania. *Human Ecology* 24(3): 315–340.

Suyanto, S., T.P. Tomich, and K. Otsuka. 1999. Agroforestry management In Sumatra. Bogor: ICRAF. Mimeo.

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CAPRi WORKING PAPER NO. 9

THE ROLE OF TENURE IN THE MANAGEMENT OF TREES AT THE COMMUNITY LEVEL: THEORETICAL AND EMPIRICAL ANALYSES FROM UGANDA AND MALAWI

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IFPRI

November 2000

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ABSTRACT

This paper examines the effects of tenure on tree management at a community level. First, several important conceptual issues arising from this particular meso-level focus are discussed. Second, a description of the key tenure and tree management issues in Uganda and Malawi is presented. In each case, data representing changes in land use and tree cover between the 1960–70s and 1990s are analyzed. In both countries, there has been significant conversion of land from woodlands to agriculture. Tree cover has been more or less maintained over time in Uganda but has decreased in Malawi. Lastly, the paper explores the relationships between tenure and tree management using econometric techniques. Tenure is found to be linked to land-use and tree-cover change in both countries, though it is not necessarily the most important factor (e.g., population pressure is the key driving force for land-use change). In Uganda, conversion of land was more rapid under the customary tenure system and tree cover on nonagricultural land better maintained under the mailo system. In Malawi there was more rapid land-use conversion and tree cover depletion where there were more changes to traditional tenure systems taking place.

CONTENTS

THE ROLE OF TENURE IN THE MANAGEMENT OF TREES AT THE COMMUNITY LEVEL: THEORETICAL AND EMPIRICAL ANALYSES FROM UGANDA AND MALAWI

Frank Place and Keijiro Otsuka*

1. INTRODUCTION

MOTIVATION FOR THE STUDY

There is increased realization that long-term economic growth in most of Sub-Saharan Africa hinges upon sustaining and improving the productivity of its natural resource base. Policymakers must face the challenge of identifying appropriate pathways for the use and management of natural resources in their jurisdictions and sets of policies that will steer their constituents towards these pathways. Unfortunately, policymakers in Sub-Saharan Africa have little information about the dynamic processes leading up to current land utilization patterns nor to related effects on the stock of natural resources and their productivity.

With respect to tree resources, empirical research has only recently begun to identify important driving forces behind household decisions to plant trees on their farms (Place 1995; Scherr 1995; Patel, Pinckney, and Jaeger 1995; Dewees 1995). Another

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body of research centers on understanding changes in forested area at the national and international levels (Deacon 1994; Capistrano and Kiker 1995; Kahn and McDonald 1995). A third scale or observational level that is particularly lacking in empirical research might be called the community or landscape level (exceptions are Cline-Cole et al. 1990 for two sites in Nigeria and Southgate et al. 1991 for 11 sites within Ecuador). Given a sample of sufficient size, this level could offer a unique insight into the factors whose magnitudes are often constant across observations in household studies from a given village but whose aggregated averages are too crude across observations at a national level. Examples include land tenure institutions, which govern the use and allocation of land and natural resources; the degree of market access, which determines the structure of market-driven derived demands for these resources; and population pressure, which is considered to be the key variable affecting the choice of farming systems in the economic literature since Boserup (1965).

This paper will first endeavor to develop an analytical approach appropriate to improve our understanding of relationship between tenure and other factors on tree resource management at the community level. Second, the paper will provide new evidence as to how communities in the case study countries of Uganda and Malawi have managed their land and tree resources and what factors seemed to be most important in their decisions. This information is valuable to policymakers who continue to struggle with the twin objectives of alleviating poverty in the short run and in preserving the natural resource base in the long run so that future generations may have access to high quality income generating assets.

This paper is comprised of six sections. The first presents an introduction to the key issues concerning the determinants of tree cover change and elaborates on important analytical issues. The second section discusses tenure systems in Uganda and Malawi. Section 3 describes the study sites for the community level analysis of tree cover change. Section 4 presents theoretical and econometric models for land-use and tree-cover change in Uganda and Malawi. The results from the econometric analyses are discussed in Section 5. Lastly, Section 6 contains the key conclusions and implications of the study.

IMPORTANT ANALYTICAL ISSUES IN THE STUDY OF TREE MANAGEMENT

Conceptual Issues Regarding Changes in Tree Stocks

Trees serve many different purposes for households and communities. Therefore, ideally, one should analyze the different tree planting and management strategies of households and communities. This is because the different strategies may be determined by unique processes and factors. However, the many species, niches, and multi-purpose nature of many agroforestry systems complicate the classification of tree management strategies. These differences are all the more difficult to identify at the community level where different households may adopt similar tree species in similar configurations for different purposes. While acknowledging that the identification of these differences is important, we do not address such subtleties in this section. For the remainder of this section, we refer to the stock of tree resources per unit area as “tree cover” and to tree establishment, management, and harvesting systems as “tree management strategies.”

One distinguishing feature that separates trees from other types of long-term land improvements is that tree cover can grow and shrink without human interference through natural regeneration and fire and disease for instance.[1] That is, in addition to purposeful management of tree resources, there is a "biological supply side" implying that one cannot equate the *presence* of trees with *investment* in trees and increases in tree cover could simply result from neglect of the land by a land manager.

Another unique aspect of trees is their link with land tenure. First, it is well established that historically in Sub-Saharan Africa, the investment of labor in clearing of communal woodland was a necessary condition in establishing private rights to land (Ault and Rutman 1979; Noronha 1985; Bruce 1988). Second, in many societies, tree planting was seen as a way of establishing long-term rights to land (Fortmann and Bruce 1988). Third, certain tree species carry with them tenurial implications such as those that are customarily used for boundary demarcation or others that are viewed as "communal" trees (many types of indigenous fruit trees for example).

The observations above have implications on our analysis of investment in tree strategies. First, household level analyses are useful for understanding specific tree management objectives and strategies, whether the focus is on the household or community level. Second, careful attention must be paid to the treatment of tenure variables in the context of tree management. Some tenure variables cannot be viewed as

[1] This is not true of all species or of all purposeful tree systems such as a timber plantation.

exogenous given their strong links to trees. For instance, the duration of rights to land may be related to prior tree planting efforts.

Conceptual Issues Regarding Trees at the Community Level

Tree cover and tree strategies are found across virtually all tenure and land-use systems on a landscape.[2] Thus the study of tree cover, to be comprehensive, must cover an entire spectrum of landscapes and key decisionmakers managing the different lands. The reason for this is that the patterns of tree cover and the tree management strategies observed differ across tenure and land-use systems. For instance, tree cover density tends to be lower on agricultural land and higher on other land-use types such as forest and woodland. In the case of tenure systems, regardless of the degree of management of common pool resources, the vast proportion of tree planting is found on private agricultural land. Furthermore, trees on different landscapes are linked because there are complementary and substitution relationships between trees in different locations brought about because many of the tree products desired by households can be obtained by trees located anywhere on the surrounding landscape.[3]

Added to this complexity is the fact that tenure and land-use systems are often dynamic. Thus, changes in tree cover are the dresult of complex interactions of changes in

[2] The use of “tenure system” in this context is taken to be a broad classification such as “private” or “communal” within a customary tenure regime. A land-use system may be agriculture, woodland, bushland, forest, and wetland, among others.

[3] Restricted or limited rights of access to farm land, nonfarm land, and trees on these lands will affect the degree to which possibilities for complementarities or substitutions exist.

tenure, changes in land use, and changes in tree densities on each tenure/land-use niche. It is vitally important to take these different processes into account for they have their own "driving forces" and critical actors. For example, decisions on tree density on agricultural land may be purely an individual choice. However, the tenure conversion process by which the individual acquired his/her farm may have involved others such as state authorities, local authorities, clan leaders, and extended family members.

In summary, studies of tree cover change for the purpose of addressing issues of biomass supply must include the different types of land uses and tenures found across the landscape.[4] Past studies that have focused solely on the implications of forestland for biomass supply have limited usefulness. Furthermore, the analysis of the different niches must be made in an integrated manner owing to the interactions of trees and other production systems. Lastly, it is crucial in models of tree cover changes to distinguish among the different processes affecting tree cover change.

Conceptual Issues Regarding Tenure at the Community Level

Numerous studies at the farm level have been able to conceptually define and empirically measure several important tenure variables affecting farmer incentives. These include those related to the nature of land holdings (e.g., farm size), the nature of land rights, duration of land rights, and possession of formal tenure documents, among others. In comparison, there is very little understanding of tenure factors at the community level. How can the diverse set of institutions within a community be effectively aggregated and

[4] For certain objectives (e.g., biodiversity, fauna), studying the changes to forests alone may be sufficient.

captured? At very broad levels, major legal tenure systems such as customary, freehold, and state systems can be viewed as exogenous. Many other tenure variables are likely to be endogenous at the community level. For instance, customary systems may differ in a number of ways including the degree of individualization (the extent to which rights are held by families as opposed to the state or communal authorities), exclusivity, and property inheritance patterns.

Conceptual Issues Regarding Land-use and Tenure Conversion at the Community Level

The dominant types of conversions have been tenure conversions from nonprivate to private and land-use conversions from nonagriculture to agriculture land uses. While the two types of conversions are clearly related, we first discuss each separately beginning with tenure conversion.

The major tenure conversion in sub-Saharan Africa has been towards privatization of land rights in arable areas (Noronha 1985; Migot-Adholla et al. 1991). In the literature, this has been linked to population growth and commercialization of agriculture (Migot-Adholla and Bruce 1994). However, there are three factors limiting the rate of conversion. First, a household cannot cultivate unlimited land area and local customs (for meeting equity objectives) may not allow the conversion of an area larger than what can be cultivated by the household. Second, there may be transaction costs associated with converting land which stem from the community's desire to maintain woodlands, wetlands, and the like for equity, reducing exposure to risk, or long-term productivity reasons. These costs are likely to increase with the proportion of land already converted.

Third, these benefits from woodlands may also generate collective action for management of woodland resources that could impose restrictions on conversion of land.

Whether or not land use is changed before, during, or following a tenure conversion is an empirical issue and depends on the relative profits and associated risks of different activities as well as access to capital and other resources. Tenure change may be preconditioned on land-use change where chiefs may require conversion to agriculture (often more specifically to food crop production) as a prerequisite for allocating land. This is embedded in strong adherence to equity motives over commercialization considerations. While land use can change from crop-based agriculture to other land uses this is not widely observed except for allocation of fields to woodlots, pastures, or long fallows. Equally rare from observation appears to be endogenous conversion from private tenure to other types of tenure.

2. BACKGROUND ON CASE STUDY COUNTRIES OF UGANDA AND MALAWI

Uganda and Malawi were selected as case studies for two primary reasons. First, they are part of a multicountry study examining the role of tenure on tree resource management that also included Ghana, Nepal, Vietnam, Indonesia, and Japan. The set of seven countries was selected to represent a range of different tenure regimes. Second, these particular countries were selected from among a handful of candidates because of the availability of aerial photographs from different dates (so that changes in tree resource stocks could be evaluated).

Uganda is a landlocked country of about 19 million people, of which slightly less than 90 percent reside in rural areas. The average rural population/cultivable land ratio for all of Uganda is 88/km^2 and ranges between 51 and 319 in the districts containing our study sites (World Bank 1993). Langdale-Brown (1960) estimated dense forest area to be over 25,000 km^2 in the mid 1920s and over 11,000 km^2 in 1958. In 1990, estimated tropical high forest area was 7,000 km^2, representing about 3 percent of land area (World Bank 1993). The annual rate of deforestation (including all types of natural forests) was estimated to be about 0.9 percent between 1980 and 1990 (World Bank 1994). As in most countries in Sub-Saharan Africa, the area under agriculture has expanded significantly at the expense of formerly wooded areas (Hosier 1989). It is feared that the more recent expansion has occurred on marginal lands not well suited to intensive agriculture. Trees are not only important for environmental stabilization, but there is also major demand on woody vegetation for energy needs, as it is estimated that about 90 percent of cooking and heating energy comes from wood (World Bank 1996). Given that the area under closed forest remains small, concern about the sustainability of woody biomass naturally directs one to the more abundant agriculture land, woodland, bushland, and wetland areas found on the landscape.

Malawi, as elsewhere in Sub-Saharan Africa, has experienced a significant change in its landscape cover. Although reliable figures are hard to come by, the Forestry Department estimates the annual deforestation rate to be 1.3 percent per year in the 1980s (World Resources Institute 1994). This has raised concern about the future supply of fuelwood and other tree products and environmental services (French 1986; Hyde and

Seve 1993; and Dewees 1995). Much of the deforestation is believed to be linked to conversion of miombo woodlands into agricultural land. This involves expansion onto steep slopes and other fragile lands in many cases. Per capita food production has declined over the 1980s and early 1990s. Moreover, Bojo (1994) presents data showing high soil erosion rates and the subsequent high costs to the Malawian economy, which is heavily agriculturally based (World Bank 1995).

TENURE SYSTEMS IN UGANDA

Across our study sites in Uganda, several land tenure systems were prevalent prior to 1975, and despite the *de jure* nationalization of all land in that year, the same tenure systems are recognized both in the perceptions of the population and in formal land tenure reform debates. The most widespread of the tenure regimes is customary land tenure, which is virtually the only tenure system operating in our eastern and northern sites. Customary lands in our sites were traditionally governed by clans who allocated plots of land to members. In many of the sites by the early 1900s, households had settled on lands and acquired strong permanent rights to specific parcels (Bazaara 1992). In some areas, power shifted from clans to chiefs following colonial intervention, but in 1966, the Ugandan government formally abolished kingdoms and this led to loss of control over land by traditional authorities in some cases. Some urban elites seized this opportunity to claim customary lands through the newly developed Land Commission. All customary systems follow patrilineal rules of descent and, in our study region, inheritance is the most common method of land acquisition.

In the Buganda region of central Uganda, the major tenure system is the “mailo” tenure system. Vast tracts of land were given to notables and elites by the colonialists beginning in the early 1900s and were known as private “mailo” land. A large area of land (958 square miles) went to the chief of the Buganda, known as the Kabaka. Owners, lacking labor to till such large land areas, and wishing to attain esteem in the community, received fees, rents, or other payments (e.g., sharing of output) by settling tenants (“kibanja”) on their land. Subsequently, landlords powers to evict tenants were restricted by a 1928 law that required full compensation for any investments. Later, in the 1975 land reform, all rents were abolished. Although only mailo owners may acquire titles to the land, many tenants have very strong rights over land they occupy, including the right to bequeath. Today, some mailo owners occupy and farm their land; however, in many areas, occupation of land is overwhelmingly by “kibanja” tenants.

Other nonallocated land in the Buganda region was initially classified as Crown Land and included land considered as “waste.” During the reign of traditional rulers, this land was loosely administered by chiefs and was akin to customary land, though Muhereza (1992) describes the management of many of these areas as resembling open access. Settlers on these lands in the Buganda region face more tenure security risks than do settlers on customary land in other regions because this region surrounds the capital, Kampala. The insecurity arises from the allocation of leaseholds to wealthy individuals and elites. In some highly publicized cases, these new settlers have evicted families (renamed “squatters”), who had occupied the land for several generations. It is difficult to know how many evictions there have been, but the local populations are well aware of them. Some occupants on public land claim that the state administers the land while others mention the Kabaka. Because of this ambiguity and the increased potential for conflict over rights to these lands, we distinguish them from the customary areas in the eastern and northern sites and refer to such land as "public" land.

TENURE SYSTEMS IN MALAWI

While there are three major tenure systems prevailing in Malawi, state, estate, and customary, our study sites are almost wholly from the customary tenure sector and this paper will focus only on this tenure system.[5] The customary sector consists mainly of smallholders and a key distinction here is between matrilineal and patrilineal ethnic groups. When land was abundant, both systems vested land in chiefs and village headmen. The village headmen in turn would cede rights over specific tracts of land to families and family leaders. New lands could be opened through requests to family leaders and village headmen.

In the matrilocal cum matrilineal system practiced by the Chewa and Yao in our study sites, husbands moved to live in the wife's village and land was traditionally passed from mother to daughter or from family leader to female family members (Mkandawire 1983/84). Again traditionally, the couple often resided permanently in the wife's village.[6] Matrilocal systems are distinct from those matrilineal systems where the couple moves to or

[5] The customary sector is estimated to occupy about 70 percent of land area. For more information on the state and estate tenure systems see Dickerman and Bloch (1991).

[6] This system is akin to matrilineal systems observed in some parts of Asia, such as Sumatra (Otsuka et al. 1997).

otherwise resides in the husband's village and the husband would acquire land from a village headman or family leader in his village. In this case, land would then pass from uncle to nephew or niece (perhaps through the family leader). This practice was virtually absent among our sampled households. We also found that traditional matrilocal and matrilineal practices were being circumvented by households who relocated to husband's villages or to new villages.

A patrilineal (and patrilocal) system, common in the north of Malawi, is similar to those elsewhere in Sub-Saharan Africa in that men claim land ownership and can pass on all land and property to their children. Married couples reside permanently in the husband's village. It has been customary among the Ngoni and Tumbuka at our sites to favor sons over daughters in inheritance practices.

The various modes of transfer and tenure arrangements might have different incentives on farm and tree management due to differences in tenure security. Land that passes through inheritance from parents to children, including from mother to daughter, seemingly offer the appropriate incentives to households to make long-term investments (labor and capital) on the land. While these appear to be the majority of cases in matrilocal systems, two types of situations are of concern with respect to the tenure security of males in our sample areas. The first is where husbands reside in the wife's village on what they believe will be a temporary basis; they may desire to leave their wives' villages to gain independence from the wives' families, to be able to pass on land to their sons, or to take up more favorable income generating opportunities. Each of these motives can reduce their incentives to work in their wives' villages. A second case concerns rights to land following death or divorce of a spouse. Upon divorce, the husband must leave the wife's village and similarly, following the death of the wife, the husband's rights to residence are not at all guaranteed (traditionally, they would be expected to return to their village). Where either a death or divorce becomes more likely, the nonresident spouse is likely to increase activities that enhance short-term returns at the expense of long-term returns. These have been hypothesized in the literature as hindering agricultural development (e.g., Dickerman and Bloch 1991; Nankumba 1994) under the assumption that males are the key decisionmakers over long-term residence and investments and therefore the tenure security of men acts as the critical constraint (Mkandawire 1983/84).

The customary sector includes both private and communal lands. The process of privatization in Malawi mainly concerns the permanent allocation of land to households primarily for cropping purposes. As a consequence of high population densities, farm holdings in much of Malawian customary land are small. There are also communally held lands, held by the clan or village headman, which are reported to be virtual open-access resources, with few rules on user group membership or use rates (Coote et al. 1993a; 1993b). One notable exception is the Village Forest Area system initiated in the 1920s, rekindled recently by the Forestry Department, in which communities demarcate woodland areas to be placed under special management rules (which are always conservation oriented). To date, these are very few in number and those in operation are very small in size.

3. METHODOLOGY AND DESCRIPTION OF STUDY SITES

SAMPLING

The sampling units chosen in both countries reflected units defined by the respective governments. In Uganda, the sampling unit was a parish, which is the smallest administrative unit for which georeferenced boundaries are known (they average 30 square kilometers in size). In Malawi, the unit selected was a census enumeration area and the average was 12 square kilometers in size. The boundaries of both parishes and enumeration areas were created by the governments to contain roughly similar sizes of population. Thus, in areas of high population density, the administrative areas are smaller whereas in low population density areas, they are larger. In Uganda, the parish also relates to a decision-making entity (the Local Council 2 level). In both Malawi and Uganda, these boundaries are drawn so that villages rest entirely within a single unit. We found that in Uganda, there were often five or six villages in a parish; in Malawi, we found two or three villages in a census enumeration area. The group surveys therefore sought representation from multiple villages.

To achieve the purposes of the study, the selection of sites required variation in land tenure systems, variation in population density, and availability of aerial photographs. The last criterion was not constraining in the case of Malawi, where countrywide aerial photographs are available for several dates, including the early 1970s and the mid-1990s. In Uganda, coverage of old aerial photography flown between the late 1940s to early 1960s is extensive, while recent (late 1980s to mid-1990s) aerial photography is highly selective. The widest recent air photo coverage was a wide strip north of Lake Victoria and south of Lake Kyoga starting from the Kenyan border in the east up to Kiboga District in the west. Where recent air photo coverage is missing in Uganda satellite images are available which were used in this study as well.

A second factor considered in sampling was tenure system. In Uganda, this is relatively easy to account for because the major tenure systems have well known boundaries that correspond closely to current district boundaries. Similarly, in Malawi we ensured a variation in customary tenure system (patrilocal vs. matrilocal) by sampling across different geographical regions.

The final variable of concern, population density, was not explicitly accounted for in the sampling procedure as it was felt that sufficient variation would emerge by following a random selection process based on geographical stratification. After stratifying by 11 districts in Uganda and by four broad regions in Malawi, samples were drawn randomly.[7] In Uganda, 64 parishes were selected for study from the districts of Kiboga, Luwero, Mukono, Kamuli, Iganga, Tororo, Mbale, Kumi, Lira, and Apac. In Malawi, 57 enumeration areas were analyzed more or less in equal numbers from north (Mzuzu Administrative Development Division, or ADD), north-central (Kasungu and Salima ADD), south-central (Lilongwe and Mchinji ADD), and south (Machinga and Blantyre ADD).

[7] Exceptions were urban centers and state-protected areas that were excluded. In Uganda, we also excluded extremely large parishes (of over 150 km^2) as we felt we could not obtain reliable field information for such sizes. This excluded less than 2 percent of parishes.

DATA COLLECTION MEASUREMENT OF VARIABLES

The data for this study came from three primary sources. The land-use cover and tree density data were generated entirely from aerial photos and satellite imagery, which were checked in the field. The variables hypothesized to affect land-use and tree cover were obtained either from secondary sources or from socioeconomic field surveys. Following discussions about the data sources and methods of data acquisition, mention will also be made about the analytical methods used.

Land-use cover data were acquired from a combination of aerial photography and satellite imagery in Uganda, and exclusively from aerial photography in Malawi. Tree cover estimates could only be obtained from aerial photography. Thus, in Malawi the number of sampling units for land-use and tree-cover change are identical, while in Uganda land-use figures are available for a greater number of parishes than are tree density figures.

In both countries, remote sensing data were acquired for two distinct periods of time. In Uganda, photos from eight different flight contracts were used and these were flown between 1948 and 1961. However, almost all were taken between 1957 and 1961. The recent aerial photography used was mainly flown in 1995 covering 42 parishes. In Malawi, aerial photographs were used for both periods of assessment, i.e., the 1971–73 period and then 1995. We used the year 1960 for Uganda and 1971 for Malawi as the year for which we collected information on initial conditions of explanatory variables such as population density.

Land-use Cover

A classification scheme was developed to describe land-use cover. Agricultural land includes all land for which a discernible field pattern could be detected with a whole complex of covers ranging from crops, fallows, grazing patches and clusters of trees and woodlots. Wooded land was divided into four types: plantations, tropical forests, woodlands, and bushlands. Although data were collected for each, in our analyses, plantations and forests were grouped together as were woodlands and bushlands. Remaining land was further disaggregated into grasslands, wetlands, urban land, barren land, and water. More details for land-use and tree-cover classifications can be found in Breyer (1996).

Tree Cover

Forests either were closed (100 percent tree cover) or slightly degraded (80–100 percent cover). Four subclasses of woodland/bushland and wetlands were distinguished based upon tree and shrub crown (or canopy) cover. Using woodlands as an example, open woodland has a crown cover density between 2 and 20 percent. Medium woodland has a crown cover density between 20 and 40 percent. Dense woodland has a crown cover between 40 and 60 percent. And finally very dense woodland has a crown cover density between 60 and 80 percent. For agricultural land, a different tree cover methodology was used. In Uganda, it was decided to sample agricultural land areas, calculate the proportion of area under tree cover in each sample area, then take the average of the samples as an indicator of aggregate tree canopy cover in agricultural land within a parish. In Malawi, agricultural tree cover was mapped according to ranges of cover, but bounds were much tighter than for nonagricultural land (e.g., 0–2 percent, 2–10 percent, 10–20 percent, and 20–40 percent).

Explanatory Variables

A field survey was administered at each of the sites (parishes or census enumeration areas) to collect information on hypothesized explanatory variables and to provide additional information about the characteristics of woody vegetation. The survey was administered to groups (comprising elders, local leaders, and extension, among others) in each site and generally took three to four hours to complete. The survey included sections on proximity of the site to markets and infrastructure; demographic variables; farming systems and livestock holdings; common tree species and characteristics; tree management interventions and markets for tree products; and tenure regimes and associated rights to land and trees. To the extent possible, questions distinguished the base year situation from the current (1995–96) situation.

Unique to Uganda was the participatory drawing of broad tenure boundaries (i.e., between customary, mailo, public, and leasehold tenure regimes) within parishes overlaid on remote sensing images. In Malawi, a similar approach was planned, but we found that customary tenure occupied all land in nearly all sites. Due to the complexity of cultural practices and tenure systems in Malawi, we also implemented a household and plot level survey to better assess key variables such as patterns of residence and mode of land acquisition. Other explanatory variables were taken from secondary sources. This includes population, average annual rainfall, soil type, soil texture, and elevation.

DESCRIPTIVE INFORMATION

General Description of Sites

Table 1 displays the means of important explanatory factors hypothesized to affect land-use and tree-cover change. There is considerable similarity among the set of sites in Uganda and Malawi in terms of population density, population growth and distance to tarmac. One notable difference is with respect to rainfall, where the Malawian sites were significantly drier than those in Uganda. Although there is a distinct drier zone encompassing the northernmost sites in Uganda, most of the Ugandan sites are in favorable agricultural zones with two rainy seasons. It is important to mention that each of the variables exhibited a high degree of variation across sites within a country. Many different cropping systems are found in the Ugandan sample, banana, coffee, maize, and sorghum to name a few. The Malawian sites, on the other hand, are unified by their emphasis on maize. There have been noted cases of pest, disease, and drought, in both countries, but perhaps the most noteworthy event affecting the use of land was the Ugandan war of the 1980s which, among other things, led to displacement of people in some of the sites. More details of site characteristics can be found in Place and Otsuka (forthcoming).

Table 1—Means of some key explanatory variables

Variable	Uganda	Malawi
Population density (Uganda: 1960, Malawi: 1971)	79	65
Annual population growth	4.5	4.1
Distance from site to major city (km)	181	120
Distance from site to tarmac (km)	25	25
Average annual rainfall (mm)	1230	915
Percentage of land in customary tenure	50.2	100.0
Percentage of land in mailo tenure	39.4	–
Percentage of plots acquired through the wife's family	0	46.0

Source: IFPRI-ICRAF (1996); Uganda Ministry of Finance and Economic Planning (MFEP) (1992); FAO (1984); Green and Mkandawire (1997).

Tenure Variables Uganda. As indicated above, there were three main types of tenure regimes whose boundaries remained fixed throughout the study period in the study areas. Customary land was found in 37 (58 percent) of the parishes. Customary land covered the entire parish area in 30 parishes and it occupied about 50 percent of all land in the study area. The mailo land tenure system was found in 29 (45 percent) of parishes and comprised 39 percent of all land area in the study. Within mailo land, we were also able to identify the approximate percentage of owners who were absentee. In 34 percent of mailo areas, virtually all mailo owners were resident while the remaining two-thirds had moderate to high levels of absentee ownership. Public land was found in 24 (38 percent) of parishes, occupying about 10 percent of total land area.

In all tenure categories, individual rights to plant trees and to cut nontimber trees were ubiquitous. The only tree right to exhibit much variation concerned the right to cut timber trees (e.g., *Chlorophora excelsa),* which reflected differences in awareness of the legal protection for these species. As for land rights, in only a few cases was the unrestricted right of sale noted. Nearly all of these cases were in mailo land (where 55 percent of parishes reported prevalence of unrestricted rights). On the other hand, the unrestricted right of sale did was not common in any of the customary land areas surveyed or in 15 of 16 public land areas. Free grazing, hence less-exclusive rights to land, was reported for 32 percent of customary areas, 66 percent of mailo areas, and 42 percent of public lands. A recent study found that despite high rates of privatization of land rights, secondary rights to certain resources (e.g., grasses and firewood) remained strong under different tenure systems in Uganda (Baland et al. 1999). The higher percentage within the mailo tenure category may reflect the fact that large and often absentee owners are unable to enforce exclusion rights and that it is mainly on the larger mailo farms where supplies of such communally used resources are found.

Malawi. The major difference between customary tenure systems in Malawi was in the pattern of land inheritance. Over 90 percent of all sampled parcels were acquired from parents, with about 46 percent determined to have been through the wife’s side of the family. The prevalence of matrilineal inheritance systems is strongest in the south, weakest in the north where patrilineal systems dominate, and is moderate in the transitional north-central zone. The Chewa, a traditional matrilineal and matrilocal group, was the most prevalent group, found in 48 percent of enumeration areas. In our sample, 30 percent of enumeration areas had other matrilocal or matrilineal groups as a majority, while 23 percent of enumeration areas reported that patrilineal groups were the most prevalent.

Further questions regarding land rights and markets did not produce much variation in response. For instance, there was not one purchase of land among the 570 households surveyed and the right of sale was not recognized by any of the communities surveyed. Likewise, there was little variation in responses by groups to questions on other land and tree rights.

Land-use Cover and its Change

For discussion purposes, the land-use cover classifications have been grouped into agriculture, forest or plantation, woodland, bushland, and wetland. The figures in the tables are simple averages across observational units (parishes or enumeration areas).[8]

Uganda. Table 2 shows the broad land-use patterns as of 1960 and 1995 (across 64 parishes) in Uganda. Agriculture was the most widespread land use in 1960 and in 1995. The share of land under agriculture increased over the period from .57 to .70. The increase in agriculture came largely at the expense of bushland and woodland whose share fell from .28 to .18 during the same time period. Forested land also saw its share cut in half over the period from .04 to .02. On the other hand, wetland area remained fairly constant at .11 in 1950s and .10 in 1990s. Some wetlands were found to be difficult to convert due to perennial waterlogging.

[8] Using a weighted aggregation, the proportion of land under agriculture would be lower since the sampling units for which the share of agriculture is low are generally larger (because of the relationship to relatively low population density).

Table 2—Land use in Ugandan and Malawian sites at two points in time (share of land under each land-use category)

Country	Land Use	Time Period	
Uganda		1960	1995
	Agriculture	.57	.70
	Woodland/bushland	.28	.18
	Forest	.04	.02
	Wetland/grassland	.11	.10
Malawi		1971-73	1995
	Agriculture	.52	.68
	Woodland/bushland	.33	.19
	Forest	.01	.01
	Wetland/grassland	.14	.13

Source: IFPRI-ICRAF (1996); Green and Mkandawire (1997); Breyer (1996).

In Malawi, the data on land-use change paints a similar picture as in Uganda, though the change seems to have occurred in a more rapid manner (Table 2). The share of land in agriculture increased over the 1971-95 period from .52 to .68 across all study sites. There was substantial variation among the study sites, with the range being from +.73 to –.32. This expansion came almost exclusively from woodlands and bushlands, whose share of land area fell from .33 to .19. The remaining land-use categories remained nearly constant: wetlands at around .14 and forests at around .01.

Tree Cover and its Change

Uganda. Table 3 shows the simple average tree cover canopy across sample sites in 1960 and in 1995. The proportion of area under trees has remained nearly constant at

.31.[9] Movements in aggregate tree cover change are influenced by two key processes, change in land use (see above) and change in tree density on particular land uses. The change in land use has had a negative impact on aggregate tree cover since forests, woodlands, and bushlands, which have been reduced, have traditionally had higher proportions of tree cover than agriculture. However, tree cover densities on the specific land-use categories did not remain constant. The most impressive increase was found on agricultural land. Our samples found that while in 1960 average proportion area under trees was .23, in 1995 the proportion had been increased to .28. This increase partially offset the negative effect of land-use change on tree cover (i.e., reduced area under forest and woodland) and led to the realization of a constant aggregate tree cover. Average tree cover on woodlands and bushlands decreased slightly from .44 to .42. Tree cover density on forested land (see the definition above) was unchanged at .97 and that on wetlands was unchanged at .17. Given these changes, the contribution of agricultural land to total tree canopy (taking into consideration proportion of area and tree density) increased from 35 percent in 1960 to 58 percent in 1995.

[9] Recall that data on tree cover is from 42 parishes rather than the full 64 used for land use change. This excludes the northern districts of Apac, Lira, and Kumi that would be expected to have a lower tree density due to their dryness.

Table 3—Tree cover in Ugandan and Malawian sites for two points in time (proportion of land under tree canopy cover)

Country	Land Use	Time Period	
Uganda		1960	1995
	Agriculture	.23	.28
	Forest	.97	.97
	Woodland/bushland	.44	.42
	Wetland	.17	.17
	Aggregate	.31	.31
Malawi		1971–73	1995
	Agriculture	.02	.02
	Nonagriculture	.24	.17
	Aggregate	.17	.10

Sources: IFPRI-ICRAF (1996); Green and Mkandawire (1997); Breyer (1996).

Malawi. Table 3 displays some summary statistics pertaining to tree canopy cover across the enumeration areas. In 1972, the average canopy cover was estimated to be about 17 percent, but the median was much lower, at 9 percent. By 1995, tree cover had fallen to an estimated cover of 10 percent (the median being only 3 percent). There are significant differences in tree cover according to whether the primary land use was agriculture or not. Table 3 shows that tree canopy cover in agriculture land was very low in the sites, estimated to be only around 2 percent in both years. This level of cover has remained constant across most enumeration areas as noted by the fact that the change in absolute tree cover was between –02 and +.01 for 80 percent of the sites. Tree cover in nonagricultural areas was much higher, but has shown a more marked decline. From a level of about 24 percent in 1971, tree cover in nonagricultural areas has dropped to 17 percent.[10] As many as 44 sites experienced a decrease in nonagricultural land tree cover, while nine showed an increase.

4. THEORETICAL AND ECONOMETRIC MODELS OF TREE COVER CHANGE AT THE COMMUNITY LEVEL

THEORETICAL FRAMEWORK AND HYPOTHESES

As mentioned in the introduction, there are two types of decisions of concern: decisions concerning the choice of land-use system and decisions concerning the management of trees within the resulting land uses. We hypothesize that land-use choice is linked primarily to two key factors: the expected profits from alternative land uses and the costs (ease) of conversion from one land use to another.[11] We now analyze these decisions in Uganda and Malawi under the assumption that there are two land uses available to households and communities, agriculture and woodland. More detailed theoretical models are developed for Uganda and Malawi in Place and Otsuka (forthcoming), and Place and Otsuka (1997), respectively.

In Uganda, there are three types of exogenous tenure systems in which to analyze land-use and tree-cover decisions. In customary land, evidence indicates that the use of

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[10] Again, note that because the northern enumeration areas are larger and have a greater tree density, the weighted average tree cover for Malawi would be much higher than indicated by our simple averages across sites.

[11] Considerations of risks (e.g., climatic risk) may play a more important role if individuals are risk averse.

woodlands is virtually open-access. As such, expected profits from woodlands are low and there are strong benefits from conversion to private tenure and agriculture. Moreover, conversion is not restricted by tenure institutions that follow the common rules of accommodating land demands from new households and rewarding the conversion of land with stronger individual rights to land.

The case of mailo land is quite different, due principally to the restrictions on tenancies that have arisen from land tenure policy and resulting distortions on land use. Mailo owners now have strong incentives not to “lease” land to tenants. Because land is unevenly distributed in mailo areas (there are still some relatively large landowners remaining) the restrictions on leasing/renting, along with possible inefficiencies of crop production due to labor supervision costs (as found in Asia, see Hayami and Otsuka 1993), tend to preserve uncultivated areas (e.g., woodlands or grazing lands). Leasing/renting could equally have emerged in customary land, but the relatively equitable distribution of land did not provide the necessary incentives for this to occur. This reinforces the tendency that the proportion of agricultural land is lower in mailo land than in customary land (and thus more areas with high tree cover). The tenure security of mailo owners is essentially independent of land-use patterns while in the case of public land, conversion to agricultural land has been regulated to some degree by the State. Lastly, there is no counterpart on mailo or public land to the customary institution to provide land to all its members. Thus, we hypothesize that, other things being the same, the rate of conversion to agricultural land is higher in customary land than mailo and public land.

On the other hand, incentives to invest in tree resources will be affected by tenure security, which influences the future returns to investment expected to be captured by those who actually invest (Besley 1995). Individual land rights are strongest in private mailo owned by resident owners who usually manage their lands directly, and have both incentives and capacity to manage land and tree resources intensively. Mailo tenants also have strong planting rights with the exception of a few high-value timber trees. Therefore, we hypothesize that tree densities are highest in mailo land and lowest in public land where uncertainty and insecurity has been evidenced in some areas and at some times. We also hypothesize that within mailo land, areas managed by resident owners have greater tree density than those managed by absentee owners, as the latter have less control over the disposition of trees. Farmers in customary land may have strong rights to plant trees and the action of tree planting can help strengthen one's rights in land. We therefore expect tree densities on agricultural land to be higher in customary land than on public land, but expect no difference in tree cover in nonagricultural land since tenure is essentially open-access in both cases.

In Malawi, as in Uganda, it has been noted that there are few management rules regulating the use of woodlands. Thus, woodlands tend to be open-access which means that individuals have incentive to degrade or convert woodlands whenever they can gain short-term profit by doing so. In comparing the incentives for degrading or converting land between matrilocal and patrilocal households, there appears to one overriding factor. Because husbands in patrilocal households have greater security of tenure (in many, but not all cases), they will have higher expected profits from agriculture than their matrilocal counterparts. Thus, given that men are the primary decisionmakers regarding land use, we hypothesize that incentives for conversion are greater among patrilocal households.

We expect that where tenure security for males is greater, more sustainable land-use systems are chosen by men. In our case, this implies greater investment in tree planting or preserving tree resources in patrilocal rather than in matrilocal systems. However, because open-access seems to prevail in woodlands throughout Malawi, we anticipate that such differences will only be observed on agricultural land. Thus, for woodlands, our hypothesis is that there are no significant differences in tree cover under the different customary systems. In the case of agricultural land, we were unable to test the hypothesis because there was hardly any variation in tree cover change on agricultural land (this itself suggests that residence patterns have had little impact on tree cover on agricultural land).

Econometric Testing

Although expected profits feature as a key factor in our framework, we have no way of directly measuring the profits of alternative activities. Instead, we use proxies to reflect prices and productivity, and include tenure variables to proxy for the probability of realizing expected returns. Prices are determined by relative factor endowments and market access and these are captured by population density, proportion of land under agriculture in base year, distance to paved road, and distance to major urban center. Productivity is captured by environmental variables such as soil type and annual rainfall.

In Uganda, tenure refers to the three broad tenure regimes found in the study sites: mailo, public, and customary tenure. Specifically, the proportion of land under each of two tenure categories was used as explanatory variables (the third tenure category is the base case for comparison). These tenure measures can be reasonably considered as exogenous to the communities. Some further distinctions within these categories, such as the degree of individualization of rights or the degree of absentee ownership in mailo tenure, are also tested.

In Malawi, the tenure variable is the proportion of plots acquired through the wife's family and as such is an index of the importance of the matrilocal system. This variable should rightly be treated as endogenous since there appears to be quite a bit of latitude within communities and families insofar as land acquisition methods are concerned. We do include this as dependent variable in a single equation model and present the results. Using this variable, actual or predicted, in second stage regressions on land-use change, tree cover change, or yield change resulted in insignificant coefficients in all cases. However, we found that by interacting the tenure variable with geographical (and therefore ethnic) zone, some interesting results are obtained. Unfortunately, it is difficult to endogenize the interaction terms through estimation and the tenure variables are therefore assumed to be exogenous. In all cases, we estimate the equations independently. In Malawi, we also estimated the three natural resource management equations simultaneously using three-stage least squares. Those results are essentially the same as those reported here.

The econometric models tested are as follows:

Econometric Models Tested and Methods Applied	
Uganda	
Land-use change	*ƒ* (tenure, profit indicators, productivity indicators)
Method	OLS, 64 observations
Tree-cover change in agricultural land	*ƒ* (tenure, profit indicators, productivity indicators)
Method	OLS, 42 observations
Tree-cover change in nonagricultural land	*ƒ* (tenure, profit indicators, productivity indicators)
Method	OLS, 67 observations (from 42 sites)
Malawi	
Proportion of plots acquired through matrilineal ties	*ƒ* (profit indicators, productivity indicators, ethnic variables)
Method	Two-stage least squares, 57 observations
Tree-cover change in nonagricultural land	*ƒ* (tenure, profit indicators, tree characteristics, yield change, land-use change)
Method	Two-stage least squares, 57 observations
Land-use change	*ƒ* (tenure, profit indicators, productivity indicators, tree-cover change, yield change)
Method	Two-stage least squares, 57 observations

5. EMPIRICAL FINDINGS

Before turning to the specific findings, it should be emphasized that the explanatory power of the models is very high. In Malawi, adjusted R-squared measures ranged from .52 to .80 in most equations and in Uganda the same values ranged from .52

to .72. There were also several significant variables in each equation and these are now discussed in more detail.

UGANDA

The results in Table 4 indicate that the type of land tenure regime affects the change in agricultural land share. Customary tenure is positively related (in comparison to public land) to agricultural land conversion in all models. This could imply the existence of weak indigenous institutional management of lands in which land clearing is not regulated. It could, however, also indicate a purposeful strategy on the part of indigenous institutions to respond to demands for agricultural land by its ever-increasing constituents. There is no significant difference in land-use change between mailo and public tenure systems in any of the models. This may be related to the fact that there are some controls over conversion of these lands on part of individual owners (mailo land) and the government (public land).

Table 4—Two-stage least squares independent regression models for Uganda

Variable	Change in Share of Agricultural Land	Tree Cover on Agricultural Land	Tree Cover on Non-Agricultural Land
Constant [a]	.012 (0.71)	.523** (2.21)	-.837** (-3.12)
Share of customary tenure	.181** (2.08)	.047 (0.69)	-.052 (-1.00)
Share of mailo tenure	.026 (0.28)	.187* (1.91)	-.011 (-0.27)
1960 population density	.0020** (2.52)	.00035 (0.32)	.0010 (0.88)
1960 population density squared	-.000003** (-1.96)	.0000003 (0.29)	-.000003** (-2.49)
Population growth (predicted)	0.33** (2.00)	-.0127 (-0.65)	.065** (2.79)
Number of dry days	.0008 (0.90)	.00001 (0.01)	.0055** (3.76)
Sandy soil	– –	-.129** (-2.85)	.181** (3.40)
Distance to paved road	.0022** (2.60)	-.0028** (-2.64)	.0028** (2.29)
Distance to Kampala	-.00002 (-0.07)	.0002 (0.43)	-.0004 (-1.20)
1960 share of agriculture land	-.651** (-7.67)	-.362** (-3.26)	.356** (2.90)
1960 agricultural tree cover	– –	-.971** (-6.41)	-.291* (-1.93)
1960 nonagricultural tree cover	– –	-.076 (-0.76)	-.520** (-5.29)
Coffee important crop	– –	.063 (1.45)	– –
Adjusted R-squared	.59	.72	.52

Note: ** –significant at 5 percent level; * –significant at 10 percent level.
a. t-statistics in parentheses

Population variables were extremely important in explaining land-use change. Increased agricultural land share was linked to higher population growth and higher population density, the latter at a nonlinear decreasing rate. Other important variables in the change in agricultural land share regressions were the 1960 share of agricultural land and the distance to a paved road. The coefficient on the 1960 share of agricultural land was negative and very strong; this is expected because at higher share levels, the potential for additional expansion is less and the value of the resources in nonagricultural land may rise sufficiently to warrant some regulation or protection. Distance to a paved road was positively and significantly related to increased agricultural land share in all cases indicating that greater agricultural expansion during the 1960–95 period was taking place away from major roads. This is likely due to the simple fact that land near main roads was heavily populated and already converted in response to market opportunities prior to 1960.

Table 4 also shows the results from the tree cover change regression on agricultural and nonagricultural land respectively. Among tenure variables, the main effect found was that tree cover change on agricultural land was positively related to mailo tenure (compared to public land). There were no observed differences between "more exclusive" and "more open" mailo land, but positive tree cover change was stronger in mailo land dominated by resident owners as opposed to absentee owners (both of which may include numerous tenants). These results (not shown here) support our hypothesis that the highly individual rights to land and trees in mailo land (compared to public land) lead to greater incentives for long-term investment in trees, especially where mailo owners are resident. No other tenure variables were statistically significant, including none in the nonagricultural land regression. This indicates, *inter alia*, that trees on nonagricultural land are managed similarly under different tenure systems.

Population density and population growth had much less impact on tree cover change than on land-use change. The exception was the positive and statistically significant relationship between predicted population growth and tree cover in nonagricultural land. The reason for this is not apparent but the variable may be picking up the effect of the 1980–86 war, which may have simultaneously ravaged vegetation cover and lowered population growth in these sites.[12] This indicates that although increased population unambiguously leads to conversion of land to agriculture, the effect of population on tree cover or its change on agricultural or nonagricultural land is ambiguous.

Though there are several other statistically significant results, we highlight only three. Distance from a paved road was negatively related to the change in agricultural tree cover change. This is the expected effect if market access leads to more favorable prices for outputs and induces adoption of tree planting for coffee/shade, fruit, and fuelwood. Table 4 also indicates that proximity to paved roads has adversely affected tree cover in nonagricultural lands. Both results together suggest that in areas near paved roads incentives for exploiting trees are greater; only in agricultural land, where tenure is individualized, has this led to improved long-term tree management. The coffee variable was not significant, showing that tree cover change did not depend exclusively upon increased coffee plantings, though these certainly did contribute to improved tree cover.[13] Lastly, it is worth noting the significance of the 1960 tree cover variable. The strong negative signs on the 1960 tree cover variables indicate that individuals and communities are induced to react to the increasing scarcity value of trees by planting and protecting

[12] Indeed the effect disappears when a dummy variable for parishes strongly affected by the war is included. The war dummy itself was not significantly related to land-use or tree-cover change when included.

[13] Our data indicate that tree cover change was greater in parishes where coffee was important than where it was not. However, these coffee-growing parishes have favorable climate and infrastructure, which promote the adoption of noncoffee tree species. Lastly, as earlier mentioned, a great deal of coffee is intercropped with other trees in agroforestry systems.

tree resources. This is especially true in the case of agricultural land as evidenced by the high coefficient estimate.

MALAWI

The first column of Table 5 shows the results of a regression model explaining the prevalence of the matrilocal system. While our study design (rapid community survey) is not well suited to the explanation of tenure arrangements, the results are reported for two reasons. First, an understanding of the relationships between tenure and other variables sharpens the interpretation of the results in the main regressions. Second, it was deemed important to demonstrate that relationships between tenure and other variables can be quantified at suprahousehold levels. About two-thirds of the variation was explained by the included explanatory variables. Prevalence of the matrilocal system was found to be related to the southern zone, to the non-Chewa matrilineal groups, closer proximity to paved roads, and further distance from major cities. These results indicate that the non-Chewa groups are more likely than the Chewa to retain their traditional matrilineal practices and differentiate themselves from patrilocal groups. Chewa, especially in the nonsouthern zone, are more likely to be changing. In areas more remote from major cities, traditions appear to be better maintained. Proximity to roads has the opposite effect of proximity to cities and is difficult to explain. Interestingly, neither population pressure nor population growth had a significant impact on the pace of change in traditional inheritance practices.

Table 5—Two-stage least squares regressions for extent of matrilineal system, land-use change, and tree cover change in Malawi

Variable	Extent of Matrilineal System	Change in Share of Agricultural Land	Tree-Cover Change on Nonagricultural Land
Constant	-13.762 (-1.22)	-.919* (-1.84)	.406* (1.74)
North-central zone	-.039 (-0.24)	-.099 (-0.70)	-.441** (-3.46)
Southern zone	.309** (2.16)	-.081 (-0.56)	-.423** (-4.78)
Pct of population of main ethnic group	.0002 (0.10)	– –	.0004 (0.93)
1970 population density	.007 (1.19)	.011* (1.95)	.002 (0.46)
1970 population density squared	-.00003 (-1.04)	-.00005* (-1.65)	-.00001 (-0.50)
Log of distance to tarmac	-.061** (-2.32)	-.011 (-0.61)	.003 (0.25)
Log of distance from tarmac to major city	.065* (1.94)	.028 (1.14)	-.026** (-2.52)
1970 log of yield	– –	.108** (2.01)	– –
1970 share of land in agriculture	-.006 (-0.03)	-.588** (-3.00)	-.109 (-0.93)
1970 woodland tree cover	– –	– –	-.748** (-6.06)
1970 census area tree cover	– –	-.272 (-0.59)	– –
Proportion of trees that coppice well	– –	– –	.045 (1.37)
1970 percentage of Village Forest Area to total area	– –	– –	.002** (2.83)
Log of trees planted by external projects	– –	– –	-.001 (-0.23)
1970 pct of households with cattle	– –	.002* (1.66)	.0004 (0.84)
Mean Altitude	– –	.00009 (0.98)	– –
Average years since plots acquired	.007 (1.23)	– –	– –
Chewa ethnic group	-.126 (-1.37)	– –	– –
Patrilineal ethnic groups	-.201** (-2.66)	– –	– –
Percentage of plots acquired by women in north zone	– –	-.419 (-1.15)	-.569** (-4.35)
Percentage of plots acquired by women in north central zone	– –	-.011 (-0.07)	.179* (1.89)
Percentage of plots acquired by women in south zone	– –	-.158* (-1.66)	.044 (0.63)
Population growth[a]	.022 (0.59)	.020 (0.67)	.003 (0.15)
Change in woodland tree cover[a]	– –	-.780** (-1.99)	– –
Change in yield[a]	– –	.107 (1.18)	-.112** (-2.82)
Change in share of agricultural land[a]	– –	– –	-.143 (-1.25)
Adjusted R-squared	.59	.46	.69

Note: Figures in parentheses are t-values. Regressions are corrected for heteroscedasticity.

** significant at 5 percent level; * significant at 10 percent level.

a. Fitted values from first stage instrumental variable regression used.

Both tenure and population density had statistically significant impacts on land-use change. Conversion of woodlands into agricultural land was accelerated in patrilocal areas relative to matrilocal areas, but in the southern region only. Within the southern region, more patrilocal practices indicate areas experiencing more profound changes to the traditional system. Thus, greater change in the traditional tenure system is associated with greater land-use conversion. Population density has the expected positive, but diminishing effect on the rate of conversion of woodlands to agricultural land. Population growth, however, was not significantly related to conversion.

The initial share of agricultural land was negatively related to conversion as expected. The log of yield was significant and had a positive effect on conversion also, as expected. Greater conversion to agriculture is associated with faster loss of nonagricultural tree cover. This would be anticipated if the resulting loss in tree cover lowered profits of woodlands relative to profits from conversion to agriculture. Finally, conversion to agricultural land is associated with a greater percentage of households with cattle in the initial period. This is contrary to the notion that households with cattle would prefer to retain more woodland cum grazing land.

The change in woodland tree density is found to be related to tenure, but not in the manner hypothesized earlier. In the northern region, more matrilocal systems led to faster decline in tree cover. However, in the north central region, the presence of matrilocal systems appears to increase tree cover. Tenure did not play a role in the more densely settled southern region. A consistent explanation for this is that faster loss of trees is associated with the influx of migrant groups, the matrilineal groups into the patrilineal north and the patrilineal groups into the Chewa dominated north central. These types of households may well have different long-term strategies than indigenes and make the creation and enforcement of conservation rules more difficult.

We found that the proportion of land under Village Forest Areas had a positive effect on tree-cover change (as seen in smaller decreases in tree cover). These were identified by respondents as specially managed areas, implemented with the assistance of the Forest Department. Since our surveys suggested that these areas are very small, the presence of a Village Forest Area may also proxy for a broader interest in managing tree resources. The change in tree density was strongly and negatively related to the initial period tree cover, suggesting that change is more rapid when the scarcity value was lower. Tree cover loss was found to be more severe in areas further from major cities. This is contrary to expectations, but may simply mean that woodlands nearer to cities were cleared prior to 1970 (this would be expected under virtual open-access conditions). Tree cover loss was also greater where yield change was higher (less negative). This is not self evident, but it may be that yield losses are not as great in areas where tobacco is more prevalent (residual impact of fertilizer use) in which case we would expect greater removal of trees for tobacco drying. Finally, tree cover change is related to region. There has been greater tree density loss in the north-central region, characterized by estate development and high wood demands for tobacco drying and curing. There has also been greater tree density loss in the southern region, where demand for wood for fuel and shelter is acute.

6. SUMMARY AND IMPLICATIONS

Our data find, that given current conditions and institutions, conversion of land into agriculture will continue with its negative consequences on tree cover. In Uganda, the effect is mitigated significantly by relatively high tree densities on farms. Aggregate tree cover was the same (.31) in 1960 and 1995. In Malawi, tree cover on farms is very low with little change. Off-farm, there is evidence of significant depletion as tree cover has declined by about 33 percent between 1972 and 1996. Thus, off-farm sources continue to provide a substantial amount of tree products to households and have not been replaced by agroforestry systems on farms.

What may contribute to the differences between Uganda and Malawi? A number of factors may play a role. First, there is likely more competition for land from crop enterprises in Malawi where farmers must produce all their food crops in a single rainy season. Second, the coffee and banana systems found in many of the Ugandan sites are highly suited to integration with trees. Third, most types of vegetation grow better in Uganda due to favorable ecological conditions. Fourth, until very recently, Malawian farmers had a single parastatal source for all agricultural inputs. While this proved adequate in the provision of inputs necessary for maize production, it offered virtually no other options for farmers, including tree seed. Lastly, the 1980–86 war in Uganda had a positive impact on vegetation in some of our sites. Such factors appear to play a stronger role than tenure factors.

In order to increase the tree resource base, the most promising strategy is to support tree planting in agricultural land. This strategy is compatible with farmers' incentives, as land rights are generally well established on agricultural land. Our analysis suggests that infrastructure policy can also play a catalyzing role in changing the stock of tree resources. Connection to markets could raise long-term benefits from resources and improve household incentives to manage them. We found that in Malawi, proximity to major urban areas was positively associated with yield change and at the same time did not lead to degradation of tree resources over the study period. In Uganda, proximity to a paved road positively affected tree cover on agricultural land. The fear that infrastructure development will have deleterious effects on the environment is therefore questioned in these countries.

On nonagricultural land, prescriptions are less clear. In the presence of loss of land area and even depletion of trees on remaining areas in Malawi, one encouraging finding was that when tree cover became very low, further depletion was somehow better controlled by communities. This may indicate that under extreme scarcity, the value of the woodlands rises to a sufficient level to induce improved management.

What are some research implications? First, assessing tree cover in nonforested land is markedly more difficult than on forested land. Detailed analyses are certainly not possible on the types of satellite imagery available, especially in past years. Second, one must be cautious in interpreting the results on tree cover. Tree cover may not be a good proxy of biomass and certainly cannot be used to make inferences on biodiversity. Hence, this single measure should not be over-used as a proxy to assess natural resource management performance. Third, we have not established any link between tree cover and social welfare. It may well be that some communities are better off after some tree cover loss while others are better off after some tree cover increase. Fourth, our unit of analysis was a defined administrative boundary and we were not able to neither measure nor include tree resources from adjacent areas in our analysis.

As for our understanding of the role of tenure factors, there are clear tradeoffs among the different approaches taken. We have selected numerous sites in order to be able to have sufficient variation in tree cover assessments and to ensure adequate degrees of freedom to disentangle the effects of many mitigating factors. A consequence of the large sample size was the cost of obtaining in-depth information about social and economic variables at the community level. Nevertheless, we feel that the marriage of remote sensing data with primary and secondary socio-economic and ecological data proved to be very powerful in explaining changes in land use and tree cover. These types of marriages between disciplines should be pursued.

REFERENCES

Ault, D.E. and G.L. Rutman. 1979. The development of individual rights to property in Tribal Africa. *Journal of Law and Economics* 22: 163–82.

Baland, J-M., F. Gaspart, F. Place, and J-P. Platteau. 1999. *Poverty, tenure security, and access to land in Central Uganda: The role of market and non-market processes.* No. 216–1999/6, Serie Recherche, Cahiers de la Faculte des Sciences Economiques, Sociales, et de Gestion. Belgium: Namur University.

Bazaara, N. 1992. *Land policy and the evolving forms of land tenure in Masindi District, Uganda*. Centre for Basic Research Working Paper 28. Kampala, Uganda.

Besley, T. 1995. Property rights and investment incentives. *Journal of Political Economy* 103: 913–937.

Bojo, J. 1994. The cost of land degradation from a national perspective: An assessment of African evidence. Paper presented at the Eighth International Soil Conservation Conference, New Delhi, India, December 4-8.

Boserup, E. 1965. *The conditions of agricultural growth: The economics of agrarian change under population pressure*. London: Allen and Unwin.

Breyer, J. 1996. *Land use cover change in Central Uganda*. Report prepared for IFPRI and ICRAF, Nairobi, Kenya.

Bruce, J. 1988. Is indigenous tenure a development constraint? Land Tenure Center, University of Wisconsin, Madison. Mimeo.

Capistrano, A.D. and C.F. Kiker. 1995. Macro-scale economic influences on tropical forest depletion. *Ecological Economics* 14: 21–29.

Cline-Cole, R.A., H.A. Main, and J.E. Nichol. 1990. On fuelwood consumption, population dynamics and deforestation in Africa. *World Development* 18: 513–527.

Coote, H., J. Luhanga, and J.D. Lowore. 1993a. *Community use and management of indigenous forests in Malawi: The case of chemba village forest area*. FRIM Report No. 93006. Zomba: Forestry Research Institute of Malawi.

________. 1993b. Community use and management of indigenous forests in Malawi: The case of three villages in the Blantyre City fuelwood project area. FRIM Report No. 93007. Zomba: Forestry Research Institute of Malawi.

Deacon, R. 1994. Deforestation and the rule of law in a cross-section of countries. *Land Economics* 70: 414–430.

Dewees, P. 1995. Trees on farms in Malawi: Private investment, public policy, and farmer choice. *World Development* 23: 1085–1102.

Dickerman, C. and P. Bloch. 1991. *Land tenure and agricultural productivity in Malaw*i. LTC Paper 143. Madison, WI: Land Tenure Center.

FAO. 1984. *Agroclimatic data for Africa countries south of the equator*. Rome: FAO.

Fortmann, L. and J. Bruce. 1988. *Whose trees? Proprietary dimensions of forestry*. Boulder: Westview Press.

French, D. 1986. Confronting an unsolvable problem: Deforestation in Malawi. *World Development* 14: 531–540.

Green, R. and V. Mkandawire. 1997. *Land relations and management of trees in Malawi: Land use change determination*. Research report prepared for IFPRI and ICRAF, Nairobi, Kenya.

Hayami, Y. and K. Otsuka. 1993. *The economics of contract choice: An agrarian perspective*. Oxford: Clarendon Press.

Hosier, R.H. 1989. The economics of deforestation in Eastern Africa. *Economic Geography* 64: 121–136.

Hyde, W. and J. Seve. 1993. The economic role of wood products in tropical deforestation: The severe example of Malawi. *Forest Ecology and Management* 57: 283–300.

Kahn, J.R. and J.A. McDonald. 1995. Third-World debt and tropical deforestation. *Ecological Economics* 12: 107–123.

Langdale-Brown, I. 1960. *The vegetation of Uganda*, series 2, no. 6. Research Division, Uganda Department of Agriculture, Kampala, Uganda.

Migot-Adholla, S.E., P. Hazell, B. Blarel, and F. Place. 1991. Indigenous land rights systems in Sub-Saharan Africa: A constraint on productivity? *World Bank Economic Review* 5: 155–175.

Migot-Adholla, S.E. and J. Bruce. 1994. Introduction: Are indigenous African tenure systems insecure? In *Searching for land tenure security in Africa*, ed. J. Bruce and S.E. Migot-Adholla. Dubuque, Iowa: Kendall/Hunt.

Mkandwire, R. 1983/84. Customary land, the state, and agrarian change in Malawi: The case of the Chewa peasantry in the Lilongwe Rural Development Project. *Journal of. Contemporary African Studies.* 3: 109–128.

Muhereza, E. F. 1992. *Land tenure and peasant adaptations: Some reflections on agricultural production in Luwero District, Uganda*. Centre for Basic Research Working Paper 27. Kampala, Uganda.

Nankumba, J. 1994. The potential of agroforestry technology under customary land tenure in Malawi: A Case of Lilongwe District. Lilongwe: Bunda College. Mimeo.

Noronha, R. 1985. *Review of the literature on land tenure systems in Sub-Saharan Africa*. ARU 43. Agriculture and Rural Development Department, World Bank.

Patel, S.H., T.C. Pinckney, and W. Jaeger. 1995. Smallholder wood production and population pressure in East Africa: Evidence of an environmental Kuznets curve? *Land Economics* 71: 516–530.

Place, F. 1995. *The role of land tenure in the adoption of agroforestry in Burundi, Uganda, Zambia, and Malawi: A summary and synthesis*. Land Tenure Center Report. Madison, WI.

Place, F., and K. Otsuka. Population pressure, land tenure, and tree resource management in Uganda. *Land Economics,* forthcoming.

________. 1997. *Population, land tenure, and natural resource management: The case of customary land in Malawi*. EPTD Discussion Paper No. 27. Washington, D.C.: International Food Policy Research Institute.

Scherr, S. 1995. Economic factors in farmer adoption of agroforestry: Patterns observed in Western Kenya. *World Development* 23: 787–804.

Southgate, D., R. Sierra, and L. Brown. 1991. The causes of tropical deforestation in Ecuador: A statistical analysis. *World Development* 19: 1145–1151.

Uganda Ministry of Finance and Economic Planning (MFEP). 1992. *The 1991 population and housing census (district summary series)*. Entebbe, Uganda.

World Bank. 1993. *Uganda: Agriculture.* World Bank Country Study, Washington, D.C.

________. 1994. *World Development Report*. Washington, D.C.

________. 1995. *World Development Report.* Washington, D.C.

________. 1996. African Development Indicators for 1996. Washington, D.C.

World Resources Institute. 1994. *World Resources 1994–95.* Oxford: Oxford University Press.

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ELSEVIER

Agricultural Economics 20 (1999) 37–49

AGRICULTURAL ECONOMICS

Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia

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Received 23 July 1996; received in revised form 6 May 1998; accepted 20 May 1998

Abstract

In this paper, we test the hypothesis that land held under varying configurations of property rights will be farmed at different levels of production efficiency. Production data were collected from 477 plots in a fairly productive, mixed farming system in the Ethiopian highlands. Interspatial measures of total factor productivity, based on the Divisia index, were used to measure the relative production efficiency of three informal and less secure land contracts (rented, share-cropped and borrowed) relative to lands held under formal contract with the Ethiopian government. Although the informally-contracted lands are farmed 10–16% less efficiently, the analysis indicates that farmers of such lands actually apply inputs more, rather than less, intensively (i.e., more inputs per unit of land). The gap in total factor productivity thus results from the inferior quality of inputs (or lack of skills in applying them) rather than a lack of incentive to allocate inputs to mixed crop-livestock farming. For this reason we find no empirical basis to support the hypothesis that land tenure is a constraint to agricultural productivity.

1. Introduction

Many agricultural policy decisions in sub-Saharan Africa (SSA) are affected by the belief that land must be privatized or that people should have exclusive and secure rights on their lands (e.g., titled lands). An important argument in favor of land reforms is that farmlands held under exclusive and secure land rights are more productive than farmlands held under other forms of rights. If true, then reforms to title lands or individualize land rights should improve production efficiency. The hypothesized greater production efficiency of privatized lands, however, may be an illusion if other public policies such as provision of rural infrastructure, promotion of market efficiency, dissemination of information about new technologies and access to credit are not in place (Atwood, 1990). From a public policy view point, better information on the relative efficiency of farm lands under different tenure contracts would provide a better indication of how land tenure systems affect resource use and thereby the overall productivity of farming operations. If we can measure the relative production efficiency of alternative land tenure systems, we can then determine the productivity gains possible through land reforms. If land tenure arrangements are major sources of productivity differences, then efforts to develop technologies will be secondary to land reform policies.

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PII: S0169-5150(98)00067-X

Although the question of relative production efficiency of indigenous land rights is central to a discussion of land reform in SSA, there is relatively little rigorous empirical research due to lack of adequate disaggregated data. With the exception of few studies (Place and Hazell, 1993; Besley, 1994; Bruce et al., 1994; Gavian and Fafchamps, 1996; Hayes et al., 1997) the subject has not benefitted from rigorous empirical analysis. Further, most studies have covered only areas of rain-fed agriculture. Questions remain about the suitability of indigenous land rights for irrigated farming, extensive pastoral and livestock-based systems and communal forestry areas (Place and Hazell, 1993).

The objective of this paper is to examine the relative production efficiency of alternative land tenure arrangements and the sources of differences in productivity levels in Ethiopia as a case study. In 1974, the country nationalized rural lands, redistributing land use rights 'to the tillers' but maintaining land ownership in the hands of the state. Land sales were outlawed. Tenancy relations, such as sharecropping and renting were prohibited. In recent years, the restrictions on informal land transactions have been lifted and there are currently an array of formal and informal means by which farmers can obtain land. The varying degrees of security and rights associated with these arrangements make Ethiopia appropriate for case study of differences in productivity with land tenure.

The current study differs in several ways from similar studies by Place and Hazell (1993), Besley (1994), Gavian and Fafchamps (1996) and Hayes et al. (1997). First, it focuses on a farming system in which livestock contribute not only 40% of the country's agricultural gross domestic product, and provide most of the power for plowing and threshing. Second, the data used for the analysis were highly detailed, based on short-term (3-day) recall and actual measured yields, rather than end-of-season recall and qualitative measures. Unlike most other studies, labor hours per plot were collected. Finally, where most studies have attempted to gauge efficiency from econometric estimation of reduced-form production functions, this analysis relies on the concept of interspatial total factor productivity (TFP) as defined by (Denny and Fuss, 1980 and Denny and Fuss, 1983). The TFP method is well suited to the complexity and diversity of smallholder farming because it summarizes across fields with varying inputs and outputs. The use of the TFP method permits comparisons across systems with multiple outputs. Thus, while controlling for differences in input levels, we can examine differences in the output of land under different tenure arrangements. The TFP method does not isolate the impact of long term investment. It rather focuses on allocation of variable input levels.

2. Land tenure issues in Sub-Saharan Africa

Despite the large body of literature, the degree to which prevailing land tenure contracts constrain agricultural productivity in SSA is unresolved. Some authors argue that informal contractual tenure arrangements (e.g., tenancy or sharecropping) and other forms of indigenous land tenure rights result in an inefficient allocation of resources as well as reduced incentives to improve agricultural lands (Hayami and Otsuka, 1993). The argument is that land tenure arrangements that assign land rights to the community or to a landlord rather than to the principal land user, discourage long-term investment in land improvements. Individual farmers without secure private rights may not be able to claim fully the returns on their investments in, or attached to, land. Informal contractual tenure arrangements may fail to promote investments required for conservation. Accordingly, reforms such as the privatization or individualized land rights, the abolition of sharecropping and land redistribution are viewed as policy instruments that can improve agricultural productivity (Dorner, 1977; Ip and Stahl, 1978; Harrison, 1987; Hayes et al., 1997).

Other authors, however, argue that the form of land tenure has little bearing upon allocative efficiency and attribute the poverty of the agricultural sector in SSA to agricultural factor endowments and public policies rather than to the prevailing tenure arrangements. This second school of thought cites evidence that indigenous tenure arrangements are dynamic and evolve in response to population pressure and factor price changes. They argue that privatization of land rights, whereby farm households acquire a complete set of transfer and exclusive rights over land, occurs with increases in population pressures and agricultural commercialization (Cohen, 1980; Boserup, 1981; Noronha, 1985; Feder and Noronha, 1987; Pinckney and Kimuyu, 1994; Platteau, 1996). Place and Hazell (1993) found that land rights were not significantly related to yields in Ghana, Kenya and Rwanda, thus undermining the common view that land rights constrain agricultural productivity. They further concluded that lack of access to credit, insufficient human capital, and labor shortages adversely affect investment decisions more than insecurity of tenure. Gavian and Fafchamps (1996) tested whether traditional land tenure systems allocate land efficiently and whether insecurity affects the manner in which households allocate manure (a short-to-medium run land improvement strategy) among their fields. They found evidence that tenure insecurity incites farmers to divert soil-enhancing resources to more secure fields whenever possible. The ability to sell land, however, does not effect the allocation of these resources.

3. The conceptual framework

Most productivity analyses are based on partial productivity measures such as yield per hectare (land productivity) or output per person (labor productivity). Such productivity measures can be misleading if considerable input substitution occurs as a result of widely differing input prices due to market imperfections. Although partial productivity measures provide insights into the efficiency of a single input in the production process, they mask many of the factors accounting for observed productivity differentials.

A conceptually superior way to estimate productivity – and therefore production efficiency – is to measure total factor productivity (TFP) defined as the ratio of aggregate outputs to aggregate inputs used in the agricultural production process. There are two basic approaches to the measurement of productivity: the growth accounting approach, which is based on index numbers, and the parametric approach, which is based on an econometric estimation of production, cost or profit functions. In this paper we use the index number approach for three reasons. First, with the index number approach, detailed data with many input and output categories can be used regardless of the number of observations over time. There are, therefore, no problems of degrees of freedom or statistical reliability in working with small samples. Second, there is no need to aggregate outputs into a single index, thus avoiding input–output separability assumptions. Finally, under certain technical and market conditions, the econometric and index number approaches are equivalent. Recent advances in growth accounting theory have shown that non-parametric methods do indeed impose an implicit structure on the aggregate production technology (Ohta, 1974; Diewert, 1976; Diewert, 1981; Denny et al., 1981).

The major difficulty with the index number approach is to derive aggregate output and input measures that represent the numerous outputs and inputs involved in most production processes. Earlier approaches to TFP used a Laspeyres or Paasch weighting system where base period prices were used as aggregation weights. However, the Laspeyres or Paasch indexing procedure is inexact except when the production function is linear and all inputs are perfect substitutes in the relevant range (Christensen, 1975; Diewert, 1976). The most popular indexing procedure is the Divisia index which is exact for the case of homogenous translog functions (Capalbo and Antle, 1988). The translog function does not require inputs to be perfect substitutes, but rather permits all marginal productivities to adjust proportionally to changing prices. Hence the prices from both production systems being compared enter the Divisia index to represent the differing marginal productivities. There have been relatively few applications of this approach in the context of farming systems. Ehui and Spencer (1993) have used the Divisia approach to TFP to measure the sustainability and economic viability of alternative farming systems in Nigeria.

Assume that the agricultural process in land held under tenure system i at time t can be represented by the production function:

$$Q_{it} = F(X_{it}, T_{it}, D_i) \quad (1)$$

where Q_{it} is the output level, X_{it} is a vector of factor inputs, T_{it} is an index of technology, and D_i is a vector of dummy variables for every tenure system other than the reference base system.[1] T_{it} and D_i denote also intertemporal and interspatial efficiency difference

[1]This section is based on Denny and Fuss (1980, 1983).

indicators. Eq. (1) assumes that the production function in each tenure system has common elements as well as differences resulting from the tenure arrangement, which are maintained by the additional argument D. Suppose that we wanted to know the difference between the level of output on land held under tenure system i at time s, and land held under tenure system o at time t. Application of Diewert's (Diewert, 1976) quadratic lemma[2] to a logarithmic approximation of Eq. (1) gives:

$$\Delta \ln Q = \ln Q_{is} - \ln Q_{ot} = \frac{1}{2}\sum_{k}\left[\left.\frac{\partial \ln F}{\partial \ln X_k}\right|_{X_k=X_{kis}} + \left.\frac{\partial \ln F}{\partial \ln X_k}\right|_{X_k=X_{kot}}\right][\ln X_{kis} - \ln X_{kot}] + \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial D_i}\right|_i + \left.\frac{\partial \ln F}{\partial D_i}\right|_o\right][D_i - D_o] + \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{is}} + \left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{ot}}\right] \times [\ln T_{is} - \ln T_{ot}]$$

Let us define the interspatial (i.e., tenure) effect as:

$$\theta_{io} = \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial D_i}\right|_i + \left.\frac{\partial \ln F}{\partial D_i}\right|_o\right][D_i - D_o] \quad (3)$$

and the intertemporal effect as

$$\mu_{st} = \frac{1}{2}\left[\left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{is}} + \left.\frac{\partial \ln F}{\partial \ln T}\right|_{T=T_{ot}}\right][\ln T_{is} - \ln T_{ot}] \quad (4)$$

Constant returns to scale and perfect competition in input and output markets imply that $(\partial \ln F/\partial \ln X_k) = s_k$, where the term s_k represents the cost share for the kth input. Using these assumptions, we can rewrite Eq. (2) as

$$\Delta \ln Q = \frac{1}{2}\sum_{k}[s_{kis} + s_{kot}][\ln X_{kis} - \ln X_{kot}] + \theta_{io} + \mu_{st} \quad (5)$$

From Eq. (5) the output differential across tenure systems and time periods may be broken down into an input effect, a tenure system effect and an intertemporal effect.

Let A denote the land input. Eq. (5) can be rewritten as

$$\Delta \ln\left(\frac{Q}{A}\right) = \frac{1}{2}\sum_{k\neq A}[s_{kis} + s_{kot}]\left[\ln\left(\frac{X_{kis}}{A_{is}}\right) - \ln\left(\frac{X_{kot}}{A_{ot}}\right)\right] + \theta_{io} + \mu_{st} \quad (6)$$

where $\Delta\ln(Q/A)$ denotes the change in land productivity levels[3]. The first expression on the right-hand side of Eq. (6) denotes the weighted sum of differences in factor intensities. Let us define this expression as

$$\rho_{io} = \frac{1}{2}\sum_{k\neq A}[s_{kis} + s_{kot}]\left[\ln\left(\frac{X_{kis}}{A_{is}}\right) - \ln\left(\frac{X_{kot}}{A_{ot}}\right)\right] \quad (7)$$

The difference in land productivity can therefore be decomposed into three effects: (i) a factor intensity effect ρ_{io}; (ii) a tenure system effect (θ_{io}), and (iii) an intertemporal effect (μ_{st}). If we want to measure the production efficiency levels across tenure systems at a given point in time (where t=s), we rearrange the terms to isolate the tenure effect:

$$\theta_{io} = \left[\ln\left(\frac{Q}{A}\right)_i - \ln\left(\frac{Q}{A}\right)_o\right] - \frac{1}{2}\sum_{k\neq A}[s_{ki} + s_{ko}] \times \left[\ln\left(\frac{X_{ki}}{A_i}\right) - \ln\left(\frac{X_{ko}}{A_o}\right)\right] \quad (8)$$

The expression θ_{io} is the Tornqvist–Theil approximation (Tornqvist, 1996; Capalbo and Antle, 1988) to the change in productivity levels due to the type of tenure contract at a particular point in time. The difference in the TFP of two systems is a function of the differences in land productivities and factor intensities. Factor intensities are the weighted sum of

[2]Diewert (1976) quadratic lemma basically states that if a function is quadratic, the difference between the function's values evaluated at two points is equal to the average of the gradient evaluated at both points multiplied by the difference between the points: $F(Z^1 - F(Z^0) = \frac{1}{2}[F(Z^1) + F(Z^0)]^{\mathrm{T}}(Z^1 - Z^0)$ where $F(Z^r)$ is the gradient vector of F evaluated at Z^r, r=0,1.

[3]Dividing by A is the equivalent of presenting agricultural data on a per unit area basis (e.g., per hectare or acre). The final TFP figures are the same whether or not land is used as a numeraire, but the interpretation of the components does not correspond to those described in Eq. (8).

differences in the level of variable inputs applied per unit of land.[4]

In the case of multiple outputs, the Tornqvist–Theil quantity index can also be used to aggregate the various outputs into a single index:

$$\left[\ln\left(\frac{Q}{A}\right)_i - \ln\left(\frac{Q}{A}\right)_o\right] = \frac{1}{2}\sum_j [r_{ji} + r_{jo}] \times \left[\ln\left(\frac{Q_j}{A_i}\right)_i - \ln\left(\frac{Q_j}{A_j}\right)_o\right] \quad (9)$$

where r_{ij} and r_{jo} denote the jth output revenue share in systems i and o, respectively. Q_j denotes the jth output level.

Eq. (8) indicates that there are two components that contribute to any observed differences in TFP. First are changes in the level of land productivity. This is the major component underlying TFP differentials. Second are changes in factor intensities. TFP is therefore the residual, or the portion of change in output levels not explicitly explained by changes in input levels. However, increases in factor intensities may occur without any increase in TFP. Changes in TFP levels and factor intensities are not independent but they are of different significance. Increases in TFP will occur if land productivity increases proportionally more than increases in factor intensity levels. But increases in land productivity that are due to increases in factor intensities are qualitatively (although not quantitatively) less significant than changes in TFP. Indeed land productivity will increase if a farmer applies more purchased inputs. Unless there are improvements in the use of these inputs, this will be a change in factor intensity and not TFP. It is clear that with TFP changes, in contrast with factor intensity differentials, the farmer's capability to produce more with the same resources has improved.

[4]Although this study focuses on only one time period, the general expression shown in Eq. (6) can be specialized to provide a comparison of the rate of growth of productivity due to technical change for a particular system over time (D_i=D_o and s=t+1).

$$\mu_{t+1,t} = \left[\ln\left(\frac{Q}{A}\right)_{t+1} - \ln\left(\frac{Q}{A}\right)_t\right] - \frac{1}{2}\sum_{k\neq A}[s_{k,t+1} + s_{kt}] \times \left[\ln\left(\frac{X_{k,t+1}}{A_{t+1}}\right) - \ln\left(\frac{X_{kt}}{A_t}\right)\right]$$

μ_{t+1} measures the intertemporal TFP of a production system over two periods. It is the Tornqvist–Theil approximation to the change in productivity levels due to technical change.

4. Study area and data collection

For the last two decades in Ethiopia, all rural lands have been owned by the government in the name of the people. Lands were nationalized in a country-wide campaign in 1975, expropriated from both large landlords and small peasant farmers alike. Control over this resource was given to the representatives of lowest level of government, the Peasant Association (PA). PA officials periodically redistributed land between households based primarily on family size. To be eligible for land at the time of the next distribution, a farmer was required to register with the Peasant Association at age 18 or when he married.[5] When the Transitional Government of Ethiopia took power in 1991, it imposed a moratorium on land distributions until such time as a new land policy was formulated. Although the Constitution of 1994 re-iterated the inability of private citizens to own or sell land, it remained vague on the question of land distribution. To this day, this policy has yet to be clarified, although some regions of the country have undertaken or are planning rural land redistributions.[6] The International Livestock Research Institute (ILRI) conducted a study in 1994 to present evidence on ways farmers in the Ethiopian highlands gain access to land and the production and management strategies they use to cultivate and maintain that resource.

4.1. Study area

The study area was selected from one of the most productive regions of the country, the Arsi Zone of Oromia Region. Four peasant associations in the Tiyo *woreda* (district) – Abichu, Bilalo, Ketar Genet and Mekro Chebote – were selected for their varying altitudes and thus mix of crop and livestock activities. A census carried out in March 1994 provided a sampling frame for classifying households based on their official access to state lands. Households classified as peasant association members (PA) were those

[5]The original law does not distinguish between men and women. In practice, however, women are usually registered as independent PA members and allocated land in their names when, for some reason, they cannot depend on their spouse for land, as with widows, divorcees and wives in polygamous marriages.

[6]For a more thorough description of the recent evolution of land tenure legislation in Ethiopia, see Girma and Zegeye (1995)

which had received at least one crop or pasture field from the government. The second tenure class was made up of households which had not yet acquired either crop or pasture land from the government (NPA) but were farming land acquired from their PA neighbors through various informal contracts. The census indicated that in the total farming population of 1671 households, 83% were PA members and the other 17% were not. To determine the appropriate sample size for both the PA and NPA samples, the Weyman procedure (Cochrane, 1963) was applied to gauge the variability of the key agricultural variables in the census data by tenure class. Based on these results, a random sample of 161 households was selected from the census list, composed of 115 PA and 46 NPA households.

These households controlled 510 crop fields from which a final sample of 317 crop fields was selected. Each of the sampled crop fields was sub-divided where necessary into plots, where a plot was defined as a distinct management unit due to the farmer's choice to plant a unique crop or intercrop there. Not only were crops such as barley, wheat, teff (*Eragrostis tef*), etc., distinguished from one another, but so too were the sub-varieties within these categories. Some fields were made up of only one plot, while others had as many as 10 plots. The sampled crop fields contained 477 separate plots for which the following data were collected:

- *Input* data on all inputs used on each plot during the main 1994 growing season (from April to December 1994). These were collected twice weekly by asking the farmer to recall his activities on that particular plot during the past three days. Data included labor time (by source, gender, age, and field operation), as well as the quantities of traction (oxen and tractors), seed, fertilizers, pesticides, and herbicides employed. The prices of all purchased inputs were likewise recorded at this time.
- *Output* data on all the quantity of all cereals, pulses and residues harvested from each plot on the field. The full amount of offtake was weighed by enumerators after threshing and winnowing operations.
- Area measures, i.e., the area of plots.

In a separate survey, the prices of all crops and residues were collected in each of the two major rural markets frequented by farmers from these PAs: Asella and Ketar Genet markets. Twice monthly, enumerators recorded prices from three samples of each crop species and sub-variety found on the sampled plots.

4.2. Description of land contracts in the survey region

There are many arrangements under which farmers gain access to crop lands in Ethiopia. As stated above, the only official contract is with the government, through the PA. There are also numerous informal contracts, made unofficially between farmers without involving the PA. Whereas patterns of land transactions vary greatly between regions of the country, results our census indicated that in 1994 in Tiyo *woreda*, 76% of all fields were allocated directly by the PA to the current farmer. The remaining 24%, originally allocated to PA members, had been informally subcontracted to other farmers.

NPA farmers rely solely on informal contracts whereas PA farmers rely on both formal contracts with the government and informal contracts between themselves. The census indicated that over one-fifth of the PA households exported, or contracted out, one of their fields and about the same proportion imported, or contracted in, at least one field. A very small proportion (2%) both imported and exported land, perhaps to lessen the distances they had to walk to their fields. Over half of the PA households farmed uniquely the lands they had been allocated by the PA.

Based on differences in the nature of these contracts – in terms of duration, rights and costs – we have grouped all fields into one of four categories: PA-allocated, rented, sharecropped and borrowed.

PA fields are those which are allocated directly to the farmer by PA officials. Because no farmer has a permanent, legally defensible claim to land, even the duration of PA contracts are fairly short-term. However, PA-allocated fields are held longer and have a greater range of rights than the informally-contracted fields. The average PA-allocated field had been used by the current farmer two and a half to four times longer than the average contracted field. Furthermore, the duration of the current contract on PA-allocated fields is indefinite, whereas most contracted fields have only one year contracts (Table 1).

Most farmers on PA-allocated fields felt able to exercise most of the usufruct rights shown in Table 1. About one-fifth felt they could not build wells, stone

Table 1
Frequency and nature of land contracts in the Arsi region in Ethiopia

	PA-allocated	Informally contracted		
		Rented	Shared	Borrowed
Share of contracts for cropped fields users	83	5	4	7
PA-member households	100	18	76	64
Landless households	0	83	24	36
No. years field used by current farmer	8	2	3	3
Duration of current contract (%)	100	100	100	100
One year	0	91	63	16
Two years	0	6	7	2
Three or more years	0	0	7	0
Permanent/indefinite	100	3	23	81
Proof of contract (*% fields*)	100	100	100	100
None required	0	27	77	96
Witnesses required	100	8	0	0
Written contract	0	65	23	4
Share of fields for which user holds the following right (%):				
Unrestricted crop choice	100	100	100	97
Fallow for 1 year	96	87	33	16
Fallow for more than 1 year	95	64	8	13
Plant trees	92	75	12	19
Install a well or pump	77	75	12	19
Build stone bunds	79	82	37	35
Build fence from natural materials	93	89	34	55
Build fence from stone/metal	79	68	14	32
Share out	98	64	53	6
Rent out	97	62	44	6
Lend out	96	61	45	6
Bequeath	99	68	34	6

Source: ILRI Field Management Survey; Rights Survey.
Notes: 'Permanent', in the case of contract duration means that the two parties will honor the agreement until the government intervenes with another distribution.

bunds or permanent fences of metal or stone but these responses may reflect more their desire rather than their right (the distinction is difficult to make to farmers, the concept of rights being rather abstract). In contrast, farmers on the informally contracted fields feel substantially more restricted in all activities except the right to choose the crop they plant. Structural changes, fallowing and subcontracting out the land were usually not possible for farmers with informal land contracts.

Although PA members are required to pay taxes, that tax is unrelated to amount of crop or pasture land they receive. In 1994, PA members were taxed 22 Ethiopian Birr (EB) per household, which, at an average holding of about 2.9 ha, equals about 7.5 EB per hectare (or US$ 1.20/ha). Essentially, therefore, PA-allocated lands are free.

Rented fields are those for which a fixed cash sum is paid – usually in advance – by the tenant to the landholder. The renter-tenant pays for all inputs and reaps all benefits (or losses) of his cropping activities. Of the informally-contracted fields, rented fields have the shortest leases. The average renter operated under a one-year agreement that was less often extended than agreements established by borrowers or sharecroppers (as indicated by the number of years the field had actually been used in Table 1. As on all informally-contracted fields, the range of use and modification rights is more restricted on rented fields than it is on PA-allocated fields. As compared with the other contracted fields, however, renters have the broadest range of rights (Table 1). They also are the most likely to have a written contract. The average cost for renting a field in the survey area was 352 EB per hectare in 1994 (US$ 56/ha). Rented fields made up about 8% of all cropped lands in Tiyo woreda in 1994 and 33% of the area's contracted fields.

Sharecropped fields involve a commitment by both partners to share the costs of the inputs and the benefits of the outputs.[7] Sharecropped fields are held somewhat longer than rented fields, with 23% under long-term agreements and an average holding time of three years (Table 1). The reverse is true in terms of rights; the considerably more restricted range of rights on sharecropped than rented fields reflects the lack of autonomy for the share-tenant in this partnership. In the survey year, the cost of the sharecropped contract was two and a half times greater than that for rented fields. After deducting the landholder's share of all labor and inputs from his share of the outputs, the average cost of a sharecropped contract was 935 EB per hectare (US$ 148/ha).[8] Sharecropped fields made up 4% of all cropped lands in Tiyo woreda in 1994 and 17% of the area's contracted fields.

Borrowed and gift fields are those given by the landholder to the user free of charge. Borrowed fields are given for a defined period, whereas gift fields are usually given for a longer, but indefinite period (i.e., until the next land distribution). Both types of fields are almost always given by relatives, usually by parents who give out part of their holdings to their newly-married family members. As offspring or relatives of the landholder, many of these farmers contributed labor to the landholders' fields. These contributions were difficult to monitor and have not been valued here. Because the basic attributes of gift and borrowed fields are very similar, they have been combined under the same rubric in this analysis (borrowed/gift). The duration of the average borrowed/gift contract comes closest of all the three informal contracts to the PA-allocated fields, with fully 81% of users operating under a long-term arrangement (Table 1). Borrowed/gift fields had an average holding time of three years and as relatives, the two parties rarely require a written document. The range of rights, however, is quite restricted, roughly the same as sharecropped fields, more restricted than rented fields and much more restricted than PA-allocated fields. As with shared fields, these restrictions represent the partnership underlying the borrowing arrangement, in this case between family members. Borrowed/gift arrangements are fairly common, making up 12% of all cropped lands and half of all contracted fields in 1994.

4.3. Defining security

Theory suggests farmers will be reluctant to invest in insecure fields. But the concept of security is complex and elusive, depending in great measure on the farmer's subjective assessment of the political and legal climate. Bruce et al. (1994) describe security in terms of the formal duration of rights, the protection of rights and the robustness of rights. The analysis by Place and Hazell (1993) employs qualitative variables to represent tenure security in terms of bundles of transfer rights: limited (cannot be permanently transferred), preferential (can be bequeathed or given) and complete (can be sold). Besley (1994) measures land tenure security in terms two variables: the number of transfer rights the farmer can exercise without approval from the family members and the number of transfer rights for which such approval is needed.

In this study, we define land tenure security as a combination of the expected longevity of the contract and the breadth of rights to carry out a range of field-related activities. Because none of the tenure contracts is long-term or alienable and nearly all farm lands are under exclusive control only for the duration of the growing season (becoming open to grazing animals in the dry season), the definition of security is necessarily relative. The four tenure arrangements described above have been ranked from 1 to 4 based on the information presented in Table 2 in terms of (a) duration (a combination of past holding and current contract length), (b) use rights (planting, fallowing),

[7] *Equl* and *Siso* are local names of the two most common contracts, meaning equal sharing and two-third share, respectively (from the tenant's point of view). Under either contract, most labor is provided by the share-tenant. In spite of these simplified names, there are numerous permutations on these arrangements, based on the specific endowments of the two contracting partners.

[8] Note that 1994 was a good crop year in the Arsi Region and, therefore, the cost of the average share contract was higher than usual.

Table 2
Relative ranking of the security of land tenure arrangements in the Arsi region in Ethiopia

	PA-allocated	Informally contracted		
		Rented	Shared	Borrowed
Duration	4	1	2	2
Use rights	4	3	2	2
Modification rights	4	3	2	2
Transfer rights	4	3	2	1
Total	16	10	7	6

Based on the data on contract duration and rights displayed in Table 1, the land contracts have been order from 1 (least) to 4 (most). The sum of these rankings is given in the row entitled 'Total', and represents a qualitative measure of tenure security.

(c) modification rights (trees, wells, fences, bunds) and (d) transfer rights (share, rent, lend, bequeath). A ranking of 4 indicates the given tenure arrangement was superior to all the other arrangements on the particular measure; conversely a ranking of 1 indicates that tenure arrangement ranked lowest. Where there was no notable difference between the two categories, an equal score has been granted (Table 2).

This ranking procedure permits us to order the land tenure arrangements in terms of declining security: PA, rented, shared and borrowed. Although PA-allocated lands are not 'secure' in a truly long-term sense, the security offered by the government is necessarily greater than what farmers can offer each other under renting, sharecropping and borrowing contracts. Furthermore, most farmers on PA-allocated lands claim to the right to undertake important investments (modifications to the field) or transfers, whereas farmers on informally-contracted fields feel unable to undertake major improvements to fields. Generally, renters have less security but a wider range of rights than either sharecroppers or borrowers. What distinguishes the latter two groups is the stiff price tag paid by sharecroppers in kind to the landholder.

4.4. Transforming the production data

For the purposes of this analysis, the different types of land contracts are hypothesized to have different effects on the structure of production in the region. We have conducted pair-wise comparisons between those lands allocated by the government (i.e., PA-allocated) and each type of land received under an informal farmer-to-farmer arrangement (i.e., rented, sharecropped or borrowed lands).

To have an adequate number of observations in each field tenure class, the analysis has been restricted to wheat, barley and legume plots which constitute 82% of the plots surveyed.

Within each generic crop category (i.e., wheat, barley and legume) farmers distinguished numerous sub-varieties.[9] Because not all sub-varieties were found in each tenure system, grains were aggregated into three categories – wheat, barley and legumes – and all residues were grouped together. Likewise, because not all inputs were used in each of the four tenure systems, more generic input categories have been formed: human labor, power (oxen and tractor), chemicals (fertilizer and herbicides) and seed.

Given that the different tenure arrangements had multiple and dissimilar crop outputs and inputs, it was necessary to aggregate the varying input and outputs into meaningful categories to permit application of the Tornqvist–Theil indexing procedure, as shown in Eqs. (8) and (9). Implicit output indices of wheat, barley and legumes were calculated by dividing the total value of all output by the price index obtained by weighing the individual output prices by the revenue share of each crop. A corresponding input quantity index for labor, power, chemicals and seed was computed as the ratio of total expenditures in each input category to the weighted price index of that input. The latter was measured as an index of all prices of individual input prices weighed by the cost share of each input.

All inputs and outputs enter the calculations on a per hectare basis; land enters the model with a quantity value of one along with the associated per hectare price for each tenure category. This method of including land as a numeraire permits the output and input components to be interpreted as land productivity and factor intensity, respectively, as shown in Eq. (8).

The prices used for these models were derived from several sources. Output and seed prices were drawn from the twice-monthly survey of retail prices in the two major markets in the area. Based on the observation that most farmers market their crops in the three months following harvest, the December through

[9]Because these distinctions were not made by trained agronomists, we refrain from calling these cultivars.

Table 3
Comparisons of total factor productivity, land productivity and factor intensities by tenure arrangements in the Arsi region in Ethiopia

	PA-allocated	Informally contracted fields		
		Rented	Shared	Borrowed
Total Factor Productivity	1.00	0.90	0.87	0.84
Land Productivity	1.00	0.96	0.91	0.92
Wheat	1.00	1.12	1.21	0.95
Barley	1.00	0.88	0.78	0.95
Legumes	1.00	0.96	0.98	1.03
Residues	1.00	1.01	0.99	0.99
Factor Intensity	1.00	1.06	1.05	1.10
Labour	1.00	1.00	0.99	0.98
Power	1.00	1.01	0.99	1.01
Chemicals	1.00	1.04	1.06	1.10
Seed	1.00	1.01	1.01	1.01

February price average was used to represent output prices; based on the similar observation that seeding is carried out in May and June, the average of the market prices for these months was used to represent the value of seed, whether purchased or reserved from last year's stock. Prices for purchased inputs such as fertilizers, herbicides, pesticides, and tractor power were derived from averages cited by farmers in the course of the production survey. Pricing unpurchased inputs such as human and animal labor was more difficult. Although there is a labor market, hired labor made up only 7% of total labor time. For the purposes of the TFP computations, all labor was valued at the market rate, disaggregated by activity where there were significant differences in daily wages by activity. Assuming the opportunity cost of most household labor is not as high throughout the growing season as the wage rate for labor hired at peak periods, this method most likely overstates labor component of total input costs. (Analyses to test the sensitivity of the results to this method indicated that using the hired labor rate did not distort the final results). As the market for animal labor is even thinner than that for human labor[10], it was impossible to gather good data for this input. The final prices used were derived from key informant interviews.

[10]When farmers need additional animal power, they tend to swap between themselves.

5. Productivity estimates

Table 3 shows the average total factor productivity levels for each of the three informal contracts (rented, shared and borrowed lands) relative to the PA-allocated land tenure type. Land and total factor productivity levels are lower for these contracts relative to the PA-allocated arrangement. Borrowed lands have the lowest TFP levels producing 16% less output than the PA-allocated lands using the same input bundle. The shared lands are 11% less efficient than the PA-allocated lands, whereas rented lands are only 7% less efficient.

The overall land productivity levels for informally-contracted fields are also lower than for PA-allocated fields. However, the gap is smaller than the gap in TFP levels due to the relatively high levels of factor intensity on informally-contracted fields. The higher level of total inputs (labor, power, chemicals and seeds) applied to informally-contracted fields increases the level of land productivity but not the level of TFP. For example, the factor intensity level on borrowed land is 10% higher than the PA-allocated lands but the TFP level is 16% lower.

Although Eq. (8) provides an excellent framework for decomposing the change in TFP into its various components, we can also express the changes in the levels of inputs as a percentage of the change in land productivity. Table 4 indicates that differences in most

Table 4
Sources of productivity differences: informally-contracted fields relative to government (peasant association) -allocated fields in Arsi region in Ethiopia

	Rented	Shared	Borrowed
Differences in TFP (percentage points)	−10	−13	−16
Land productivity (output)	−4	−9	−8
Total factor intensity	6	5	10
Labor	0	−1	−2
Power	1	−1	1
Chemicals	4	6	10
Seed	1	1	1
Differences in TFP as share of difference in land productivity (%)	250	144	200
Total factor intensity	−150	−56	−125
Labor	0	11	25
Power	−25	11	13
Chemicals	−100	−67	−125
Seed	−25	−11	−13

input levels between the informally-contracted lands and PA lands were positive, whereas differences in land productivity were negative thus resulting in a negative change in TFP levels for all lands under informal contracts. Chemical inputs (fertilizers and herbicides) were the major contributor to higher levels of inputs for all the informal contracts, whereas the contribution of animal power, human and seed remain roughly the same. The increase in the level of chemicals was inversely proportional to the degree of land tenure security as defined above. The more insecure the land, the more farmers applied chemical inputs. The largest increase (10%) was for borrowed lands.

The high input intensities, combined with low land productivity ratios and thus low TFP, indicate that the capacity of rented, shared and borrowed lands to produce more output is not hampered by under-investment in variable inputs due to land insecurity. Rather than applying less input, as theory would suggest, farmers on informally-contracted fields applied more inputs, in particular, more chemical fertilizers.

There are several reasons for this high input/low output combination on informally-contracted fields. First, informally-contracted fields may have poor soil quality. Although data on the physical description of these fields failed to show a significant difference in slope or erosion on the informally-contracted fields, there was some evidence of differences in soil type. Borrowed fields in particular were less likely to be found on the rich black soils that characterize much of the Ethiopian Highlands. (More precise assessments of soil quality were not done). Furthermore, borrowers almost always receive their land from their fathers who share a piece of their limited PA-allocated holdings. Dependent on their father's generosity for this free land, borrowers are thus stuck with what they are given, as compared with renters and sharecroppers who have somewhat more bargaining power to search for better land. Many reported not finding land until well into the plowing season. To the extent that landholders may continually contract out the same plot year after year (to different farmers), the inherent quality of those plots may be low. It is thus possible that the quality of all informally-contracted fields, and especially borrowed fields, is lower than PA fields.

Second, land-importing farmers may use labor inefficiently. As young adults, borrowers usually have strong obligations to contribute labor to the family farm. Additionally, they tend not to own the oxen needed to plow their borrowed fields. Although they use the same amount of total human and animal days per hectare as PA farmers, they do so by relying on labor and oxen exchanges, after tending to family fields. This would imply that borrowers were not planting and harvesting at the optimal time. Thus, it appears likely that the TFP efficiency gap is due to youth, poor soil quality and timing rather than tenure insecurity.

6. Conclusions

The reform of land policies in Sub-Saharan Africa has received much attention in recent years. Many authors believe that farm lands held under indigenous or informal land contracts in sub-Saharan Africa are less productive than those held under title or individualized land rights (e.g., owner cultivation). Others argue that the indigenous tenure arrangements have little bearing on crop productivity because they are dynamic and evolve in response to changes in land values. This debate will continue so long as there is insufficient empirical evidence to support the arguments. Using plot-level data and the concept of interspatial total factor productivity, this analysis determined the relative production efficiency of four alternative land tenure arrangements prevailing in one region of Ethiopia. Lands allocated by the government are the most secure because farmers have relatively greater duration and a greater range of rights on them compared to the informal tenure arrangements. There are no privately owned lands in Ethiopia to use as a standard, thus we focused on lands formally allocated by the government (PA-allocated lands), as well as those informally exchanged between farmers (rented, shared and borrowed lands).

The results of our study show that although the production efficiency of farming differs by tenure contract, the differences were relatively small and not attributable to the use of fewer variable inputs as a result of insecurity. Informally-contracted lands were relatively less productive than the PA-allocated lands. Borrowed lands were the least efficient, followed by shared and rented lands. With a TFP level of 0.84, borrowed lands were the least productive. These were followed by shared lands (0.87) and rented lands (0.90). As shown in the conceptual framework (Section 2), TFP is a function of both land productivity and factor intensities. The land productivity levels for informally-contracted lands were lower than unity, but the factor intensity levels were greater than unity, indicating that overall lower levels of TFP were due to increases in quantities of factor inputs without a corresponding increase in land productivity (Table 4). Further decomposition of the factor intensity levels identified chemical inputs as the major source of differences. Because of the relatively high use of chemical inputs on less insecure fields, we suggest that other more important factors contribute to the low productivity levels of farming operations than tenure, such as soil quality, farmer endowments and farmer experience. In other words, productivity determines tenure than vice versa. Thus there seems to be little evidence to say that changing tenure arrangements per se will change productivity, unless it can also change soil quality and farmer experience.

Although this study uses a different methodology than appears in most analyses of agricultural productivity and property rights, it supports the conclusions of those who argue that land tenure does not constrain productivity at the current level of development in Sub-Saharan Africa. The results of our study suggest that the government should assess farmers, demand for formalization of informal land tenure contracts.

Acknowledgements

The authors thank Charles F. Nicholson, Mohammad Jabbar, and two anonymous referees for very helpful comments and suggestions. Nega Gebreselassie and Amare Teklu assisted in editing the manuscript.

References

Atwood, D., 1990. Land registration in Africa: the impact on agricultural production. World Dev. 18(5), 659–671.

Boserup, E., 1981. Population and Technological Change. University of Chicago Press, Chicago.

Bruce, J.W., Migot-Adholla, S.E., Atherton, J., 1994. The findings and their policy implications: institutional adaptation or replacement. In: Bruce, J.W., Migot-Adholla, S.E., (Eds.), Searching for Land Tenure Security in Africa. The World Bank, Washington, DC.

Besley, T., 1994. Property Rights and Investment Incentives: Theory and Evidence from Ghana. Unpublished manuscript, Research Program in Development Studies, Princeton University, USA.

Capalbo, S.M., Antle, J.M., (Eds.), 1988. Agricultural Productivity Measurement and Explanation. Resources for the Future, Washington, DC.

Christensen, L.R., 1975. Concepts and measurement of agricultural productivity. Am. J. Agric. Econom. 57(5), 910–915.

Cochrane, W.G., 1963. Sampling Techniques, 2nd ed. Wiley, New York.

Cohen, J., 1980. Land Tenure and Rural Development in Africa. In: Bates, R., Lofchie, M. (Eds.), Agricultural Development in Africa. Praeger, New York.

Denny, M., Fuss, M., Wavermann, 1981. The measurement and interpretation of total factor productivity in regulated industries, with an application in Canadian telecommunications. In: Productivity Measurement in Regulated Industries. Academic Press, New York.

Denny, M., Fuss, M., 1980. Intertemporal and Interspatial Comparisons of Cost Efficiency and Productivity. Working Paper No. 8018, Institute for Policy Analysis, University of Toronto. Toronto, Ontario.

Denny, M., Fuss, M., 1983. A general approach for intertemporal and interspatial productivity comparisons. J. Econometrics 23, 315–330.

Diewert, W.E., 1976. Exact and superlative index numbers. J. Econometrics 4, 115–145.

Diewert, W.E., 1981. The Economic Theory of Index Numbers: A Survey. In: Deaton, A. (Ed.), Essays in the Theory and Measurement of Consumer Behaviour in Honour of Sir Richard Stone. Cambridge University Press, London.

Dorner, P., 1977. Land Reform and Economic Development. Kingsport Press, Kingsport.

Ehui, S., Spencer, D., 1993. Measuring the sustainability and economic viability of tropical farming systems: a model from sub-Saharan Africa. Agric. Econom. 9, 279–296.

Feder, G., Noronha, R., 1987. Land right systems and agricultural development in sub-Saharan Africa. World Bank Res. Observer 2, 143–169.

Gavian, S., Fafchamps, M., 1996. Land tenure and allocative efficiency in Niger. Am. J. Agric. Econom. 78, 460–471.

Girma, T., Zegeye, A., 1995. Land tenure structure and development in Ethiopia: a case study of 10 peasant associations in Wara Jarso Woreda, Ethiopia. in: A Paper Presented at the Sub-regional Workshop on Land Tenure Issues in Natural Resources Management, The Sahara and Sahel Observatory, Natural Resource Management Programme. Economic Commission for Africa, Addis Ababa, 11–15 March 1996.

Harrison, B., 1987. The Greening of Africa. Paladin Grafton Books, London.

Hayes, J., Roth, M., Zepeda, L., 1997. Tenure security, investment, and productivity in Gambian Agriculture: a generalized probit analysis. Am. J. Agric. Econom. 79, 369–382.

Ip, P.C., Stahl, C.W., 1978. Systems of land tenure, allocative efficiency, and economic development. Am. J. Agric. Econom. 00, 19–28.

Noronha, R., 1985. A review of the literature on land tenure systems in sub-Saharan Africa. Report No. ARU 43, Agriculture and Rural Development Department, The World Bank. Washington, DC.

Ohta, N., 1974. A note on the duality between production and cost functions: rate of return to scale and rate of technical progress. Econom. Stud. Quart. 25(1), 63–65.

Hayami, Y., Otsuka, K., 1993. The Economics of Contract Choice. Clarendon press, Oxford.

Pinckney, T.C., Kimuyu, P.K., 1994. Land tenure reforms in east Africa: good, bad, unimportant. J. Afr. Econom. 3, 1–28.

Place, F., Hazell, P., 1993. Productivity effects of indigenous land tenure systems in sub-Saharan Africa. Am. J. Agric.Econom. 75, 10–19.

Platteau, J.-Ph., 1996. The evolutionary theory of land rights as applied to sub-Saharan Africa: a critical assessment. Dev. Change 27, 29–86.

Tornqvist, L., 1936. The Bank of Finland's consumption price index. Bank of Finland Monthly Bull. 10, 1–8.

CAPRi WORKING PAPER NO. 6

LAND TENURE AND THE ADOPTION OF AGRICULTURAL TECHNOLOGY IN HAITI

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October 2000

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ABSTRACT

There has long been an active debate in Haiti—as in many other developing countries—over whether or not the customary tenure system constrains technology adoption and agricultural development, and whether cadaster and land titling should be national priorities. This paper contributes to this debate by reviewing and interpreting the body of literature and new empirical evidence concerning the relationship between land tenure and the adoption of technology in rural Haiti. The findings suggest that (a) formal title is not necessarily more secure than informal arrangements, (b) informal arrangements based on traditional social capital resources assure affordable and flexible access to land for most people, and (c) perceived stability of access to land—via stability of personal and social relationships—is a more important determinant of technology adoption than mode of access. The paper concludes that there is no definitive relationship between tenure and technology adoption by peasants; peasants are preoccupied more by political and economic insecurity than insecure tenure; and rather than tinkering with formalizing tenure, policy makers should prioritize other more fundamental rural sector reforms. The paper ends by considering some of the implications for theory and suggests several avenues for future research on land policy.

CONTENTS

LAND TENURE AND THE ADOPTION OF AGRICULTURAL TECHNOLOGY IN HAITI

Glenn R. Smucker[1], T. Anderson White[2], and Michael Bannister[3]

1. INTRODUCTION

Experts commonly cite Haiti's complex land tenure system as a key constraint—sometimes *the* key constraint—to agricultural intensification and rural development. These claims have led to calls for national cadastral survey and titling programs to update the formal land tenure system and unleash the rural sector (see USAID 1985, World Bank 1991, IDB 1992, FAO 1991 and 1995, APAP 1995, Nathan 1995, FAO/INARA 1997, MARNDR 1992, Renaud 1934, Victor 1993). At least one pilot cadaster and titling program has been established, and major new investments in land reform are under consideration. The conventional wisdom holds that Haiti's tenure system constrains peasant investment and adoption of technology since a majority of parcels are informally divided and the formal system for administering tenure is ineffective.

These arguments correspond to prevailing property rights theory as represented by Boserup (1965) and Demsetz (1967)—that private, individualized tenure is the most efficient in situations of land scarcity. On the other hand, the empirical evidence suggests that the informal

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system appears reasonably efficient from a peasant perspective, and has evolved in response to other pertinent factors.

The findings described in this paper support Baland and Platteau's claim (1998) that prevailing property rights theory underappreciates three important variables: the role of the state, social capital, and the distributional concerns of local people. The evidence suggests that land scarcity in Haiti is acute, and labor—in simple, aggregate terms—is in abundant supply; however, access to labor remains a critical issue for most Haitian peasants. In this rural context of extreme cash scarcity, labor serves as the primary medium of exchange. Access to a colleague's labor is, on the margin, more important than access to land.

Empirical evidence from Haiti challenges the proposition that direct interventions to reform tenure—especially large-scale cadastral survey and titling—should be a priority for rural Haiti. Instead, more fundamental reforms must first be addressed. Furthermore, the evidence shows that peasant social relations support agricultural intensification even in the absence of formalized property rights and titles.

The purpose of this paper is to contribute clarity to this debate by reviewing and interpreting the body of literature concerning relationships between land tenure and the adoption of technology in rural Haiti. The paper first summarizes the modern context of peasant production and Haiti's statutory and customary tenure systems. The paper then reviews the results of previous studies on tenure and adoption, and the recent national household Baseline Survey of food security commissioned by USAID (BARA 1996a, 1996b, 1997) and analyzed by the World Bank (Wiens and Sobrado 1998). Next, the paper presents important new data from the PADF agroforestry impact survey (Bannister 1998a, 1998b) and concludes with a discussion of findings, including implications for theory and future research.

CONTEXT OF PEASANT PRODUCTION

In 1804 Haiti became the New World's second republic and the world's first nation of free citizens to achieve independence from Europe. A colonial social structure based on acute class stratification set the stage for Haiti's post-independence evolution as a deeply divided society.[4] After 1804, the masses of former slaves established themselves as independent freeholders—a reconstituted peasantry.[5] Peasant society emerged as largely self-regulating to cope with geographic isolation, exclusion from the political system, exploitative market relations, regressive taxes, and the virtual absence of state investment in the rural sector. In response, Haitian peasants created a complex network of local institutions to ensure social security and channel access to land, labor, and capital.[6]

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[4] See Leyburn (1966), Mintz (1974a), and Farmer (1994) for reviews of colonial history and implications for national development; James (1963) and Saint-Louis (1970) on the Haitian revolution; Trouillot (1990), Fass (1988); Lundahl (1979, 1983, 1992); and Cadet (1996) on Haiti's political economy and poverty.

[5] Mintz (1974a) coined the term "reconstituted peasantry," and identified the antecedents of peasant production strategies under the slave plantation regime of colonial Saint-Domingue. See Leyburn (1941) and Moral (1961) for historical origins and the early evolution of Haitian society, and Lundahl (1979) for economic history including the role of land.

[6] For reviews of the emergence and nature of rural institutions see Barthelemy (1989, 1996) and field ethnographies including Murray (1977), Smucker (1983a), and Woodson (1990). See Lundahl (1992) for a review of the informal system of social security in Haiti, and SACAD and FAMV (1993) for a synthesis of numerous papers on peasant agricultural strategies.

Historically, peasant agriculture has been Haiti's primary economic activity. An estimated 59 percent of Haiti's population is rural—one of the highest rates in the region.[7] Most farmers in Haiti are mountain peasants with farm units composed of several dispersed field plots. Recent national surveys confirm that the vast majority of peasants continue to be owner-operators by purchase or inheritance (see Table 1); however, average landholdings are small, fragmented, and generally of poor quality.[8]

Land, labor, and social relations are the most important assets of the household economy. Peasants actively manage kin ties, fictive kinship (godfatherhood), patron-client relations and other special relationships as social capital that can be leveraged for access to land, labor and capital. Cash resources are extremely scarce; farm strategies tend to be labor intensive. Land is the most significant tangible asset and serves as a powerful fulcrum for access

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[7] Demographic data are based on population projections estimated at 7,630,997 in 1998. The most recent national demographic survey (see Cayemittes 1995) was undertaken by the Enquête Mortalité, Morbidité et Utilisation des Services (EMMUS-II) of the Institut Haitien de l'Enfance (1994/95). This survey estimated the rural population at around 63 percent in 1993 and decreasing due to out-migration from rural areas and rapid urban growth, around 4 percent annually in the capital city.

[8] See Zuvekas (1978) for available census data. According to national census data of 1971, the average size of peasant holding is less than 1.5 hectares, and the average plot size is less than 0.8 hectares. The census data on farmland and its distribution may not be reliable. The census data do not recognize mixed status categories, nor do they distinguish production units from landholding units. Nevertheless, the census data are indicative of the fragmentation and small size of peasant farms. The recent USAID survey, interpreted by Wiens and Sobrado (1998), found that over 90 percent of farmers have access to land and that two-thirds own land either through purchase or inheritance. The average farm size is about 1.7 hectares and these farms are comprised of an average of 3.7 dispersed plots. Farmers average only 0.6 hectares of good or mixed quality soil.

to labor and capital resources. Farmers are acutely aware of micro-site variations, such as topography and soils, and actively diversify land portfolios and cropping

Table 1: Distribution of modes of access to land[a]

	Parcels in each category						
Source	Ownership[b]	Purchase	Divided Inheritance	Undivided Inheritance	Rent	Sharecrop	Other
	(percent)						
Wiens & Sobrado (1998)[c]	65.5	32.4	33.1	7.5	8.4	11.9	6.6
Bannister (1998)[d]	53.2	38.5	14.7	21.0	12.6	10.0	3.3
USAID (1995)[e]	58.2	38.6	19.7	14.0	12.1	5.5	10.2
ADS II (1988)[f]	61.0	–	–	13.0	9.0	9.0	7.0
Zuvekas (1978)[g]	60.0	–	–	–	14.3	14.4	11.1

Notes:

[a] Tenure categories as defined here include direct access to land by virtue of ownership and indirect access through tenancy.

[b] Ownership is defined as "purchased" plus "divided inheritance" plots. "Purchased" and "divided inheritance" categories do not distinguish formal from informal transactions, and may not have updated title.

[c] Data source: USAID food security survey—a nation-wide, area-frame Baseline Survey of 4,026 households (BARA 1996a, 1996b, 1997).

[d] Data source: PADF/PLUS agroforestry impact study—a list-frame survey of 5,658 plots and 1,540 households. The category of "other" includes leasehold on state lands, and plots controlled by a land "manager" for absentee landlords.

[e] Data source: Interim Food Security Information System (IFSIS)—a nationwide, area-frame sample of 5,000 agricultural parcels. In this survey, the "other" category includes "gift" (1.32%) and "other arrangements" (8.87%).

[f] Data source: Agricultural Development Support Project (ADS II, 1988)—a nation-wide, area-frame sample of 1,307,000 parcels. In this survey, the "other" category includes "rental from state" (4%), "without title" (2%), and "other" (1%). The "ownership" category includes purchased and divided inheritance lands.

[g] Data source: Institut Haïtien des Statistiques (HIS)—a nation-wide census of 1,484,385 plots. In this survey, the "other" category includes "rental from state" (3.8%).

patterns to manage risk and spread out harvest cycles. As a strategy for survival, most peasants tend to focus on reducing risk rather than maximizing production. Managing a peasant household's stock of social capital is the key element of this strategy.[9]

Recent surveys indicate that 81 percent of rural households fall below the poverty line.[10] This alarming level of poverty reflects a precipitous decline in Haitian agriculture. Production per capita dropped 33 percent since 1980 and agriculture's contribution to GNP dropped from 47 percent in the 1970s to 24 percent in 1996.[11] This abrupt decline coincides with acute land scarcity, the closing of the agricultural frontier, and prolonged political and economic crisis in Haiti since the mid-1980s. The agricultural sector is significantly decapitalized and there is limited public investment in rural infrastructure. A shortage of off-farm employment opportunity heightens the extent of rural poverty. Despite recent efforts to decentralize and democratize the

[9] The literature on Haitian peasants includes numerous references to risk management, agricultural strategies focused on survival issues and food security, and the importance of retaining a diversity of plots, cultigens and income sources. See Smucker (1983a, 1983b), Ehrlich et al. (1985), BARA (1997), Kermel-Torres and Roca (1993), Gagnon (1998), Zuvekas (1978), Wiens and Sobrado (1998), Moral (1961), and SACAD and FAMV (1994b).

[10] See Wiens and Sobrado (1998) on the USAID food security baseline survey (BARA 1996a, 1996b, 1997). They find 67 percent of households surveyed below the indigency line, 81 percent below the poverty line, and only 28 percent of food consumed by peasants as self-produced. The indigency line is defined as the local cost of reaching the FAO minimum nutritional standard of 2,240 calories daily per capita with a diet that matches the food expenditure percentages of the average sample household.

[11] See USAID (1997) among others. This document also reports a decline of 33 percent in the number of calories consumed per person per day since 1980. Further, agriculture's share of total export value fell from around 60 percent in the 1970s to less than 10% by the end of the 1980s.

economy and the state, reform efforts have yet to make a palpable difference in rural areas. The peasantry remains in a state of chronic and growing crisis.[12]

2. LAND TENURE SYSTEM

ORIGINS

In 1804, the new Haitian state acquired immense holdings by confiscating French colonial estates and asserting state ownership of all unclaimed lands. Informally, newly freed slaves established themselves as independent agriculturists in areas of weak government control. Victor (1993) estimates that over a third of Haiti's present territory was settled outside of government control. Between 1807 and 1817, President Pétion distributed 150,000-170,000 hectares to some 10,000 beneficiaries (Moral 1961). Land distribution in Haiti today remains significantly more egalitarian than elsewhere in the Caribbean and Latin American region (Lundahl 1997; Zuvekas 1979).

OWNERSHIP, LAW AND CUSTOM

The literature on Haitian land tenure is based primarily on local community studies, old census data, especially the census of 1971, and other more recent survey data. Community studies include research in widely dispersed areas of the country, lowland plains, and mountain communities. Review of the literature suggests that categories of access to land are fairly

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[12] See the World Bank (1998), *Haiti: The Challenges of Poverty Reduction*. For a review of the economics of long term rural decline, see Lundahl (1979), "The Haitian peasant

standard throughout most of rural Haiti. The duality of formal and informal systems is applicable in all regions of the country.[13]

Identifying characteristics of Haitian land tenure include the following: (1) individual, private property is the rule, (2) peasant smallholders predominate over large holdings, (3) the majority of peasant farmers are owner-operators of their own land, (4) peasant farms are composed of several non-contiguous parcels, (5) most peasants are simultaneously landlords and tenants, (6) land is readily bought and sold without updating title, (7) inherited land is divided equally among all children of the deceased, (8) farm holdings are built up over the course of a lifetime, then divided and dispersed (Oriol 1996; Bloch et al. 1988).

Land tenure categories discussed in this paper are categories of access rather than strictly legal categories based on title or lease contracts. This includes direct access to land by virtue of ownership and indirect access through various forms of tenancy or usufruct. Table 1 summarizes overall distribution of agricultural plots by direct and indirect modes of access. A farmer may own, rent, and sharecrop several plots. Therefore, it is important to distinguish farm operations (land use) from its proprietary base (land ownership and control).[14]

Haitian peasant holdings are firmly grounded in the concept of private property. Peasant land ownership originates from formal and informal purchase, inheritance, and gifts.

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sector is caught in a downward spiral of circular and cumulative causation which slowly depresses the standard of living among the peasants."

[13] See FAO/INARA (1997), Victor (1993), Bloch et al. (1988), Ehrlich (1985), Renaud (1984), and Zuvekas (1978).

[14] See Wiens and Sobrado (1998), Bannister (1998), Bloch, Lambert, Singer, and Smucker (1988).

According to national surveys, peasant owner-operators own 37 percent of all agricultural parcels by purchase, 23 percent via divided inheritance, and 15 percent via undivided inheritance (averages based on Table 1).[15] Other forms of access derive from a variety of arrangements including usufruct, non-formalized gifts of land, pre-inheritance, plots controlled by land managers for absentee landlords, and leasehold on state land.

In keeping with the profound dualism of Haitian society, land tenure arrangements are marked by two parallel systems—one legal and the other customary.[16] In practice, the two systems are interactive and constitute a type of legal pluralism rather than two discrete systems.[17] Statutory (legal) land transactions and entitlement rely heavily on documents prepared by notaries and updated survey. In general, peasant land transactions reflect skepticism of notaries, land surveyors, and virtually all agents of the state including the judiciary.

[15] Findings of INARA (1997), Oriol (1997), Wiens and Sobrado (1998) and Bannister (1998a) are consistent with earlier findings. See Zuvekas (1979) for an earlier compilation of studies demonstrating ownership.

[16] See MARNDR (1992), Victor (1989 and 1993), Bloch et al. (1988), and Montalvo-Despeignes (1976), among others, on the dualism of law and custom, and reviews of Haitian land law and pertinent literature.

[17] See Benda-Beckman (1995) for a definition of legal pluralism drawn from legal anthropological studies: " . . . the simultaneous existence of multiple normative constructions of property rights in social organizations (legal pluralism)."

In the customary system, people make land available in response to family obligations, special ties to fictive kin (godparenthood), and various forms of clientship (e.g., labor relations, personal loans, banking of favors). Normatively, kinship groups have an obligation to make land available to all family members. Informal (customary) tenure arrangements among peasant farmers tend to be self-regulatory. Peasant farmers occasionally update title to inherited land, but ownership rights stem primarily from kinship ties and transactions not regulated by law. Most farmers hold land by extra-legal agreements, but owners of informally divided inheritance plots may also refer back to master deeds three or four generations removed (Murray 1977; Barthélémy 1996).

There is a lively land market in among peasants in Haiti. Land sales are driven by consumption and the need for cash in a household economy characterized by extreme cash scarcity. In addition to its value as a basic factor of production, land is held as a store of value or insurance fund for crisis, illness, burial, ceremonial obligations, schooling, or out-migration (Murray 1977; FAO/INARA 1997).

The recent FAO/INARA study estimates that 95 percent of land sales in rural Haiti avoid the formalities prescribed by Haitian law. There is some evidence that updated title is more common in irrigated zones or peri-urban areas subject to high rents and speculative land values. Farmers make every effort to avoid, diminish, or postpone notarial fees, survey costs, taxes, and other charges for land registration and updated title.[18] From a

[18] See Bruce and Migot-Adholla (1994) for reports of such practices in Africa.

peasant perspective, avoiding surveys also diminishes the risk of land loss due to the high cost of surveying and revising current plot lines to conform to old master deeds. In the Haitian context of legal pluralism, formal title is not necessarily more secure than informal arrangements, although it is demonstrably more expensive and considerably less flexible than the informal system.[19]

In general, patterns of inheritance redistribute family land with the passing of each generation. In both law and custom, all recognized children have equal rights to a share of parental land holdings. The mechanism of inheritance tends to maintain egalitarian distribution of land; however, subdivision also perpetuates fragmentation and diminished plot size over time. With high population growth, the size of farm units and individual plots has diminished dramatically since the nineteenth century. The effects of fragmentation are mitigated by out-migration, consolidation of shares (usually by men since women commonly marry out and move away from the family land base), and customary restrictions against selling inherited land to outsiders (non-kin) (Barthélémy 1966). Customary norms assure potential access to land by all members of the family, but the system rewards family members who stay on the land rather than migrating or marrying outside the community.

Strictly from a legal perspective, the most striking feature of the overall system is the prevalence of legally undivided inheritance land, and a general reluctance to update title for land transfers. From a statutory perspective, undivided family inheritance retains

[19] See FAO/INARA (1997, Chapter 5.4), FAO/IDB 1998, 24, Oriol (1996), Murray (1977), Moral (1961), McLain et al. (1988), Bloch (1988), Victor (1984), Smucker (1983).

its legal status as a single block of land even when subdivided by custom. Once divided by custom, these shares are readily bought and sold informally among heirs. Consequently, the percent of legally undivided family inheritance is undoubtedly higher than shown in national census and survey data. Land access categories in Table 1 do not distinguish statutory from customary forms of land purchase or inheritance.

As illustrated in Table 1, about 10 percent of all agricultural plots are accessed via rental agreements and 10 percent via sharecropping agreements. Most sharecroppers are not solely dependent on sharecropping. Peasants generally view sharecropping as a favor to the tenant since land and cash are both scarce. Paying rent in cash is commonly viewed as a favor to the landlord—perhaps a relative faced with a heavy burden of funeral debt. Some tenants retain continuous access to rented or sharecropped land for many years. Others rent land for shorter periods when the tenant's own holdings are in fallow or otherwise occupied (McClain et al. 1988).

In the customary system, people also make land available by usufruct, especially to kinfolk. Usufruct may be limited to specific rights such as the right to harvest particular trees or bushes (coffee, fruit), grazing, or agricultural use for a single growing season. Usufruct may also take the form of pre-inheritance plots with the understanding that the beneficiary will cover the giver's eventual burial costs. Some inheritance land remains undivided—even informally—for several generations. In such cases, co-heirs and their descendants may retain joint use rights to house sites, wood lots, pasture, or ceremonial sites (Smucker 1983; Oriol 1996; Barthélémy 1996).

Leaseholders and squatters on state land are a significant exception to the rule of private property. Oriol (1993) calculates the number of state leaseholders at around 35,000 or roughly 5 percent of rural households and 10 percent of agricultural land.[20] Peasant leaseholders on state lands treat their leases as though they were private property—buying, selling, renting, sharecropping, and inheriting their lease rights by customary agreements.[21]

3. LAND TENURE SECURITY

In this context of legal pluralism, with the prevalence of informal modes of access to land, what ultimately defines land tenure security and insecurity? From a juridical perspective, clear and defensible title derives ultimately from the state. Clear title should presumably ensure long-term access to land, freedom to alienate the asset, and freedom from the threat of eviction. As a corollary, juridical insecurity exists when the landowner or land user lacks the necessary legal status (clear title, lease) or the institutional means (court system, law enforcement) to enforce property and leasing rights.

By these measures, peasant farmers in Haiti do not enjoy land tenure security. This juridical insecurity stems from contradictions in land law and weak institutions of enforcement. First, most peasant landholdings are not covered by updated title. This is

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[20] ADS II (1986) estimates 4 percent of agricultural parcels under state leasehold. Victor (1993) notes that estimates of state land vary from 100,000 to 300,000 hectares. There are no verifiable inventories of farmers on state lands or the amount of state land.

[21] See Bloch et al. (1988) and author interviews (Smucker and Delatour 1979; Smucker and Smucker 1979) with leaseholders on the offshore island of La Gonave and the Northwest Department.

due in large part to the high transaction costs. Secondly, those with updated title cannot adequately defend their rights in a court of law. Victor (1993) views insecurity as a permanent feature of Haitian land tenure and a direct product of the Haitian political system.[22]

What emerges from field studies is a generalized peasant distrust of the law, and primary reliance on social relations and customary arrangements to ensure access to land. Most peasants are aware of procedures for formalizing land ownership. They value updated title to land; however, customary arrangements are standard in virtually all peasant households. Co-heirs may revert to the formal system to sell inherited land to outsiders (non-kin). In most of rural Haiti, the formal system is a recourse of last resort in managing land conflict (see Murray 1978a; Smucker 1983a).

Peasants may turn to the formal system when the informal system proves unable to resolve conflicts over inheritance or rightful ownership. This course of action is prohibitively expensive for most peasant households. Recent research on land conflicts adjudicated by the courts has concluded that the courts are often unable to arrive at a definitive judgment, and that the judicial apparatus is generally unable to enforce its judgments (FAO/INARA 1997).

Customary law privileges the possessor. Peasant rights and claims are strengthened by continuous presence on land. Co-heirs who remain on the land assume

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[22] Clear title does not provide protection from intervention by powerful outsiders, land invasions to reclaim lost land, or the takeover of unoccupied land, usually in the aftermath of changes in government (FAO/INARA 1997; Moral 1961). Such incursions, however, are more commonly reported on state lands, peri-urban zones, irrigated zones, or sites with speculative value.

control of absentee shares and consolidate adjoining shares of inheritance into larger blocks of land. Co-heirs and kinfolk have priority for land purchase. Longstanding sharecroppers or leaseholders also enjoy priority over others for the opportunity to purchase (Smucker 1983b).

Poverty is itself an important source of land tenure insecurity. In a cash starved peasant economy, farmers find it difficult to expand their land base by purchase, and are not inclined to invest scarce savings to update title. Furthermore, viable land holdings are not transmitted intact to the next generation. Subdivision gives each member of the next generation a stake in the land—however meager that stake might be. This is a two-edged sword: people have a stake in the land—a social safety net and access to land through of customary law, but for most people the land base is inadequate by traditional peasant standards. Mintz (1974b) describes this as a "concealed proletariat"—land-poor smallholders who rely heavily on agricultural day labor or other intermittent sources of income. The overall system redistributes the wealth in land, mitigates poverty, and, in effect, shares the poverty.

The FAO/INARA study (1997) assessed the formal land tenure system and concluded the following: (a) the judicial system is incapable of guaranteeing land tenure security even for those able to take full advantage of it, and (b) the system actively generates land conflict and insecurity.[23] This tends to confirm Victor's assessment that agrarian law is contradictory and ill adapted to the rural social context and Haiti's customary system (Victor 1993). For example, the FAO/INARA study identified five separate means of formal entitlement, a situation that generates rival ownership claims.

Tenure security is significantly undercut by the absence of a functioning, independent judiciary to ensure enforcement. Most peasants are virtually excluded from due process by the inaccessibility of courts. There are no courts in Haiti's 565 rural sectional jurisdictions, and only a small number of courts are authorized by law to judge land disputes. The lower courts most accessible to peasants have very limited formal authority over land disputes. FAO/INARA notes that the courts are interminably slow, corrupt, and politicized. Therefore, broad based reforms and a viable system of justice are essential pre-conditions for land tenure security.[24]

Haiti today lacks a comprehensive, operative system for recording land ownership. Victor (1993) supports the cadaster as an essential tool in reforming the system, but notes that Haitian laws on cadaster have never been implemented and cadaster projects have generally failed. The government together with foreign agencies or investors has carried

[23] See Chapter 2, La sécurité foncière et ses garants: "…il n'y a en Haiti aucune garantie ou sécurité foncière opposable à tous." See Chapter 3, La gestion des conflits: droits et propriété et tribunaux: "Le dysfonctionnement des institutions préposées à assurer la sécurité foncière…est générateur d'insécurité foncière et producteur de conflits fonciers, violents ou larvés."

[24] See FAO/INARA 1997, especially chapters 2 and 3 cited above, and FAO (1995).

out cadastral surveys as an element of project investment or agro-industry. This has sometimes had the effect of excluding peasant smallholders (FAO/INARA 1997).

Local cadasters were undertaken in irrigated zones of Haiti's Gonaives Plains (1974-79) and the Artibonite Valley (1950s, 1980,1982). In these cases, physical cadasters were undertaken with the promise of land reform, but delivery of title to peasants never materialized (Victor 1993). It is also interesting to note that landowners within the perimeters of these local cadasters have commonly made a choice not to register subsequent land transactions despite the offer of free registration. There is some evidence of success in the use of physical cadasters to regulate water rights—an approach based on water users within an irrigated perimeter—regardless of tenure status (Hauge 1984).

In a context of high risk within the statutory system, it is hardly surprising that peasants rely heavily on extra-legal maneuvers. The customary system offers a more manageable level of risk. Customary arrangements lower financial and transaction costs. They are flexible and adapted to daily realities of peasant decision-making. For the vast majority, the informal system assures at least minimal access to land—the pivotal asset of peasant livelihood. Peasants use mixed patterns of tenure to defray labor costs, ensure cash flow, and meet social obligations based on kinship ties or patron-client relations. Finally, the customary system is locally controlled and addresses household imperatives to manage risk, enhance social security, and set aside an insurance fund.

The literature on Haitian land tenure describes a context of legal pluralism. In current practice, customary forms prevail and appear more reliable that the statutory system. Haitian peasants are more concerned with security in tenure rather than tenure security. That is, secure access is not defined by title security. Rather, peasant smallholders are concerned most of all with stability of access. Assured access is largely dependent on kinship status and one's personal stock of social capital.[25]

4. TECHNOLOGY ADOPTION AND TENURE

The vast majority of Haitian peasants claim land ownership through formal and informal procedures. At issue is whether peasants feel secure enough to adopt agricultural technologies and invest in their land. This section first reviews the results of previous studies on tenure and the adoption of agricultural technologies and then presents new evidence from the agroforestry impact survey conducted by the Pan American Development Foundation.

RESULTS FROM PREVIOUS STUDIES

National Food Security Baseline Survey

Between 1994 and 1996, USAID funded the Baseline Survey, a national-level survey on food security that included questions on land tenure, adoption of agricultural technologies, inputs, production, demography, and nutrition.[26] This survey of 4,026 households

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[25] See Locher (1988), Murray (1978a) and 1979), SACAD/FAMV (1994a and 1994b), and Bloch et al. (1988). McClain et al. (1988) collected data on length of occupancy for all tenure types, finding a high incidence of lengthy periods of tenure even for short-term forms of tenure.

[26] Under USAID sponsorship, three NGOs, CARE, the Adventist Development and Relief Agency (ADRA), and Catholic Relief Services (CRS) conducted the food security Baseline Survey, each in a different region of the country. The Bureau of Applied Research in Anthropology (BARA), University of Arizona, analyzed and published the findings. For the detailed reports, see BARA (1996a, 1996b, 1997).

generated the most comprehensive set of household data of the 1990s and the only national-level data relating tenure, adoption, and productivity. Wiens and Sobrado (World Bank 1998) analyzed the data to better understand the dynamics of rural production and poverty. Only the findings related to tenure will be reported here.

First, Wiens and Sobrado examined simple correlations between tenure type and agricultural practices. Five types of land access—purchased, inherited-and-divided, rented, sharecropped, inherited-and-undivided—were tested against four types of practices—cropping pattern, degree of crop diversification, input intensity, and the adoption of soil conservation techniques. Wiens and Sobrado tested the partial correlations while holding area cultivated and area of good or mixed quality soil constant, as these variables may be associated with particular tenure patterns and may mask other relationships if not held constant.

As judged by partial correlation coefficients with $p \leq 0.05$, they found no significant relationships between tenure and agricultural practices tested, except for sharecropping. Sharecropping was positively correlated with the proportion of agricultural output represented by corn, rice, and chickens, and negatively associated with growing vegetables and other cash crops. Sharecropping was not negatively associated with purchased input, but was negatively associated with the practice of fallowing.

Next, Wiens and Sobrado prepared a regression to predict crop output per hectare using data on 2,922 farms. Though the regression was highly significant, again, variables indicating tenure types were not significant, except for sharecropping which was found to be negatively related. In addition, they found that sharecropping had productivity levels 72 percent of the average.

Finally, Wiens and Sobrado tried to determine the characteristics of “successful” peasants. This they defined as those who worked at least 0.3 hectares and had relatively high levels of crop productivity and household expenditures. They prepared a logistic regression to determine the probability of being successful or not. Again, the distribution of tenure types was not significantly different between the successful and unsuccessful peasants at $p \leq 0.1$. Successful peasants had no different access to their land than did unsuccessful peasants. This finding corroborated another result from the entire sample of households: farmers own (including access via purchase, divided and undivided inheritance) approximately two thirds of all land worked regardless of income level. Wiens and Sobrado concluded that tenure was not generally a constraint on technology adoption or on production and increases in income. Their findings on sharecropping were consistent with interpretation of sharecropping as a mutually advantageous practice to mitigate risks on marginal land.

Local Level Project Studies

Perhaps the majority of agricultural and natural resource management projects have focused on technology transfer and proposed a relatively short menu of technologies to peasants in contrast to broader based rural development projects.[27] Some of these projects have assessed the relationship between tenure and technology adoption.[28]

The most pertinent study was Smucker (1988) who carried out field research and summarized findings from six community studies assessing factors affecting peasant planting of project tree seedlings. He found that peasants preferred to plant on purchased and divided inheritance lands; however, they regularly planted on undivided inheritance lands and other short-term forms of tenure. In some communities with less purchased land available, the majority of trees were planted on undivided inheritance lands (Buffum 1985). In all six communities, peasants planted trees on rented and sharecropped plots in addition to owned plots. In a separate, but related survey, Conway (1986) surmised that planting trees on undivided land was a strategy to enhance individual claims to specific portions of jointly inherited land.

After reviewing the evidence from Conway (1986) and six community studies, Smucker (1988) concluded that peasants expressed a clear but far from exclusive preference for adoption on purchased and divided tenures. These findings corroborated those of a similar study assessing correlations between tenure and adoption of soil conservation methods (Pierre-Jean and Tremblay 1986). Smucker surmised that, although the tenure system as a whole was

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[27] See White and Jickling (1992) on projects offering a limited menu of technologies, and Durette, *Manuel de l'agronomie tropicale* (1991) on rural development projects.

[28] Zuvekas (1978) and Murray (1978a) reviewed the literature on tenure and found no conclusive links between tenure constraints and failure to adopt.

characterized by insecurity, this limitation was commonly overcome by personal ties and obligations, and did not prevent peasants from planting trees on a broad range of tenure types.

In the area of Les Anglais in southern Haiti, McClain et al. (1988) carried out land tenure research and tested for tree cover, tenure categories, and length of occupancy. They noted a strong correlation between length of occupancy and degree of tree cover regardless of tenure category—including trees on typically short-term tenures such as sharecropping. This remarkable finding, that tenure categories and length of occupancy were not significantly correlated, suggests that sharecropping and rental arrangements were renewed regularly and provided uninterrupted access comparable to long-term categories of tenure. The FAO/INARA study in nine different agro-ecosystems lends some support to this finding (1997).

White and Runge (1994, 1995) assessed the collective adoption of watershed management in multi-owner watersheds of Maïssade. The study asked two questions: (1) what factors were associated with individual choice to participate in the collective management activity; (2) what factors were associated with the emergence of watershed management regimes? White and Runge found no significant difference between the tenure status of participant and non-participant groups, and no significant difference in the distribution of tenure types in successful and unsuccessful watersheds. The emergence of successful watershed regimes was explained by two factors: significant economic gain from the action, and a critical mass of social capital derived from labor exchange practices and the existence of producer groups. Both conditions were necessary, and neither sufficient.

In a context where labor commonly substitutes for cash as a medium of exchange, White and Runge concluded that labor in times of need was effectively more important than cash or tenure. The need for labor and the social organization of labor diminished the potential for disputes over tenure. The authors further concluded that a preoccupation with tenure status was misplaced, and deflected attention away from social and cultural determinants of access to land. Land title or tenure type was not the key factor, but rather the degree to which individuals were incorporated in a nexus of enduring and well adapted set of personal and social relations (White and Runge 1995).

The sum of local level project evidence suggests that farmers make investment decisions based on their perception of prospects for long-term access to a plot—regardless of its tenure status, including investments that actively enhance their prospects for long-term access. This suggests that perceived stability of access to land—via stability of personal and social relationships—is a more important determinant of technology adoption than mode of access.

NEW EVIDENCE: THE PADF IMPACT STUDY

The Pan American Development Foundation (PADF) implements the Productive Land Use Systems (PLUS) project financed by USAID. This agroforestry extension project provides plant materials and technical assistance to interested farmers, and has reached 100,000 hillside farmers since 1992. In 1996, PADF carried out an impact survey of PLUS farmers that included information on land tenure and adoption of agroforestry practices (Bannister 1998a, 1998b). Survey conclusions may not characterize all Haitian farmers;

however, comparison with household data reported by Wiens and Sobrado (1998) suggests that both samples represent similar populations in terms of access to land and soil fertility.[29]

The survey collected data on all plots worked or owned by 1,540 peasant households for a total of 5,663 plots, and additional information on 2,295 plots having project-inspired agroforestry practices including site characteristics, crop yields, technician observations, and farmer perceptions of agroforestry practices adopted. The sample represented 5.6% of the 27,728 farmers who had adopted project technologies prior to January 1, 1995. The survey was repeated in the spring of 1998 with 931 farmers (1 percent of eligible farmers) and 1,658 plots.

Tenure and Plot Characteristics

Bannister tested for correlations between tenure and plot distance from the residence, area, topographic position, slope, elevation, erosion, and farmer perception of

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[29] The number of persons per household is the same (5.78 for Wiens and Sobrado, 5.6 for PADF), but other characteristics of the household are somewhat different. PADF households contained on average 54% males, with 85% of heads of household being male. The corresponding percents for the Wiens and Sobrado sample were 49% and 72%, respectively. The average percent of heads of household having six or fewer years of school was 58% for Wiens and Sobrado, but 85% for the PADF sample. The average size of the total holdings per household was 1.7 hectares for PADF, 1.78 hectares for Wiens and Sobrado. Of this total, the PADF households averaged 1.26 hectares owned (purchased plus inherited), and 0.59 hectares in good or mixed soil quality. The corresponding numbers for Wiens and Sobrado were 1.20 hectares and 0.62 hectares, respectively. Purchased plot area accounted for 37% of PADF households' total area, and 32% of the Wiens and Sobrado households' total area. The largest 1% of farms occupied 8% of the total area for PADF and 10% of the total area for Wiens and Sobrado.

soil fertility.[30] Residential garden plots were more likely to be purchased. Farmers had purchased 49 percent of residential plots, 35 percent of nearby plots, and 37 percent of distant plots.[31] Among plots visited by technicians, sharecropped plots were somewhat more distant than plots in other tenure categories.[32] Purchased plots averaged 0.53 hectares, significantly larger than divided, undivided, and sharecropped plots. This suggests that buying/selling markets have worked against the poor.[33]

The survey found no significant differences between tenure types in terms of elevation, topographic position, slope, or severity of erosion.[34] There were statistically significant differences in soil fertility (see Table 2). A higher percent of purchased plots were in the high fertility category compared to other plots, and there was no evidence of use of organic fertilzers on these plots.[35]

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[30] Tenure categories in the PADF survey included some state rentals and plots managed by caretakers for absentee landlords. These categories are not noted here, as they were not introduced in earlier discussion of the land tenure system, and are not directly pertinent to the focus of this paper.

[31] 3 by 5 cross tabulation, Pearson's chi-square, p-value .000.

[32] Kruskall-Wallis test, p-value .000.

[33] Kruskall-Wallis test, p-value .000.

[34] 3 by 8 cross tabulation, Pearson's chi-square, p-value .694.

[35] Soil fertility was described for each visited plot on a five point qualitative scale by the farmer being interviewed, one being very infertile, 5 very fertile. Responses were recoded into the three categories shown in Table 2. These categories are apparently the same as those used in the Wiens and Sobrado study. However, in the PADF study fertility information was collected only for the subset of household plots actually visited. The Wiens and Sobrado study obtained fertility information for all plots in the household, but did not compare it to tenure status.

Table 2: Percent of plots in three soil fertility classes by tenure category

	Farmer's evaluation of soil fertility			
Tenure	Low	Medium	High	No. of plots
Purchased	14	37	49	948
Divided inheritance	13	45	42	324
Undivided inheritance	19	38	43	482
Sharecropped	18	38	44	189
Rented	22	41	38	284

Notes: Pearson's chi-square p-value for the 3 by 5 cross tabulation is .001.

Tenure and the Adoption of Agroforestry Technologies

Sampled farmers had installed project technologies on 41 percent of available plots and reported significant yield increases.[36] Previous studies indicate that project soil conservation structures can significantly increase yields. Crop yields were measured by technicians in farmers' plots during a series of case studies conducted in January 1995 (Lea 1995a, 1995b). Increases of 70% in sorghum yield were noted in hedgerow gardens and increases of 60% to 120% in rock wall gardens in controlled experiments on adjoining plots.

Overall, the impact survey indicates that farmer decisions to adopt new technologies are correlated with several plot characteristics in addition to tenure. Table 3 shows the percent of project plots in each tenure category. Hedgerows, which are relatively easy to install, are the most commonly adopted technology. Undivided inheritance, sharecropped, and rented plots have higher adoption rates for hedgerows than purchased or divided inheritance. The opposite

[36] The PADF impact survey asked farmers questions regarding the differences in crop yield they attributed to the presence of soil conservation structures, but the authors do not consider these recall responses reliable. Haitian farming systems contain a large number of crops, harvest is sometimes done in stages and in small amounts, new crops are sometimes planted due to the improved microclimate created by soil conservation structures, and there was

is true for crop bands, gully plugs, trees, and top-grafting. For those technologies, the highest adoption rates are found in plots with purchased or divided inheritance plots. For rock walls, the highest adoption rates are found on rented and sharecropped plots, but the differences are not significant.[37]

Table 3: Percent of <u>project plots</u> by tenure and technology adoption, 1996 survey[a]

Tenure	Hedgerow	Crop band	Rock wall	Gully plug	Trees[b]	Top grafting	No. of plots
Purchased	54	6	29	19	55	11	948
Divided Inheritance	59	4	29	11	47	12	324
Undivided Inheritance	63	4	27	16	51	9	482
Sharecropped	68	2	32	16	23	4	189
Rented	67	3	36	16	23	4	284
P-value[c]	.000	.033	.078	.017	.000	.000	

Notes:

[a] Row percents do not sum to 100 percent because most plots had more than one project practice.

[b] Trees seedlings raised by the farmer with project assistance and planted on the plot during 1995.

[c] Pearson's chi-square significance for the 2 by 5 cross tabulation for each practice.

The 1998 survey shows adoption by tenure category for all plots controlled by participating households (see Table 4). Adoption rates are somewhat different from those of Table 3, but in general they confirm the previous findings. Table 4 shows that adoption rates for hedgerows are higher for undivided and sharecropped plots than for divided, rented, and purchased categories of tenure. Crop bands, gully plugs, and trees are more frequently adopted on purchased plots. Rented and purchased plots have the highest percent of rock walls. Top

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confusion regarding whether or not the question referred to crops in the alleys or crops grown within the structures themselves.

[37] Level of significance of 95 percent.

grafting is still found more frequently on purchased and divided plots, but the differences are not significant. Notably, percentages of soil fertility (Table 2) and soil conservation practices (Tables 3 and 4) are quite similar across different tenure types. Based on these results, an extension program would not need to target technologies towards or away from any particular tenure type.

Table 4: Percent of <u>all household plots</u> by tenure and technology adoption, 1998 survey[a]

Tenure	Hedgerow	Crop band	Rock wall	Gully plug	Trees[b]	Top grafting	No. of plots
Purchased	24	5	15	8	36	4	1382
Divided Inheritance	19	4	12	7	33	4	517
Undivided Inheritance	29	2	13	7	34	2	688
sharecropped	28	3	8	4	20	2	299
Rented	23	2	16	4	16	3	432
P-value[c]	.002	.004	.011	.044	.000	.086	

Notes:

[a] Row percents do not sum to 100% because most plots had more than one project practice

[b] Tree seedlings raised by the farmer with project assistance and planted on the plot during 1997

[c] Pearson's chi-square significance for the 2 by 5 cross tabulation for each practice

Although not a project intervention, the presence of mature trees on a plot represents an important form of technology adoption. Bannister assessed the correlation between tenure and mature trees per hectare and found significant differences: there were more trees on purchased and divided inheritance plots (Table 5).[38] These results could indicate preference for investing

[38] All trees on the plot, either planted with project assistance or otherwise, having a breast-height diameter greater than 10 cm were counted by the visiting technician.

in land with long-term over short-term tenure. They may also suggest a pattern of asserting ownership claims by planting and maintaining trees on undivided plots. A similar analysis found more mature trees per hectare on plots with higher fertility (Bannister 1998b).

Table 5: Number of adult trees per hectare by tenure category[a]

	No. of trees per hectare	No. of plots
Divided inheritance	103[a]	324
Purchased	88[a]	946
Undivided inheritance	69[b]	481
Sharecropped	61[b]	189
Rented[b]	56[b]	283

Notes: [a] Kruskall-Wallis test, p-value .000; numbers followed by the same letter are not different at the 95% level of probablity (multiple comparisons done by paired Mann-Whitney tests with Bonferroni correction).

[b] Private rental, doesn't include leasehold on state land

Correlation between technology adoption and soil fertility (Table 6) is as important as the relation between adoption and tenure status. This is perhaps to be expected since tenure status and soil fertility are also related (Table 2); however, farmer assessments of fertility also appear to integrate other productive factors not measured by laboratory analysis of soil nutrient levels.[39]

[39] PADF had soil analyses performed on a randomly selected subset of 175 plots, 35 in each of the five qualitative categories, to determine if there was a relationship between farmers' perception and amount of soil nutrients as measured in the laboratory. No such relationship was discovered. There were no statistically significant differences in soil acidity or in the levels of soil nutrients (Ca, Mg, K, P) among the levels of fertility as perceived by farmers. Nor were there statistically significant relationships between the laboratory fertility findings and farmer's qualitative perception of soil depth, degree of "heat" (on a qualitative hot/cold scale) of the soil, or the severity of erosion found in the garden.

Table 6: Percent of fertile and infertile plots with project agroforestry practices, 1996 survey[a]

Tenure	Hedgerow	Crop band	Rock wall	Gully plug	Trees	Top grafting	No. of plots
Fertile plots	54	6	33	19	48	12	1032
Infertile plots	64	3	27	15	44	7	1263
P-value[b]	.000	.007	.001	.026	.036	.000	

Notes: [a] Fertile plots are those with soils in the top two categories of the 1- to 5-point fertility scale; infertile plots are those with soils in the bottom three categories.
[b] Pearson chi-square significance for the 2 by 2 cross tabulations.

Tenure appears to influence adoption in five of six technologies surveyed. Trees and grafted fruit trees are more common on purchased and divided inheritance plots. The value of tree products increases over time, so farmers need to protect their rights to harvest. Crop bands and gully plugs are also more common on purchased or divided inheritance plots. This is likely attributable to the high value of perennial food crops in crop contour bands (pineapple, plantain, sugar cane) and the economically important crops planted in soil collected by gully plugs (plantains, taro). Hedgerows are more commonly found on plots with other modes of access. Hedgerows are relatively easy to install, so this may reflect a strategy of risk minimization when trying a new practice or fulfilling project requirements to install soil conservation measures.

Tables 3, 4, and 6 show that tenure and soil fertility are both associated with adoption in parallel fashion. Technologies (crop contour bands, gully plugs, trees, top-grafted fruit trees) more common on purchased and divided inheritance plots are also more common on fertile plots, and conversely (hedgerows). Bannister's evidence does not allow clear separation of the relative influence of tenure and fertility on adoption; therefore, it is not possible to determine which is more important in a particular decision to adopt new technology. Bannister's analysis (1998b) finds no association between tenure status and differences in management.[40] Although overall analysis of PADF data indicates that mode of access to land is an important variable, the data show no definitive relationship between tenure status and adoption.

5. CONCLUSIONS

THERE IS NO DEFINITIVE RELATIONSHIP BETWEEN TENURE AND ADOPTION BY PEASANTS

A broad range of studies on Haitian peasant agriculture and tenure find no simple and definitive relationship between tenure status and willingness to adopt agricultural technology. Levels of investment are quite similar across tenure types. Important exceptions to the general rule include the following: (1) other things being equal, peasants prefer to plant and graft trees on purchased or divided inheritance lands, and (2) peasants prefer to adopt certain soil conservation techniques—particularly hedgerows—on parcels with shorter-term tenures such as rental or sharecropping, perhaps to strengthen their claims or rights of access to that land, or perhaps to reduce the risk of adopting the new technology. Notably, these two preferences are far from exclusive and peasants frequently plant trees and establish hedgerows on all types of

[40] Technicians evaluated the management quality of hedgerows, crop contour bands, rock walls and gully plugs. Observations were made on the percent of rows well managed, percent of rows poorly managed, the number of breaches larger than 25 cm per 100 m, and whether or not the farmer repaired the breaches. The statistical tests found no significant tenure related differences in management for any of the agroforestry technologies promoted by the project.

tenure. This supports the basic contention that tenure is not the preeminent criterion for investment.

Approximately 60 percent of all agricultural parcels are purchased or divided inheritance plots (see Table 1); therefore, tenure is not a constraint for adopting technologies with long time horizons such as tree planting or grafting on the majority of parcels in Haiti. The various studies also suggest that tenure is not a constraint to agricultural intensification and soil conservation on the vast majority of parcels. However, agricultural research and extension services are available to only a small fraction of Haitian households. Despite continuously high peasant demand for agroforestry extension, Haiti's most significant effort to date reached just 25 percent of all peasant households over a ten-year period, and then ceased.[41] Peasants continued to plant trees spontaneously in the wake of this outreach program albeit on a smaller scale. The key constraint to wider adoption and continued extension services was not land tenure but funding levels and the absence of a permanent institutional base for extension.

Local-level studies suggest that certain other factors are at least as important as tenure in peasant decisions to adopt. These factors include the relative size and fertility of available plots, proximity of plots to a farmer's residence, stability of access to land, and the quality of local social capital resources (e.g., kinship and other special ties and obligations, traditional rotating labor and credit groups, grassroots peasant organizations). Where stocks of social capital are high, peasants are willing to adopt technology on short-term tenures including leasehold and sharecropping. This finding also holds for adoption of complicated watershed management regimes in degraded watersheds with multiple ownership.

The importance of these factors sheds light on the alleged preeminence of tenure as a constraint, and the fundamental importance of social capital in agricultural development. These results also suggest that development agents should give a higher priority to assessing and strengthening local social capital resources rather than updating title to land.

There is an important caveat to the finding that tenure does not generally constrain technology adoption. The research reviewed in this paper examines relations between tenure and technology adoption by peasant farmers. Therefore, findings from these studies may not hold for potential adopters who are not integrated into peasant society or influenced by traditional peasant social and cultural relations. Such cases would include the modern, capital-intensive agricultural sector and land marked by speculative values in urban areas, transportation arteries, and some lowland irrigation works. For this reason, the conclusions drawn in this paper pertain primarily to traditional, peasant smallholders.

PEASANTS ARE PREOCCUPIED MORE BY POLITICAL AND ECONOMIC INSECURITY THAN INSECURE TENURE

For most peasants in Haiti, the basic source of insecurity is poverty not tenure. The agrarian poor are preoccupied above all with protecting themselves in a broader context of

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[41] This was the Agroforestry Outreach Project (AOP) and Agroforestry II (AF II) projects funded by USAID between 1981 and 1991 and implemented by the Pan American Development Foundation and CARE (see Smucker and Timyan, 1995).

political and economic insecurity.[42] This insecurity goes far beyond land tenure and the normal risks of rain-fed agriculture on degraded sites. The pivotal constraints on peasant investment are political and economic uncertainty and the growing scarcity of productive land. Formal instruments of land registration, title, and the judicial process have high transaction costs and do not ensure land tenure security. Therefore, the peasantry's first line of defense is access to land via kinship ties and other social capital resources. The Haitian land tenure system is unlikely to evolve toward a more public, formalized system unless there is progress in solving underlying sources of insecurity, including an agricultural sector in severe crisis and the absence of credible recourse in a court of law.

In this sense, peasants are more interested in personal security than tenure security. They manage land access rights to enhance personal security. They seek security in tenure rather than tenure security. The formal system, derived from the state, is not responsive to peasant needs, nor is it credible, transparent, fair, and affordable. Peasant incentives to update title will remain weak unless more fundamental problems are addressed.

Haiti's informal land tenure system provides a modicum of social security via flexible and affordable land transfer and tenancy. The system prioritizes concerns for stability of access over particular modes of access to land. Due to impoverishment, most peasants are preoccupied with food security and risk management in a context with little margin for failure.

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[42] Political uncertainty includes but is much broader than the elections cycle or its absence. Peasant farmers have historically been excluded from the national political system, and the Haitian state has been deeply marked by a predatory character, few public services, especially in rural areas, and by very limited protection of the rights of citizens.

Peasants promote food security by strategic management of their social capital resources, including access to land.

POLICY MAKERS SHOULD PRIORITIZE RURAL SECTOR AND BROADER JUDICIAL REFORMS RATHER THAN TINKER WITH THE TENURE SYSTEM

The sum of evidence suggests that Haiti's land tenure situation is largely compatible with smallholder agricultural development. Furthermore, rural poverty and technological stagnation are due to fundamental constraints other than tenure. These constraints are driven by the paucity of investment in human and social capital and rural infrastructure, lack of investment in agricultural research and extension, deficits in capital and credit markets, lack of off-farm labor opportunities, a dysfunctional judiciary, and disenfranchisement of the rural majority.

In general, the evidence suggests that intensification and landscape wide rehabilitation will not be achieved simply by diffusing a limited range of technologies. Such technology transfer is often very useful but its impact is generally marginal—both in terms of economic and environmental impact. The evidence suggests that smallholder agriculture in Haiti has successfully intensified where fundamental constraints are alleviated and indigenous social capital has diminished peasant insecurity. Haitian peasants have long demonstrated their ability to adapt tenure maneuvers to new conditions and new opportunities.

Ultimately, formal land tenure insecurity is a subset of the generalized insecurity that peasants experience in their dealings with the legal system and the state. Land law reform is certainly needed, but premature investment in national cadaster and titling amounts to tinkering on the margins of a historically corrupt judicial system. Unless the fundamental issues are first addressed, titling programs run the risk of undermining goals of enhanced tenure security and agricultural intensification. At the very least, a viable system of justice is an essential pre-condition for land tenure security and title reform.

Investment in cadaster and titling programs is undoubtedly premature until there is clear demand for it from the peasantry, and unless titling programs are implemented directly at the local level, building on local concerns and local economic opportunities rather than the interests of powerful outsiders. Pre-conditions for such programs include local demand, access to credit and markets, and a functioning system of justice.

Titling programs could prove useful in the long run, once peasants have gained an active voice in the political system and peasant rights are better protected in the law and related formal institutions. In the meantime, in order to address rural poverty and modernize the agricultural sector, policymakers should focus on the fundamentals and the creation of an enabling environment for change.

IMPLICATIONS FOR THEORY AND FURTHER RESEARCH

Prevailing property rights theory predicts that in situations of land scarcity, tenure arrangements evolve towards more private and individuated tenures and that these forms are the most efficient. In Haiti increasing land scarcity and population pressure have coincided with private property, but these rights have remained relatively insecure, informal, and not fully individualized—a land regime characterized by legal pluralism. In this light, the attenuated status of private property rights in Haiti can be explained by the absence of a functioning state, the evolution of non-formalized resources of social capital, and the distributional concerns of peasants. Given these fundamental conditions, it appears to us that the trajectory of Haitian customary tenure remains largely efficient—and will remain efficient unless the fundamental conditions change.

Despite the growing scarcity of land, the critical issue in rural Haiti remains access to labor and social capital resources. Social capital mediates access to land. Labor substitutes for scarce cash—the most scarce of the classic factors of production. In effect, labor is the primary medium of exchange in rural Haiti, the primary currency of social relations, and the primary vehicle for personal security and survival.

This paper has addressed some aspects of Haitian land tenure but much more work remains to be done. New avenues of research and a broader diffusion of information on land and justice issues could help diffuse a tendency toward polemic and favor a more reasoned debate over agricultural policy and the requirements for legal-political reform in Haiti.

Useful lines of research might include the following: further study of rural land disputes and their disposition in Haitian courts, additional field research on the social and economic impacts of the few cadastral surveys initiated in the country, field research on informal mechanisms for regulating land disputes and on institutional alternatives to statutory mediation that build on these informal mechanisms, political analysis of the constraints to reforms in the legal system, and piloting institutional innovations that may contribute to enhancing the security of peasants in Haiti.

REFERENCES

ADS II (Agricultural Development Support II). 1988. Preliminary results of the national agricultural survey in Haiti: First Agricultural Season (February–July, 1987). University of Arkansas, Winrock International, and Haitian Ministry of Agriculture, Report #56. Port-au-Prince, Haiti: USAID. Mimeo.

APAP (Agricultural Policy Analysis Project). 1995. Haiti agribusiness assessment. Agricultural Policy Analysis Project, Phase III. Port-au-Prince, Haiti: USAID. Mimeo.

Baland, J-M. and J-P. Platteau. 1998. Division of the commons: A partial assessment of the new institutional economics and land rights. *American Journal of Agricultural Economics* 80(August): 644–650.

Balzano, A. 1986. Socioeconomic aspects of agroforestry in rural Haiti. University of Maine Agroforestry Research Component. Agroforestry Outreach Project. Port-au-Prince, Haiti: USAID. Mimeo.

Bannister, M. 1998a. Description of PADF/PLUS households and their gardens. Findings of the 1995 PADF/PLUS impact survey. PADF/PLUS Working Paper No. 1. Port-au-Prince, Haiti: Pan American Development Foundation. Mimeo.

________. 1998b. The relationship of plot characteristics to agroforestry adoption and management. Findings of the 1995 PADF/PLUS Impact Survey. PADF/PLUS Working Paper No. 2. Port-au-Prince, Haiti: Pan American Development Foundation. Mimeo.

BARA (Bureau of Applied Research in Anthropology). 1996a. A baseline study of livelihood security in Northwest Haiti. Conducted in collaboration with CARE/Haiti and the Interim Food Security Information System. Tucson: University of Arizona. Mimeo.

________. 1996b. A baseline study of livelihood security in the southern peninsula of Haiti. Conducted in collaboration with Haiti Catholic Relief Services and the Interim Food Security Information System. Tucson: University of Arizona. Mimeo.

________. 1997. A baseline study of livelihood security in the departments of the Artibonite, Center, North, Northeast and West. Conducted in collaboration with the Adventist Development and Relief Agency and the Interim Food Security Information System. Tucson: University of Arizona. Mimeo.

Barthélemy, G. 1989. *Le pays en dehors: Essai sur l'univers rural haitien*. Port-au-Prince, Haiti: Editions Henri Deschamps.

________ 1996. *Dans la splendeur d'un apres-midi d'histoire*. Port-au-Prince, Haiti: Editions Henri Deschamps.

Bastien, R. 1985. *Le paysan haitien et sa famille*. Paris: Editions Karthala.

Bertelsen, M.K., E. Dupont, and R. Swanson. 1986. Preliminary results of the Pilot agricultural survey, Departement du Sud. Report no. 15. University of Arkansas, Fayetteville/Winrock International, and the Haitian Ministry of Agriculture. Port-au-Prince, Haiti: USAID. Mimeo.

Bloch, P., G. Smucker, and R. McLain. 1988. Workshop on land tenure issues in watershed management. A report on Workshop proceedings, October 3–8, 1988, Camp-Perrin, Haiti. Madison: Land Tenure Center, University of Wisconsin-Madison. Mimeo.

Bloch, P., V. Lambert, N. Singer, and G. Smucker. 1988. Land Tenure issues in rural Haiti: Review of the evidence. LTC Research Paper 94. Madison: Land Tenure Center, University of Wisconsin-Madison. Mimeo.

Boserup, E. 1965. *The conditions of agricultural growth: The economics of agrarian change under population pressure*. London: Allen and Unwin.

Bruce, J.W. and S.E. Migot-Adholla, ed. 1994. *Searching for land tenure security in Africa*. Dubuque, IA: Kendall

Buffum, W. 1985. Three years of tree planting in a Haitian mountain village: A socioeconomic analysis. Haiti Agroforestry Outreach Project. Port-au-Prince, Haiti: Pan American Development Foundation. Mimeo.

Cadet, C. 1996. C*rise, pauperisation et marginalisation: Dans l'Haiti contemporaine*. Port-au-Prince, Haiti: UNICEF.

Cayemittes, M., A. Rival, B. Barrère, G. Lerebours, and M. Gédéon. 1995. Enquête mortalité, morbidité et utilisation des services (EMMUS-II), Haiti 1994/95. Institut Haitien de l'Enfance, Pétionville, Haiti, and Macro International Inc., Calverton. MD. Mimeo.

Conway, F. 1986. Synthesis of socioeconomic findings about participants in the USAID/Haiti Agroforestry Outreach Project. University of Maine Agroforestry Research Project. Port-au-Prince, Haiti: USAID. Mimeo.

Demsetz, H. 1967. Toward a theory of property rights. *American Economic Review* 57(May): 347–359.

Ehrlich, M., F. Conway, N. Adrien, F. LeBeau, L. Lewis, H. Lauwerysen, I. Lowenthal, Y. Mayda, P. Paryski, G. Smucker, J. Talbot, and E. Wilcox. 1985. *Haiti country environmental profile: A field study*. Port-au-Prince, Haiti: USAID.

Ewel, J. 1986. The decision-making framework for tree planting in the Agroforestry Outreach Project. Port-au-Prince, Haiti: USAID. Mimeo.

Farmer, P. 1994. *The uses of Haiti.* Monroe, ME: Common Courage Press.

Fass, S. 1988. *Political economy in Haiti: The drama of survival*. New Brunswick: Transaction Books.

FAO (Food and Agriculture Organization of the United Nations). 1991. *Agricultural technology development project: Initiating Project Brief*. 116/91 CP-HAI 21 PB. Rome.

_______ 1995. Ag*ricultural sector review and identification of projects: Sector Report, Volumes I and II*. 75/95, TCP-HAI 23. Rome.

FAO/IDB (Food and Agriculture Organization/Inter-American Development Bank). 1998. Etude socio-économique d'une aménagement hydro-agricole: Canal André aux Gonaives et d'un futur périmetre à Gilbert, près de Miregalais. Document de Travail 1. Haiti Projet d'intensification Agricole. Report No. 97/014 IDB-HAI. Port-au-Prince, Haiti: Inter-American Development Bank. Mimeo.

FAO/INARA (Food and Agriculture Organization of the United Nations/Institut National de la Reforme Agraire). 1997. Definir une politique agro-fonciere pour Haiti: Elements d'orientation. TCP-HAI-4553. Port-au-Prince, Haiti. Mimeo.

Gagnon, G. 1998. *Food security issues in Haiti: The challenges of poverty reduction*. Volume II: Technical Papers, Report No. 17242 HA. Washington, D.C.: World Bank.

Hauge, A.B. 1984. Factors in irrigation management in Haiti and the potential of water users associations. Port-au-Prince, Haiti: USAID. Mimeo.

IDB (Inter-American Development Bank). 1992. Haiti: Agricultural sector review. Port-au-Prince, Haiti. Mimeo.

James, C.L.R. 1963. *The black jacobins: Toussaint Louverture and the San Domingo revolution*. New York: Random House.

Kermel-Torres, D. and P-J. Roca. 1998. Bilan prospectif d'une agriculture de survie. In *La république haitienne: État des lieux et perspectives*, eds. G. Barthélémy and C. Girault. Paris: ADEC-Karthala.

Lea, J.D. 1995a. Revised report of rockwall case study results: Memo to CARE, PADF, and USAID. Port-au-Prince, Haiti: USAID. Mimeo.

________. 1995b. Hedgerow case study results from winter harvest 94-95: Memo to CARE, PADF, and USAID. Port-au-Prince, Haiti: USAID. Mimeo.

Leyburn, J.G. 1966. *The Haitian People.* New Haven: Yale University Press.

Locher, U. 1988. *Land distribution, land tenure and land erosion in Haiti.* Paper presented at the Twelfth Annual Conference of the Society for Caribbean Studies, July 12–14, High Leigh Conference Centre, Hoddesdon, Hertfordshire, UK.

Lundahl, M. 1979. *Peasants and poverty: A study of Haiti.* London: Croom Helm.

________ 1983. *The Haitian economy: Man, land and markets.* London: Croom Helm.

________ 1992. *Politics or markets: Essays on Haitian underdevelopment*. London: Routledge.

________ 1997. Income and land distribution in Haiti: Some remarks on available statistics. *Journal of Interamerican Studies and World Affairs* 38(2/3): 109–126.

MARNDR (Ministère de l'Agriculture, des Ressources Naturelles et du Development Rural). 1992. Reforme agraire en Haiti: Problematique et perspectives. Port-au-Prince, Haiti. Mimeo.

McLain, R.J., D.M. Stienbarger, and M.O. Sprumont. 1988. Land tenure and land use in southern Haiti: Case studies of the Les Anglais and Grande Ravine du Sud watersheds. LTC Research Paper 95. Madison: Land Tenure Center, University of Wisconsin-Madison. Mimeo.

Mintz, S.W. 1974a. *Caribbean horizons*. Chicago: Aldine Publishing Co.

________ 1974b. The rural proletariat and the problem of rural proletarian consciousness. *Journal of Peasant Studies* 1(1974).

Montalvo-Despeignes, J. 1976. *Le droit informel haitien*. Paris: Presses Universitaires de France.

Moral, P. 1961. *Le paysan Haitian: Etude sur la vie rurale en haiti*. Port-au-Prince, Haiti: Les Editions Fardin.

Murray, G. 1977. The evolution of Haitian peasant land tenure: A case study in the agrarian adaptation to population growth. Ph.D. diss., Columbia University, New York.

________ 1978a. Land tenure, land insecurity, and planned agricultural development among Haitian peasants. Report for United States Agency for International Development (USAID). Port-au-Prince, Haiti: USAID. Mimeo.

________ 1978b. Hillsides units, wage labor, and rural Haitian land tenure: A proposal for the organization of erosion control projects. Report for United States Agency for International Development (USAID). Port-au-Prince, Haiti: USAID. Mimeo.

________ 1979. Terraces, trees, and the Haitian peasant: Twenty-five years of erosion control in rural Haiti. Report for U.S. Agency for International Development (USAID). Port-au-Prince, Haiti: USAID. Mimeo.

Nathan Associates. 1995. Haiti: Analysis of legal and regulatory framework for trade and investment. Latin America and Caribbean Trade and Investment Development Project. Report for U.S. Agency for International Development (USAID). Nathan Associates. Port-au-Prince, Haiti: USAID. Mimeo.

Oriol, M. 1996. Structure foncière, réforme agraire et agro-foncière: Concepts et réalités. Le développement rural en Haiti. In *Conjonction* No. 200. Port-au-Prince, Haiti: L'Institut Français en Haiti.

_________. 1993. La mauvaise gestion des terres de l'état. In *La République Haitienne, Etat des lieux et Perspectives*, eds. G. Barthélemy et C. Girault. Paris: ADEC-KARTHALA.

Pierre, J.L. and A. Tremblay (1986). Premier bilan d'une methode d'approche de lutte antierosive sur l'amelioration des systemes de cultures en sols basaltiques (La Vallee de Jacmel, Haiti). *Recherche et Developpement Rural*, 2: 2. Port-au-Prince, Haiti.

Renaud, P. 1934. *Le régime foncier en Haiti.* Paris: Donat-Montchrestien.

SACAD (Systemes Agraires Caribeens et Alternatives de Development) and FAMV (Faculte d'Agronomie et de Medecine Veterinaire). 1993a. *Paysans, systems et crise: Travaux sur l'agraire haitien.* Tome 2, *Strategies et logiques sociales*. D. Pillot, ed. SACAD, Universite des Antilles et de la Guyane. FAMV Universite d'Etat d'Haiti, Port-au-Prince, Haiti.

________ 1993b. *Paysans, systèmes et crise: Travaux sur l'agraire Haitien*. Tome 1: *Histoire agraire et développement*, eds. A. Bory et F. Michel. SACAD, Université des Antilles et de la Guyane. FAMV Université d'Etat d'Haiti, Port-au-Prince, Haiti.

________ 1994. *Paysans, systems et crise: Travaux sur l'agraire haitien.* Tome 3, *Dynamique de l'exploitation paysanne*, eds A. Bellande et J. Paul. SACAD, Universite des Antilles et de la Guyane. FAMV Universite d'Etat d'Haiti, Port-au-Prince, Haiti.

Saint-Louis, R. 1970. *La presociologie haitienne: Haiti et sa vocation nationale (Elements d'ethno-histoire haitienne)*. Ottawa: Editions LEMEAC.

Smucker, G. 1981. Trees and charcoal in Haitian peasant economy. Port-au-Prince, Haiti: USAID. Mimeo.

________ 1983a. Peasants and development politics: A study in Haitian class and culture. Ph.D. diss., New School for Social Research, New York. Ann Arbor, MI: Text-fiche.

_________ 1983b. Supplies of credit among Haitian peasants. Development Alternatives, Inc. Washington, D.C. Mimeo.

________ 1988. Decisions and motivations in peasant tree farming: Morne-Franck and the PADF cycle of village studies. Proje Pyebwa. Port-au-Prince, Haiti: Pan American Development Foundation. Mimeo.

Smucker, G. and L. Delatour. 1979. Food Aid and the problem of labor-intensive rural development. Port-au-Prince, Haiti: USAID. Mimeo.

Smucker, G. and J.N. Smucker. 1979. HACHO and the Community Council Movement. Port-au-Prince, Haiti: USAID. Mimeo.

Smucker, G. and J. Timyan. 1995. Impact of tree planting in Haiti: 1982-1995. Haiti Productive Land Use Systems Project, South-East consortium for International Development and Auburn University. Petion-Ville, Haiti. Mimeo.

Trouillot, M-R. 1990. *Haiti: State against the nation: The origins and legacy of Duvalierism*. New York: Monthly Review Press.

USAID (United States Agency for International Development). 1985. *Haiti country environment profile: A field study*. Port-au-Prince, Haiti.

________ 1995. USAID monitoring report: August-October 1995. Port-au-Prince, Haiti: USAID. Mimeo.

_______ 1997. USAID Strategy to improve food security in Haiti. Prepared for USAID/Haiti by LAC TECH II. Port-au-Prince, Haiti: USAID. Mimeo.

Victor, J-A. 1989. *Sur la piste de la réforme agraire*. Port-au-Prince: L'Imprimeur II.

_______ 1993. La réforme agraire à l'envers. In *La République Haitienne: Etat des lieux et perspectives*, ed. G. Barthélemy and C. Girault. Paris: ADEC-Karthala.

White, T.A. and J. Jickling. 1992. *An economic and institutional analysis of soil conservation in Haiti.* Environment Department Divisional Working Paper No. 1992-33. Policy and Research Division, Environment Department. Washington, D.C.: World Bank.

White, T.A. and C.F. Runge. 1994. Common property and collective action: Lessons from cooperative watershed management in Haiti. *Economic Development and Cultural Change* 43(1): 1–41.

_______. 1995. The emergence and evolution of collective action: Lessons from watershed management in Haiti. *World Development* 23(10): 1683–1698.

Wiens, T. and C. Sobrado. 1998. Rural poverty in Haiti. In *Haiti: The challenges of poverty reduction*. Poverty Reduction and Economic Management Unit and Caribbean Country Management Unit, Latin American and the Caribbean Region. Report No. 17242 HA. Washington, D.C.: World Bank.

Woodson, D.G. 1990. Tout moun se moun men tout mounn pa menm: Micro-level sociocultural aspects of land tenure in a northern Haitian locality. Ph.D. diss., University of Chicago.

World Bank, 1991. *Haiti: Agricultural sector review*. Washington, D.C.

_______ 1998. *Haiti: The challenges of poverty reduction*. Poverty Reduction and Economic Management Unit and Caribbean Country Management Unit, Latin American and the Caribbean Region, Report No. 17242 HA. Washington, D.C.

Zuvekas C. 1978. Land tenure, income, and employment in rural Haiti: A survey. Working Document Series, Haiti. Sector Analysis Internalization Group. International Development Staff. Washington, D.C.: U.S. Department of Agriculture. Mimeo.

_______ 1979. Land tenure in Haiti and its policy implications: A survey of the literature. *Social and Economic Studies* 28(4): 1–30.

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CAPRi WORKING PAPER NO. 15

TRIBES, STATE, AND TECHNOLOGY ADOPTION IN ARID LAND MANAGEMENT, SYRIA

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IFPRI

JUNE 2001

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ABSTRACT

Arid shrub-lands in Syria and elsewhere in West Asia and North Africa are widely thought degraded. Characteristic of these areas is a preponderance of unpalatable shrubs or a lack of overall ground cover with a rise in the associated risks of soil erosion. Migrating pastoralists have been the scapegoats for this condition of the range. State steppe interventions of the last forty years have reflected this with programs to supplant customary systems with structures and institutions promoting western grazing systems and technologies. Principal amongst the latter has been shrub technology, particularly Atriplex species, for use in land rehabilitation and as a fodder reserve. This paper deconstructs state steppe policy in Syria by examining the overlap and interface of government and customary legal systems as a factor in the history of shrub technology transfer in the Syrian steppe. It is argued that the link made between signs of degradation and perceived moribund customary systems is not at all causal. Indeed, customary systems are found to be adaptive and resilient, and a strong influence on steppe management and the fate of technology transfer initiatives. Furthermore, developments in rangeland ecology raise questions about claims for grazing-induced degradation and call for a reinterpretation of recent shifts in vegetation on the Syrian steppe. Given the ineffectiveness of past state interventions, and in view of renewed understanding of customary systems and rangeland ecology, decentralization and some devolution of formal management responsibility is likely to be a viable and an attractive option for policymakers.

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TRIBES, STATE, AND TECHNOLOGY ADOPTION IN ARID LAND MANAGEMENT, SYRIA

Rae, J[1], Arab, G.[2], Nordblom, T.[3], Jani, K.[4], and Gintzburger, G.[5]

1. INTRODUCTION

Arid rangelands dominate the countries of West Asia and North Africa (WANA). Syria, at the eastern end of the Mediterranean is better endowed with arable lands than most countries in the region but still just over half its area, or 10.2 million hectares, falls below the 200mm *isohyet* and is designated as *badiah* or 'steppe' where cultivation is outlawed. In the steppe the majority of people are tribally organized and dependent on a migratory pastoral or agro-pastoral economy where mobility and natural resource management are facilitated by extensive customary systems. However, for much of this century, migratory pastoralists have been blamed for being the key instigators of land degradation. Most WANA states won their independence after World War II and pursued policies of nation building and economic growth, neither of which carved out a role for tribes or migratory pastoralism. Not only did the state generally perceive that the tribe and their mobility were divisive and unstable elements in a fledgling nation, they saw customary grazing practices as archaic, inefficient and environmentally exploitative. The tribe was seen as a political and environmental threat that if not eliminated would undermine the new state and stifle economic growth.

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[4] Steppe Directorate, Syrian Ministry for Agriculture and Agrarian Reform.
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With the assistance of the Food and Agriculture Organization (FAO) of the United Nations and other aid agencies, many WANA states sidestepped and sought to suffocate customary practices, and "green the desert" with the introduction of national rangeland management. Coming in the early years of independence for many of the WANA countries, the dominance of this paradigm had considerable influence on the direction and evolution of state institutions responsible for steppe management. This paper looks specifically at Syria and examines the impact of national policy over the past forty years on the institutions governing range management, as well as how the overlap and interface of the Syrian government and customary legal systems have shaped the history of shrub technology transfer in the Syrian steppe.

2. RANGELAND DEGRADATION: MODELS AND EMPIRICAL EVIDENCE

THEORETICAL MODELS APPLYING TO RANGELANDS

The characterization of moving tribes as creators of desert conditions has a long history among people of the settled areas in the region and further afield (Ibn Khaldun translated in Issawi 1987; Bietenholz 1963). Hardin (1968) described a rationale for this position in his influential "Tragedy of the Commons" paper. He considered the perspective of a rational herder with private ownership of livestock in a pastoral society that is reliant on pastures "open to all". Herders would follow the incentive to increase the number of their herd because they would receive direct benefit but bear only a share of the costs resulting from the delayed impact of their action. Each herder is "locked into a system that compels him to increase his herd without limit—in a world that is limited (Hardin 1968). According to tragedy theorists, effective property rights and rational rangeland management is not possible without strong state involvement. This theory has formed the rationale for state governance over rangelands and other natural resources in many developing countries.

State programs to assess, manage or increase productivity of steppe areas are also based on a model of how the steppe ecosystem functions. Predominant in rangeland management science for much of this century has been the range succession model, which derives from plant ecology (Westoby et al.1989). It assumes that the livestock sector operates in environments that are largely stable, where weather variability is limited to a narrow range and therefore inconsequential for long-term outcomes. The model supposes that a given rangeland continually returns to a single persistent state (the climax) of vegetation in the absence of grazing. By producing changes in the opposite direction, grazing pressure arising from a set stocking rate can slow or halt the successional tendency, producing an equilibrium in vegetation levels. This theory has guided the principles of the western ranching system, which were subsequently introduced in many parts of Sub-Saharan Africa and WANA to supplant customary practices. These included private rights to graze, rotational or paddock grazing systems, the establishment of water points to spread grazing pressure, the setting of a universal stocking rate, and the reseeding or re-planting of the range with grasses and shrubs.

EMPIRICAL EVIDENCE

Whereas there are widespread claims for degradation in Syria, only limited inventories and no long-term studies of the steppe flora have been carried out. Despite this, numerous references in the literature attest to the 'degraded' nature of the vegetation. A synthesis of range reports through to the mid-1950s concluded that "without exception, range management specialists and ecologists have stressed that the range grazing of the steppe and semi desert regions of Syria—is progressively deteriorating as a result of overgrazing" (FAO 1956). A 1985 study of the Syrian rangelands by the Arab Center for the Studies of Arid Zones and Dry lands (ACSAD 1992) suggested that unpalatable shrub species have become "dominant in large areas of the steppe". It went on to estimate that 25% of the steppe is affected by wind erosion to one degree or another, while water erosion affects around 6% of the area. Furthermore, almost all relevant publications issued from the International Center for Agricultural Research in the Dry Areas (ICARDA), which is based in Aleppo, are premised on the assumption of widespread degradation in the Syrian steppe (Rae 1999). Yet, evidence exists to the contrary.

An unpalatable shrub associated with a degraded steppe in Syria and neighboring regions is the spiny Noaea mucronata. An ecological study carried out by Deiri (1990) under the auspices of ICARDA, found Noaea ubiquitous in the Aleppo steppe, masking the heterogeneity of climate and soil. Apparently, dominance of Noaea in some areas is a relatively new phenomenon here (Sankary 1982) and elsewhere (Zakirov 1989; Noy-Mier 1990). Deiri and others have assumed that this shift in floral composition is the result of overgrazing for lack of good management, and that with a reduction in grazing pressure a climax community dominated by the palatable shrub Salsola vermiculata would return (Deiri 1990; Sankary 1982). However, the link between cause and effect is not adequately demonstrated.

Indeed, the basis of an alternative interpretation comes from grazing trials carried out by the FAO and the Steppe Directorate in the 1960s at Wadi al-`Azib research station in the Aleppo steppe. Over a three-year period, three sites were fenced off with a different stocking rate in each (trial A: 9ha per sheep, B: 6ha, and C: 4.5ha). No sizeable differences in average meat production per animal were reported between the three treatments. As for the vegetation, it was noted that plant density "fluctuated more between years than between stocking rate treatments" (FAO 1966), suggesting climate more than grazing determines productivity. The reported vegetation change was, however, unexpected. Spininess in plants is usually interpreted as an anti-grazing adaptation, and it has often been recorded that spiny plants increase under heavy grazing but give way once protected (Noy-Mier 1990). In treatment C, with the highest stocking rate there was a "reduction" in the spiny variety Noaea while in treatment A, with the lowest stocking rate, Noaea "increased greatly in density" (FAO 1966, 1967). The cause of this vegetation change is not alluded to by either of the reports at hand; Noaea is just described as "a spiny, undesirable shrub".

An explanation for the expansion of Noaea under reduced grazing pressure is given by another study in the Negev and Jerusalem deserts (Noy-Mier 1990). During certain periods on the open range, Noaea are exposed to heavy pressure from herbivores selecting for the rare green material. Even though spines and other types of protection save the plants from local extinction, Noy-Mier asserted they are insufficient to outweigh grazing pressure and are therefore among the first plants to benefit when an area is protected.

The crucial difference between Noaea mucronata and other shrubs is its extended growing period. Heavy grazing either end of the green season disadvantages Noaea, but when such grazing pressure is relieved the extended growing period becomes an advantage. When camels are removed from the near steppe, the pressure in late spring and summer is largely removed. Also, whereas as recently as thirty years ago almost all herders wintering (November-February) on the near steppe sustained their flocks entirely from grazing[6], today almost none do. Instead they feed their sheep on hand-feed generally imported from the settled areas[7]. Thus, rather than being due to overgrazing, the shift to Noaea mucronata is a result of changes in the composition of livestock grazing the steppe coupled with the adoption and widespread use of hand feed for winter—something encouraged by the state following the 1958-61 drought (Lewis 1987).

Conclusions like this bring into question the validity of the range succession model in arid environments. Whereas the model predicts that rainfall cycles combined with sustained grazing pressure will keep range vegetation in equilibrium, it is now thought that where droughts or other episodic events are a feature, population fluctuations hinder plants and herbivores from establishing closely linked interactions, and succession is abbreviated or non-existent (Behnke et al. 1993; Scoones 1994). This realization that equilibrium conditions are not met in many instances has led to the development of an alternative paradigm centered around two models: the non-equilibrium model, which deals with population dynamics in uncertain environments; and the state-and-transition model (Westoby, Walker and Noy-Mier 1989). In contrast to the linear succession model, it is argued that rangeland dynamics can be more accurately described by a set of discrete states of vegetation with discrete transitions between them, triggered by natural events, like floods, drought or fire, either alone or in combination with herbivore activity.

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[6] Van de Veen estimates that 58% of the Syrian sheep population, or 3.8 million head, resided in the steppe for winter grazing only shrubs, amongst them Noaea mucronata and Haloxylon articulatum (FAO 1967).
[7] In an in-depth two-year study on animal diets of 129 herds frequenting the Aleppo steppe 98% of feed needs came from hand-feeding, the remainder from crop residues. No steppe grazing was reported during the winter months (Wachholtz 1996). Perversely, pressure is relieved on the steppe to the advantage of Noaea.

Objectively apportioning responsibility for perceived or actual changes in steppe vegetation composition is therefore difficult. Grazing inevitably has an impact on shrub communities, but the nature of this impact is unclear, particularly when causes arise from a conjunction of other factors in addition to grazing. Indeed, some speculate that the landscape may in some sense be 'adapted' to grazing pressure. That is, either less resistant shrub species have been eliminated long ago or the species in these communities have adapted to grazing pressure. There is even some evidence to suggest that a certain amount of grazing pressure on arid rangelands maintains or even enhances floral species diversity (Olsvig-Whittaker et al. 1993; Perevolotsky 1995). In the case of the transition to Noaea mucronata, it seems likely that this was actually brought about by a reduction in grazing during critical times of the year.

Despite the lack of a clear consensus on the best model for predicting the extent and causes of rangeland degradation, the Syrian government, aided by international research and development institutions, has undertaken several measures to bring about a change in rangeland management for the stated purpose of improving environmental outcomes. Actions have reflected a persistent adherence to 'tragedy of the commons' and rangeland succession models. They span from centralizing the governance and enforcement of rangeland management to introducing new technologies designed to enhance the quantity and quality of rangeland vegetation. The following section will discuss shrub and plantation technologies that have been developed, extended, and often imposed on herders occupying the Syrian steppe. Despite more than 50 years of technological efforts, however, technology uptake has lagged far behind expectations. Subsequent sections elaborate on the institutional changes preceding and accompanying technical solutions that demonstrate the important role played by customary institutions in steppe management and shed light on the underlying reasons for the lack of adoption success.

3. PERFORMANCE OF TECHNOLOGIES AIMED AT IMPROVING RANGELAND CONDITIONS

ATRIPLEX SHRUB TECHNOLOGY

From its creation in 1961, the Steppe Directorate (SD) of the Syrian government was given responsibility for range management, range and pasture research, management and expansion of government wells, and organization of emergency feed during times of drought. With the assistance of the FAO, the SD embarked on a highly centralized range management initiative, setting the tenor for all future interventions. Part of this initiative included trials to identify rain-use efficient, edible plants to re-vegetate the steppe and act as a drought feed store. This was deemed necessary, for though the successional model predicted natural regeneration towards a climax community, climatic variability and the unpredictable recurrence of devastating droughts meant that natural regeneration could be a long time coming. Shrub planting would fill this temporal gap, check soil erosion and provide a source of animal feed during drought. The trials concluded in the late 1960s recommending Atriplex, a shrub species already favored by range managers elsewhere around the world, most notably Australia, South Africa and the United States (Houerou 1995).

Le Houerou, one of the most influential people involved in rangeland management and rehabilitation in the WANA region over the last thirty years, describes the planting of Atriplex species as "one of the most efficient ways to reclaim [arid lands], if not the only one" (Le Houerou 1992). The shrubs can prevent wind and water erosion and are efficient users of water (McKell 1975). They could also serve as a feed reserve in years of drought. There are around 400 species of Atriplex in the world, most in mid-latitude temperate, sub-tropical and Mediterranean zones. Though many Atriplex species exist in the Mediterranean region, their use in arid land stabilization and rehabilitation began with the introduction of the Australian variety Atriplex nummularia into Tunisia in the last years of the 19th century (McKell 1975). The introduction of this and other varieties from Australia continued after World War I in Tunisia and Morocco. By the 1950s, Atriplex was being recommended for steppe rehabilitation in FAO circles, and from the 1960s introductions took place throughout the WANA region and further afield. Although many trials of non-indigenous species showed limited promise, Omar Draz, FAO's chief advisor to the Syrian government on rangeland issues, conducted trials in 1968-69 with Atriplex nummularia that produced successful outcomes in an agricultural district of Aleppo (FAO 1974).

With the support of Draz and a wider scientific consensus for the technology, the Syrian authorities initiated programs to transfer Atriplex on the steppe. History of this intervention in Syria can conveniently be divided into two phases: 1) encouraging and later obliging agro-pastoralists to plant a part of their area with Atriplex; and then 2) the establishment of government-run fodder shrub plantations from 1987. The first phase envisaged that agro-pastoralists would forego barley cultivation over a portion of their licensed steppe area and plant Atriplex in its place. In hindsight poor adoption rates for Atriplex were a foregone conclusion. Barley is nutritious and palatable, while post-harvest stubble can be used for grazing. During drought, it can be grazed in-situ. By contrast, it can take between three and five months for sheep grazing Atriplex to get used to consuming and digesting it. Oxalates in the plant are potentially toxic to some ruminant microorganisms and can form stones in the urinary tract (Goodchild & Osman 1993). Furthermore, to compensate for the high salt content of the plant, the animal must drink between 6 and 12 liters of water day (depending on the heat of the day), twice the normal levels (Le Houerou 1992; Nordblom et al. 1995). Nor does Atriplex fit comfortably in the bedouin farming system. The "proper" time to harvest most Atriplex used in Syria is late summer and early autumn, a period when most sheep are grazing nutritious cotton residues in the settled areas (Wachholtz 1996). Not surprisingly, only a fraction of those cultivating in the steppe actually planted Atriplex, and of those all but a handful ensured their private plantation survived, the others—with the shrubs gone—again cultivated barley (Leybourne et al. 1993).

THE PLANTATION APPROACH

The poor success of government initiatives to encourage or require private adoption of range technology led directly to the 'plantation concept'. Here, the government effectively privatizes an area of steppe with a trench, plants the enclosure with shrubs, and after a period of establishment permits range users restricted access under contract and on payment of a grazing fee. The idea is not unique to Syria. In the last two decades, 470,000 ha have been taken for plantations in Tunisia, 133,000 ha in Iran, 33,000 ha in Algeria, and there are many others (World Bank 1995). In Syria, the plantations have been at the heart of state intervention in the steppe since the late 1980s and by 2000 occupied 220,000 ha.

The plantation concept came after a generation of frustrated state intervention in rangeland management and technology transfer. It represented a significant step against the tide of devolution in natural resource management elsewhere, and instead advocated centralization as a solution for sustainable development in arid regions. The actual presence on the steppe of the plantations, coupled with the fact the state had tilled and planted the land (i.e. invested), brought the formal legal system and state authorities into direct conflict with the customary land tenure system like never before.

Plantations are supposedly located where Steppe Directorate (SD) officials judge the steppe to be degraded. Only private steppe land (approximately 2%) cannot be included within a plantation; otherwise all other land (including cultivated fields and co-operative pastures) is technically state land, and can therefore be appropriated, despite the fact that customary institutions have governed land tenure for centuries. Once the site and size are determined, a committee is appointed within the Ministry of Agricultural and Agrarian Reform (MAAR), to produce a technical and economic feasibility study for the proposed plantation[8]. Socio-economic or environmental impact assessments are not regularly carried out. If the committee gives the go ahead, MAAR provides financial support for plantation establishment.

After a period of shrub establishment, averaging five years, the plantations are opened under contract for use during restricted periods, generally a couple months each in the winter and spring. Enforcement of plantation rules is the prime responsibility of the Steppe Directorate but the rules themselves are decided on at the provincial level by

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[8] The committee is composed of an agricultural economist, a geologist, and representatives from the provincial departments of the MAAR and the Steppe Directorate.

the Agricultural Council[9] and hence vary. However, the following rules are broadly applicable. The carrying capacity of all the plantations was set at three head-of-sheep per hectare in 1995, and has not changed since. In line with the succession model of plant ecology, if the SD officials feel that grazing is insufficient in a particular season, access to the plantations is delayed, truncated, or denied completely. Firewood collection camping, milking and watering are prohibited in the plantations during leasing. A deposit on the contract is also required in some provinces, including Aleppo, and where this is the case each contract is clearly designated an allotted area. The cost to a herder for a spring contract is harmonized across the country, at 125 Syrian Lira (SL) ($2.25) per hectare per month.

On the frontline of plantation rule enforcement are year-round resident guards. Those caught trespassing in Aleppo province are fined 5,000 SL, the equivalent of around $100 or the price of a two-year old ewe. The official number of trespassers prosecuted in the country since the plantations were first opened in 1995 is estimated around a thousand, the vast majority of them reportedly at two plantations in the Aleppo steppe[10].

[9] The Agricultural Council is chaired by the provincial governor and includes provincial heads for Agriculture, Finance, the Ba`th Party, and the Peasants' Union.
[10] Conversation with staff at Steppe Directorate Head Quarters, Palmyra: 4th July 1999

TECHNOLOGICAL OUTCOMES, RANGELAND MANAGEMENT AND INSTITUTIONS

Syrian authorities have sought to transfer shrub technology to the steppe through a variety of institutional arrangements, all of which have discounted customary land tenure and property rights. The underlying premise for the state approach is rooted in the 'tragedy of the commons' model of pastoral society, which hinges on the assumption of non co-operating herders and eventual degradation.

While many researchers and rangeland scientists implicate government policy itself for the decline of customary systems, a pervasive perception is that the system is unable to adapt to changing socio-economic conditions (FAO 1967; World Bank 1995; Ngaido 1997).

Customary systems in Syria, as elsewhere, have been perceived as being unable to regulate pasture use in the face of pressures from increasing human and animal populations, and a diminishing range area. Some have felt that the organizational and institutional basis on which the customary system relies is in a process of irreversible decline as an inevitable consequence of modernization (UN 1955; Abu Jaber 1966). That is, tribes weaken as they become superfluous in the presence of a maturing and ubiquitous judiciary and civil administration system.

Research on customary control and access systems in Syria is noticeable for its absence. The tribes have been identified as the cause of degradation by a process of deductive reasoning from ecology and political science theories, and re-enforced by ambivalent attitudes held by policymakers towards migratory groups. Herders' resistance to adoption of technologies and institutions imposed by government authorities is not well understood, and often attributed to irrational behavior. However, a more accurate understanding of the institutions governing rangeland management and the incentives underlying adoption behavior necessitates a detailed appreciation of the customary system, state centralization, capitalist penetration and the evolution of these institutions in Syria during the 20th century.

4. PROPERTY RIGHTS IN SYRIA: AN HISTORICAL OVERVIEW

Modern-day Syria is a relatively new phenomenon. It was originally carved out of two Ottoman Provinces after World War I and placed under French Mandatory rule before the country won its independence in 1944. A judicial-political division, called the 'steppe line', was inherited by the French and subsequently by the nationalists. It was first defined in state law in 1870 by a centralizing Ottoman government wanting to encapsulate and subject the moving camel and sheep rearing tribes of the desert interior. Within the steppe line, the state recognized the authority of customary law and courts in regulating the activities of tribal society, including land tenure issues. What amounted to a "state within a state" remained ostensibly unchanged following independence, but it was an obvious anathema to a fledgling nation, and within fourteen years customary law and tribes were formally abolished, and the steppe areas nationalized. This was of historic importance for it was the last legislation to deal specifically with the tribes and marked the final act in the long struggle by central governments to eliminate the tribes and *shaykhs* as rivals to their own power and jurisdiction.

Key to understanding property rights in Syria is the concept of legal pluralism. For a long time the formal legal system of the state, the *qanun*, co-existed with tribal customary law, *`urf*. Whereas the *qanun* is by definition written, the `urf is largely unwritten. Often the *qanun* has confirmed existing local custom, as custom is recognized as one of the sources of Islamic law, *shari`a*, itself a pillar of the *qanun* (Heyd 1973). The moving tribes were rarely subject to *qanun* prior to 1958. Amongst them customary law prevailed in all matters including marriage, divorce, homicide and property rights. These tribal legal institutions have been described as "remarkable for their sophistication, and a central feature of the culture" (Stewart 1995).

The question of property rights in the steppe area was not of much concern to the authorities prior to the 1940s. Historically, the government's principal interest in rural property rights has been in regulating and taxing cultivation. The authority of the state has broadly correlated with the extent of cultivation, and both have waxed and waned at various times in history. Cultivation's most recent expansion began in the 1840s with impetus from world trade and later a growing domestic human population. For a century this expansion was mostly accommodated within the steppe line, particularly south of Aleppo City and the Euphrates River. Rising international and local demands were also encouraging expansion of sheep numbers in the steppe. These two forces of expanding cultivation and growing sheep numbers converged along the margins of the steppe in the early 1940s, raising land scarcity and precipitating dramatic developments in both the statutory and customary land tenure systems.

THE STATUTORY TENURE SYSTEM

In Islamic law and prevalent in Syria until the 1950s, the uncultivated steppe was categorized *mawat*, or dead land. On *mawat* land no taxes were claimed by the state and all persons could "cut for fuel and for building—or collect herbage—without anyone being able to prevent him" (Ottoman Land Code 1858). As for cultivation, Sunni jurists considered vivification of *mawat* land as desirable and an activity that should be encouraged (Maktari 1971), although the state retained the right to demand consent prior to cultivation in lieu of a fee. This said, such consent was largely academic in the steppe prior to state expansion in the late 19th century and was never fully enforced thereafter. Prescriptive rights and the ancient category of *mawat* were eventually abolished in the first years of independence (1952), and all such land was re-classed as state land (*amlak dawlah*). *Mawat* was seen as a legitimization of open access and the destructive habits that this in principal engenders amongst resource users.

Nationalization not only underscored the authority of the state to regulate land use but also provided the state a tool with which to further reduce tribal power. The law, however, failed to make a material impact until 1958 when the sway of customary law among the tribes was officially abolished and a government more bent on state-led steppe development, the Socialist Ba`th Party, came to power in 1963. They originally espoused "pragmatism and evolutionism within the national framework" (Abu Jaber 1966) and advocated the dispersal and sedentarization of moving tribes in order that individual loyalty could be redirected toward national goals. The Ba'thist constitution states:

> Nomadism is a primitive social state. It decreases the national output and makes an important part of the nation a paralyzed member and an obstacle to its development and progress. The party struggles for the sedentarization of nomads by the grants of land to them [and] for the abolition of tribal custom (Art.43)

The abolition of tribal rights coincided with the start of a severe drought (1958-1961) that destroyed herds on an unprecedented scale. According to official estimates, 80% of the camel population was killed while the sheep population dropped from 6 million in 1957 to 3.5 million in 1961 (FAO 1967). The single most important government response to the drought was the establishment of the Steppe Directorate within the MAAR to take on range management and alleviate the impact of future droughts. With virgin cultivable land in the country now thought to be exhausted, considerable state resources were redirected to steppe management and animal husbandry in the hopes of stabilizing and expanding meat production. FAO had charged that over-grazing, absence of grazing control mechanisms, expansion of cultivation, and the uprooting of shrubs had together "resulted in the grazing capacity of the steppe being seriously depleted" (FAO 1973). These factors, along with the current breeding system and the region's susceptibility to drought, were implicated in adversely affecting the nation's terms of trade and balance of payments, since livestock meat and grains tended to be exported at low prices and imported at high prices.

With the guiding principles of import substitution and food security through self-sufficiency, the authorities devised a four-point plan for steppe development with assistance from the FAO, the impact of which continues to be felt today. It proposed to regenerate the steppe through controlled grazing, increase local production of forage, create feed supplies to meet emergencies caused by drought, and improve sheep fattening. Their target was 11 million sheep by 1985, which would contribute to a desired increase in per capita meat consumption and at the same time continue the valuable export trade for which there was a large demand in neighboring countries (FAO 1967). To fulfill these ambitious objectives, the Steppe Directorate initiated research in shrub technology for range rehabilitation and initiated in 1968 a rotational grazing scheme within a co-operative model termed Hema to supplant the tribal system. Showing little resemblance to a perceived indigenous mechanism of controlled grazing that inspired it, the stringency of Hema cooperative rules, the corruption of cooperative structures for political ends, and the government's inability to supply credible grazing management institutions and structures undermined the cooperative approach.

THE CUSTOMARY TENURE SYSTEM

The prevailing assumption of the inadequacy of the tribal system to manage steppe resources supposedly stems from the failure of the tribes to either evolve their institutions to adapt to changing socio-economic conditions or to resist suppression by a nationalist state. Evidence uncovered from examining the case of tribes and land tenure in the northern region of the Syrian steppe reveals an alternative history for the customary system. Indeed, there is clear indication of an evolving, resilient customary system here, one that has not only endured repression by the state but has obliged government authorities to resume a positive and active role in its institutions.

All Arab tribal individuals belong to a particular tribe, which imparts an authenticity of descent and a quality of honor that sets them apart from non-tribal society (Dresch 1993; Hourani 1991). Individual families form larger groups, called *`quam* (*sing. qom*), the fundamental organizing units within a tribe. A collection of `quam forms a maximal lineage or clan, called *fakhdh*. Families within a clan rely on group collective action and commonly hold water and pastures together (Wilkinson 1983). Generally, a council of elders guides the clan, and in many instances there is a well-respected individual amongst them, a *mukhtar* or *wajih*, who can speak for the group as a whole. A tribe is much larger, often comprising several villages or herding groups. Common to many tribes and clans is the ethno-political ideology of patrilineal descent or shared ancestry. The language of common descent does not necessarily reflect fact but is better understood as a metaphor for signifying notions of closeness (LaBianca 1990). In the wider region, most tribes also have had long histories of a specific territorial identity[11].

Tribal society has a wealth of social capital: the social relations and norms embedded in the structures of their society that regulate interactions. Things do change over time, but given that individuals involved in any of these social structures will engage in repeated interactions, each relationship is guided by expectations of predictable behavior, leading to trust and reciprocity. Such trust underpins the customary land tenure system and its flexibility. The fact that the state has had to take overt actions to break up customary systems and as yet remains unable to do away with them attests to the strength and utility of these social capital networks.

A group associated with a territory holds the exclusive right to invest in land, such as digging a well, building a house, or cultivating a field. They also hold the right to graze and exclude others, but given the nature of an arid environment and the size of any one territory, herders inevitably need to maintain flexible, reciprocal arrangements with other groups to maintain mobility. Hence, social capital is a critical ingredient upholding such arrangements and assuring mutual compliance. Events that transpired at the turn of the 20th century in the Aleppo steppe illustrate the important role played by such adaptive customary institutions in the face of resource competition.

Before the arrival of trucks, the broad region in which a tribe migrated throughout the year was (and sometimes still is) known as the *dirah*. It represented a functional area of habitual use composed of water holes and associated pastures to which the group held rights. In drought years when parts or all of a *dirah* were affected, families, groups or

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[11] In Sinai, Stewart (1986); In Yemen, Dresch (1993); Hourani (1991).

larger parts of a tribe sought water and pastures through social networks in the *dirah* of other tribes.

At the turn of the 20th century the Aleppo steppe was dominated by two neighboring sheep herding tribes, the Hadidiyin and the Mawali, and a powerful camel-herding tribe called the Sba`ah. The size of the *dirah* depended on the herding animal, with camels-herders having substantially larger *dirah* and venturing deeper into the desert then their brethren, the sheep and goat herders. These latter herders were restricted by the water dependency of their animals to the desert fringes where water sources were more frequent and plentiful. The Sba`ah spent their winter and early spring around wells of Wadi Hauran and its environs in modern-day western Iraq, 500 km southeast of the Aleppo steppe line. In spring the Sba`ah migrated to the Aleppo steppe were they stayed the summer occupying water points and pastures just vacated by the sheep herding tribes, the Hadidiyin and the Mawali. There, they traded with the settled areas, and grazed their animals on steppe shrubs largely unpalatable to sheep. This complementary and non-exclusive use of water and pastures between the sheep and camel rearing tribes has an ancient history in the region, with rights to waters and pastures in the near steppe and the time windows on seasonal movement acknowledged in a written tribal treaty signed in the last years of the Ottoman Empire (1907-1918) (Zakrya 1947).

This agreement lasted until the 1940s. In the meantime, cultivation in Syria trebled to 2.1 million ha, sheep numbers also trebled to 3.4 million head, while camels started to give way to tractors and trucks (Issawi 1951; Widmer 1936). Sba`ah households were adapting to the changing demands in the market place. Whereas they owned no sheep in 1920 they reportedly held some 80,000 ten years later (H.C.R.F.

1930). As all three tribes now had sheep in large numbers but still broadly lacked the ability to truck water, conflict arose between Sba`ah and the old sheep herding tribes over water and pastures in the near steppe during winter and spring months.

Together with an expansion of agriculture, the rising sheep numbers demanded changes in the customary land tenure system, at least in the near steppe. Of immediate concern to the Hadidiyin, the Mawali and the Sba`ah, was an untangling of their overlapping *dirah* in the near steppe and the establishment of discrete tribal territories as a basis for access rights to natural resources. Once this was achieved, investment either in water or agriculture could be undertaken without risk of inter-tribal disputes. To facilitate this shift, the disputing tribes sought an agreement through customary channels and under the auspices of the state. By far the most important of such agreements was the Damascus tribal treaty of 1956, which divided over 500,000 ha of the Aleppo steppe among the three tribes, although pre-existing claims to water and pasture were kept intact. The political process used in this treaty, and other similar ones before and after it, was based on tribal custom.

In 1958, when the role of customary law and structures was formerly abolished in Syria, the Damascus treaty and others like it were automatically annulled. The authorities assumed full responsibility for rangeland management, placing it with the Steppe Directorate from 1961. Nevertheless, customary institutions continued to exert authority over rangeland management and tribal control. Documented evidence, such as that described below, shows that substantial cooperation to regulate control and access to steppe resources persisted among herders from different tribes, despite the hostile political environment, including a significant level of tribal corporate activity in protecting rights.

In 1958, large numbers of the Sba`ah left Syria for Saudi Arabia following the abolition of tribal rights. With most of Sba`ah gone, Ghanatsah (a faction of the Hadidiyin) took the opportunity to reoccupy and claim for themselves a portion of the treaty lands called Abu al Naytel and Dayl`. They went unchallenged for more than a decade, but in 1974 Muharrab al-Rakan, a son of the supreme shaykh of Sba`ah, "and the members of Sba`ah represented by him," (SAR 1975) returned to Syria and immediately laid a claim on the Abu al-Naytel well and the lands of Dayl`.

Ghanatsah took the matter to the state authorities. The head (*mudir*) of the Palmyra administrative district carried out preliminary consultations with the disputing tribes and visited the questioned site. The "final meeting" (SAR 1975) to resolve the problem was convened on the 10th of February 1975. The decision went in favor of Ghanatsah and the old mutual border from the 1956 treaty was adjusted to the new agreement. The legal precedent for the decision was adverse possession, i.e. undisputed occupation of property for a given period of time becomes the property of the occupant.

Six years later, the situation flared up again when Muharrab attempted again to extend his area of control by cultivating his shared border with Ghanatsah in an area referred to as the "airport". This was land Ghanatsah believed was theirs. Another round of resolution talks was held. The settlement reached went again in favor of Ghanatsah. Muharrab was allowed to reap his crop "as he had ploughed and planted it" but afterwards the land would revert to Ghanatsah.

This agreement, like many others[12], was extraordinary considering the Ba`thist constitution and ideology. The decision had been reached with the full participation of the state authorities. As far as the written law was concerned the disputed land was state land and, since it was not part of a cooperative, was technically open to all Syrian citizens and their livestock. The *shaykhs'* intermediary roles were formally terminated in 1958, but two decades later little had changed in practice. Indeed, customary institutions remain the principal mechanism regulating access to steppe resources on a day-to-day basis, while the state continues to implicitly recognize and endorse tribal customary rights and practices, with high officials and Party cadres guaranteeing agreements and signing documents in the name of the state. It is important to note, however, that the Steppe Directorate of the Ministry of Agriculture, with statuary responsibility for steppe resource management, was not involved in this particular agreement. It was seen instead as a political not a land management problem per se.

CONFLICTS BETWEEN STATUTORY AND CUSTOMARY TENURE ON THE PLANTATIONS

That violations of plantation rules of access are a particular problem in Aleppo is at least partially explained by the overlap of tribal territories. Both plantations discussed below form a group of four located on lands held by the Abraz clan of the Hadidiyin.

[12] Additional post-1958 documented territorial treaties have come to light. The dates of these agreements include 1962, 1983, 1989, and 1992.

A guard at one of these plantation suggested he had turned over for prosecution no less than 200 Abraz herders in five years in addition to the "many others caught but not charged" (Conversation with the guard: Maraghah, Syria, 21st June 1999). Faysal, the shaykh of Abraz, puts the number of Abraz prosecuted as a whole at 370. Evidence from official communications on a proposed fifth plantation in the Abraz area strongly suggests that appropriation of land for the plantations was causing serious pasture shortages for the clan. Upon hearing of the proposed plantation in early 1995, Faysal wrote to the Aleppo Governor:

> Once these lands are annexed and the said plantation is established ... we would no longer have lands for our sheep to graze. We were moved from `Ein al-Zarqah and Maraghah where two plantations were established. To the north of us is the al-Haib tribe—with whom we have a bloody dispute—[and consequently] we are not welcome on their pasture. Moreover, the establishment of the plantation would cause hundreds of herders to move away, many of whom have houses in the area.[13]

As a result, the proposed plantation was abandoned, although the reason given was that the site was in fact "one of the good sites in our steppe in terms of plant cover." This episode demonstrates that past decisions for plantation location failed to assess the implications of customary land tenure and the inevitable impact this would have on the household economy of local range uses.

It is an unwritten rule within the Steppe Directorate that first refusal on plantation leases goes to local herders and clans, despite formal claims that the steppe and the plantations are open to all. Problems of who can have access to a plantation do not generally arise when the site is located entirely within a particular clan territory.

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[13] Letter to H.E. The Governor of Aleppo from Faysal al-Nuri and companions on behalf of the Abraz tribe: 13.2.1995.

However, when the plantation border cuts across tribal territories, or unwelcome groups from far afield attempt to purchase a lease on a local plantation, then the incongruence of tenure systems can result in some very serious problems. Of the four plantations under study by ICARDA in 1996, two plantations fell wholly within clan territories but the other two did not. In the latter, disputes over access between neighboring groups resulted in considerable difficulties for the authorities.

Such was the case when two clans, Bu Hasan and Jimlan (both of the Hadidiyin), attempted to gain access to the plantation and establish de facto possession of land originally held by three tribal territories: the Bu Salah of Abraz, the Twimat of Ghanatsah, and the Ma`atah, all three of which are also part of the Hadidiyin. In the previous two leasing seasons, the plantation had been leased predominately by the Bu Salah, Abraz, which had also secured the vast majority of leases for that season. The only other group to have grazed the plantation in previous seasons, and who were there again in 1996, was that led by members of Bu Kurdy (Ghanatsah) who neighbored the reserve to the north. When Bu Hasan and Jimlan also lodged requests for licenses, all applications were approved. Both Bu Kurdy and Bu Salah, however, felt that Jimlan and Bu Hasan had no right to any leases on the plantation, as their tribal grazing grounds at Hrabjah were unaffected by the plantation. They took their grievance to the plantation guard who cancelled Jimlan's and Bu Hasan's leases on the spot.

Aggrieved, Jimlan and Bu Hasan took their protest to the authorities, reiterating the formal position that any Syrian could legally take out a lease. The Hama Governor went with the heads of the provincial Steppe Directorate and Peasants' Union[14] office to Abu al-Fayad to settle the dispute. The resolution went in Jimlan's and Bu Hasan's favor. The authorities hired a local tractor and ploughed a boundary line within the plantation to separate the disputing parties. As compensation, Bu Salah and Bu Kurdy were released from all plantation rules: firewood could henceforth be collected, sheep numbers would be unregulated, and camping, watering and milking could take place in the plantation. The Head of the Steppe Directorate protested strongly against the decision but was ultimately unsuccessful in changing it. Within a few days, instead of the 22,000 sheep paid for by the Bu Salah and the Bu Kurdy groups there were now 40,000 in the plantation. The plantation was shut down after three weeks.

5. CONCLUSIONS AND POLICY IMPLICATIONS

The above discussion demonstrates the value of customary institutions supportive of herder mobility, reciprocal arrangements with respect to resource use, and inter-tribal conflict resolution mechanisms when it comes to rangeland management. Contrary to popular belief that they have broken down and disappeared, many customary institutions in Syria remain strong and continue to be influential in the property rights domain. Their inherent flexibility means they are usually better suited to the prevailing non-equilibrium environment of the Syrian rangelands when compared to the rigid statutory laws and inappropriate technologies imposed by the state. Imposition of technologies will not succeed unless tribal land tenure and institutions are taken into account. Customary institutions represent a superior foundation for an integrated and inclusionary resource

[14] The Peasants' Union is an arm of the ruling Ba'th Party and took control of co-operatives from the MAAR in 1974.

management system. The continuing existence of these institutions contradicts Hardin's assumption of the inability of resource users to coordinate their actions to avert over-exploitation. It is not possible to prove that these customary methods are environmentally sustainable since ecological studies based on the new paradigms in the field have yet to be conducted. But what these institutions do represent are the foundations of a sustainable system by reducing transaction costs and affording local legitimacy.

Past policies centralizing rangeland management were founded on misplaced assumptions about the physical dynamics of the steppe environment as well as the capacity of herders to cooperate together and regulate their use of pastoral resources. Shrub technologies like Atriplex have proven ill-suited to livestock as well as incompatible with herders' socioeconomic realities. Plantations likewise conflict with mobility objectives and customary land tenure, fueling the incidence of tribal conflict. In contrast to this failed top-down approaches are the enduring customary institutions whose sensitivity to the physical and social environment and inherent legitimacy have enabled them to overcome statutory abolition, even to the extent of obliging the authorities to recognize customary agreements.

With a fresh understanding of arid environments and the customary system, there are new opportunities for rangeland management in Syria. Tribes no longer represent a political threat as they once did, but they do represent irreplaceable social capital. With doubts raised about imported shrub technologies, plantations, and steppe policy more broadly, existing tribal systems offer a solid foundation on which to build an effective and efficient administration of steppe management and conservation. The task that now faces the authorities in Syria and elsewhere in the region is to respond to this latent opportunity and enter into a genuine partnership with the steppe users for the management and conservation of steppe resources.

REFERENCES

Abu Jaber, K. 1966. *The Arab Ba`th Socialist party: History, ideology, and organization*. Syracuse: Syracuse University Press.

ACSAD. 1992. Desertification in Syria. In *World atlas of desertification*, eds. N. Middleton and D. Thomas. London: Edward Arnold.

Behnke, R., I. Scoones, and C. Kerven. 1993. *Range ecology at disequalibrium: New methods of natural variability and pastoral adaptation in African Savannas.* London: Overseas Development Institute.

Bietenholz, P. 1963. *Desert and Bedouin in the European mind: Changing conceptions from Middle Ages to the present day*. Extramural Studies Board. Khartoum: University of Khartoum.

Deiri, W. 1990. Contribution a l'etude phyto-ecologique et de la potentialite pastorale en Syrie aride, MSc, Thesis, Institut de botanique, Universite de Montpellier.

Dresch, P. 1993. *Tribes, government and history in Yemen.* Oxford: Clarendon Paperbacks.

FAO. 1956. Report to the government of Syria on a program for improvement in sheep breeding and management. No 571. Rome.

________. 1966. Report to the Steppe Directorate: Grazing trial, Wadi al-`Azib Range and Sheep Experiment Station 1963-1966. Rome.

________. 1967. Report to the government of Syria on range management and fodder development. No.TA2351 PL:TA/43. Rome: UNDP/FAO.

________. 1973. Terminal Report: Syria 002. Intergovernmental Committee 24th Session 3-9 October 1973, p. 14. Rome.

________. 1974. Report to the Government of the SAR on range management and fodder development. SYR/58/011. Rome.

Goodchild, A. and A. Osman. 1993. *Value of Atriplex halimus and Salsola vermiculata foliage as supplements for barley straw.* Annual report 1992 of Pasture, Forage and Livestock Program. Aleppo: ICARDA.

Hardin, G. 1968. The tragedy of the commons. *Science* 162: 1243–1248.

Haut-commisariat de la Republique Francaise and Direction du Service des Renseignements du Levant. 1930. Les tribus nomades et semi-nomads des etats du Levant places sous Mandat Francais. Beyrouth: Imp Jeanne D'arc.

Heyd, U. 1973. *Studies in old Ottoman law.* Oxford: Clarendon Press.

Hourani, A. 1991. Tribes and states in Islamic history. In *Tribes and state formation in the Middle East*, eds. P. Khoury and J. Kostiner, pp. 303–312. London: IB Tauris.

Issawi, C. 1987. An Arab philosophy of history: Selections from the Prolegomena of Ibn Khaldun of Tunis (1332-1406). Cairo: The American University in Cairo Press.

Issawi, C. and C. Dabezies. 1951. Population movements and population pressure in Jordan, Lebanon, and Syria. *Midland Memorial Fund Quarterly* 29(4).

LaBianca, O. 1990. Sedentarization and nomadization: Food system cycles at Hesban and vicinity in Transjordan. Berrien Springs.

Le Houerou, N. 1992. The role of saltbush (Atriplex spp.) in arid land rehabilitation in the Mediterranean Basin: A review. *Agroforestry Systems* 18: 107–148.

________. 1995. Drought-tolerant and water-efficient trees and shrubs ('trubs') for rehabilitation of tropical and subtropical arid lands. *Journal of Land Husbandry* 1: 26.

Lewis, N. 1987. *Nomads and settlers in Syria and Jordan, 1800-1980*. Cambridge: Cambridge Middle East Library.

Leybourne, M., F. Ghassali, A. Osman, T. Nordblom, and G. Gintzburger. 1993. *The utilization of fodder shrubs (Atriplex spp., Salsola vermiculata) by agro-pastoralists in the north Syrian steppe.* ICARDA Annual Report for the Pasture, Forage and Livestock Program, pp. 142–160. Aleppo: ICARDA.

Maktari, A. 1971. *Water rights and irrigation practices in Lahj: A study of the application of customary and Shari'ah law in southwest Arabia.* Cambridge: Cambridge University Press.

McKell, C. 1975. Shrubs: A neglected resource of arid lands. *Science* 187: 803–809.

Ngaido, T. 1997. *Land tenure issues and the development of rangelands in Syria: Appraisal mission for the Badia rangeland development project in Syria*. Rome: International Fund for Agricultural Development.

Nordblom, T., G. Arab, A. Osman, A., and G. Gintzburger. 1995. *Survey of Bedouin groups with contracts to graze the government rangeland plantations at Maraghah, Aleppo Province, Syria.* Regional symposium on integrated crop-livestock systems I the dry areas of West Asia and North Africa. Aleppo: ICARDA.

Noy-Mier, I. 1990. Responses of two semiarid rangeland communities to protection from grazing. *Israel Journal of Botany* 39: 431–442.

Ostrom, E. 1990. *Governing the commons: The evolution of institutions for collective action.* Cambridge: Cambridge University Press.

Olsvig-Whittaker, L., P. Hosten, M. Shochat, and E. Shochat. 1993. Influence of grazing on sand field vegetation in the Negev desert. *Journal of Arid Environments* 24: 81–93.

Perevolotsky, A. 1995. *Conservation, reclamation and grazing in the northern Negev: Contradictory or complementary concepts.* ODI Pastoral Network Paper 38a. London: ODI.

Rae, J. 1999. Tribe and State: Rangeland Management in the Syrian Steppe. Unpublished thesis. Faculty of Geography and Anthropology, University of Oxford.

Rae, J., G. Arab, K. Jani, N. Murad, T. Ngaido, and T. Nordblom. 1996. *Socio-economics of shrub plantations in Syria.* Report to the Syrian Government. Aleppo: ICARDA.

Sankary, A. 1982. *Flora of the Syrian Steppe.* Aleppo: University of Aleppo.

Scoones, I. 1994. *Living with uncertainty: New directions in pastoral development in Africa.* London: Intermediate Technology Publications.

Syrian Arab Republic (SAR). 1975. The minutes of meeting to resolve dispute over al-del`a al-gharbieh between Muhurrab Rakan al-Murshed, the representative of Sba`ah tribe, and the members of Ghanatsah tribe [Hadidiyin], represented by Faysal al-Sfuk. Office of Chief, Secret Police. Homs: Homs Provincial Administration.

Stewart, F. 1995. Texts in Bedouin law. Unpublished copy of cases recorded in southern Sinai, the Social Studies Center. Sede Boqer:Blaustein Center for Desert Research.

________. 1986. Bedouin boundaries in central Sinai and the southern Negev. Wiesbaden: Otto Harrassowitz.

UN. 1955. *Progress in land reform.* New York: UN Economic and Social Council.

Wachholtz, R. 1996. *Socio-economics of Bedouin farming systems in dry areas of Northern Syria.* Stuttgart-Hohenhiem: Wissenschaftsverlag Vauk KG.

Westoby, M., B. Walker, and I. Noy-Mier. 1989. Opportunistic management for rangelands not at equilibrium. *Journal of Range Management* 42(4): 266–274.

Widmer, R. 1936. Population. In *Economic organization of Syria*, ed. S. Himadeh, pp. 3–38. New York: AMS Press.

Wilkinson, J. 1983. Traditional concepts of territory in southeast Arabia. *The Geographical Journal* 149: 301–315.

World Bank. 1995. *North Africa and Iran: Rangelands development in arid and semi-arid areas, strategies and policies.* Washington D.C.: World Bank.

Zakirov, 1989. *Grazing problems in Iraq, Problems of desert development.* c/c of problemy osvoeniia pustyn`, 4: 58–63.

Zakrya, A. 1947. *Tribes of al-sham.* Damascus: Dar al-Fekr.

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LAND DISPUTE RESOLUTION IN MOZAMBIQUE: INSTITUTIONS AND EVIDENCE OF AGROFORESTRY TECHNOLOGY ADOPTION

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IFPRI

February 2001

ABSTRACT

Successful adoption of natural resource management technologies requires that important fundamentals of property rights be established. Because disputes over property rights occur universally, the ability to successfully defend one's rights to property exercises a central influence on the tenure security necessary for technology adoption. However, defending rights to property rests upon the possession of evidence that is readily available and widely regarded as legitimate. This paper presents work carried out in postwar Mozambique on the availability and legitimacy of evidence pertaining to land tenure dispute resolution. What is unusual about the Mozambique case is that the physical presence of a natural resource management technology—agroforestry trees in this case—also serves as one of the most widely available and legitimate forms of evidence in the postwar period. Such an arrangement reveals important aspects about the reverse relationship between property rights and technology adoption. While such an evidence role for a technology may at first appear to encourage further adoption of agroforestry, important influences on property rights in the postwar setting serve to discourage full adoption and jeopardize the long-term presence of existing agroforestry trees. It remains to be seen if recent legislative changes regarding property rights will successfully engage customary forms of evidence and encourage full adoption of agroforestry in Mozambique.

CONTENTS

LAND DISPUTE RESOLUTION IN MOZAMBIQUE: INSTITUTIONS AND EVIDENCE OF AGROFORESTRY TECHNOLOGY ADOPTION

Joh D. Unruh*

1. INTRODUCTION

Nonadoption of natural resource management (NRM) technologies frequently occurs in an environment lacking in functioning land tenure dispute resolution institutions viewed as legitimate and workable by the parties concerned. The frequency, severity, and perception of land conflict and the character of land dispute resolution institutions have a fundamental influence on the resource access arrangements and tenure security necessary for technology adoption. Because all societies experience land disputes, the formation or evolution of customs or rules pertaining to legitimate evidence of rights to property is important to tenure security and resource access. Such evidence is a fundamental part of institutions regarding property rights, with repercussions on disputes and their resolution. If forces serve to alter the availability and legitimacy of evidence, then the associated institutions will also be altered, with implications for constraints and opportunities regarding technology adoption. This can be the case especially when an aspect of NRM technology is also regarded as evidence. This paper considers postwar Mozambique as a case study, and explores the effect of two broad forces on the availability and legitimacy of evidence regarding claims to property, and the relationship of this evidence to cashew agroforestry as an NRM technology (including adoption and maintenance).

The first influence considered stems from the disparate approaches to land tenure taken by customary versus formal tenure systems, whereby different groups attempting to access the same land may view and/or practice relationships to land very differently. This can result in evidence for a claim to land being regarded as legitimate within a tenure system but not legitimate between systems. Complicating this is Mozambique's recent history of armed conflict, which significantly altered the availability of evidence. One of the more important outcomes of these two forces acting in tandem is a comparative shift in the importance of certain forms of evidence that are both available after the war, and legitimate within and between tenure systems, including intact systems (still in place to varying degrees after the war) and disrupted systems (areas and populations constituting significant percentages of migrants). Such a shift can be especially pronounced for less powerful groups. The heightened or reduced value or utility of certain forms of evidence (and attendant institutions) has significant effect on both property rights and NRM technology adoption. The nature of such effects depends on the nature of the evidence, and its relationship to the technology in question.

With empirical research carried out in Mozambique, this analysis considers land tenure conflict resolution as a "legitimate evidence" and "available evidence" problem in

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its relationship to cashew agroforestry, where cashew trees have become highly valued forms of evidence. Important in this regard is how customary, migrant, and formal approaches to land tenure, together with the recent war, have shaped the relative legitimacy and availability of forms of evidence, and the resulting impacts on dispute resolution institutions and technology adoption.

2. BACKGROUND ON MOZAMBIQUE

THE WAR, RURAL RE-INTEGRATION, AND LAND TENURE

The recent 16-year civil war in Mozambique dislocated approximately six million people (primarily small-scale agriculturalists) from land resources to which they are now returning and reclaiming. This comprises the largest reintegration of refugees and displaced persons in the history of Africa (USCR 1993). Although the war officially ended in 1992, the lack of confidence of the general population about the actual end to the conflict delayed moves back into agriculture (USCR 1993). As a result, the UN expected to continue its resettlement activities in Mozambique until the year 2000 (Lauriciano 1995).

Resource tenure issues are increasingly coming to the fore as populations respond to what they perceive to be lasting peace, and make decisions about returning to areas of origin or migrating elsewhere and re-engaging in agriculture. Many demobilized and

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of Indiana in Bloomington, Indiana.

dislocated smallholders have returned to find their lands occupied by others, resulting in significant numbers of land disputes (Willett 1995; Galli 1992). At the same time, rural households are expanding areas under cultivation with each successive season as farmers bring areas long under fallow due to the war back into cultivation (USAID 1996). Further complicating access to land are large-scale recovery efforts to rehabilitate whole agricultural sectors, such as cashew and livestock production. These efforts involve free or greatly subsidized saplings and animals (connected to the landscape in some fashion), which are frequently used to claim land.

All land belongs to the state in Mozambique, but with limited capacity to exercise authority over land, there is considerable ambiguity over exactly what rights individuals, communities, and the state have. Even if the national land tenure framework operated perfectly and the necessary enforcement capacity existed, this would not resolve the complicated land conflicts emerging in postwar Mozambique. The central issue is less the lack of a surveying service and an official agency of coordination and arbitration, than the legitimacy of existing services with the competence and accountability to solve land conflicts for different groups (Tanner and Monnerat 1995). While recent political change increasingly recognizes the legitimacy of local, customary authority structures, the land law in place at the end of the war did not recognize customary tenure systems and therefore denied community access rights to land not currently under cultivation. The Land Law also did not recognize customary decisions that resolve conflicts between smallholders, nor customary evidence in disputes with largeholders who utilize the formal land tenure system. Thus lands incorporated in fallow systems, forest extraction, grazing, and land otherwise held by communities are recognized as vacant, and are vulnerable to occupation by commercial land interests able to obtain title, resulting in widespread land disputes (Tanner and Monnerat 1995).

One of the features of postwar land tenure in Mozambique is that agricultural reintegration for many small-scale producers has begun with an initial dependence on locations where the most fertile land, perennial water supplies, infrastructure, markets, relief services, and physical security are present together. Migration to such areas occurred throughout and after the war, with food-insecure migrants coming into conflict with long-term customary residents. However, large land interests are also most interested in property acquisition in these agronomically endowed, or “critical resource” areas. At least nine million hectares of land have been awarded through the formal land tenure system to concessions for farming, hunting, tourism, and mining activities. Practically all these concessions overlap with settlements of smallholders, who were not part of formal land allocation decisions (Moll 1996). These nine million hectares occupy the highest quality land of the 35 million hectares of arable land, including all the major river basins and land near infrastructure and towns (Moll 1996). This has generated further conflict between migrants, in-place communities, and concession holders, in an environment where property rights (including dispute resolution) institutions between these groups are problematic.

BACKGROUND ON CASHEW AGROFORESTRY IN MOZAMBIQUE

Since the introduction of cashew trees to Mozambique by the Portuguese during the colonial era, trees have been established along the entire length of Mozambique's coastline and for a distance of up to 200 km inland, covering approximately one-third of the surface area of the country (CCL 1994). In the early 1970s Mozambique was the world's largest producer of cashew nuts in shell, and cashew was the primary export commodity (CCL 1994). Cashew trees exist largely on smallholder land in Mozambique, in groves and intermixed in cropping patterns with cassava, cowpea, maize, and groundnuts (CCL 1994). Planting and maintaining new trees is a fundamental aspect of cashew agroforestry, as is removing older nonproducing trees to create space in closed canopy groves and tree/crop associations. The very large decline in cashew production is to a large extent due to tree senility resulting in low yields or the end of production in old age trees, with very little tree replacement (CCL 1994).

The war and the associated collapse of the rural economy have impacted cashew agroforestry significantly. Older trees were not removed, existing producing trees were not maintained (pruned, brush cut away from beneath trees and so on) and perhaps most importantly, new trees were not planted over large areas of the country as populations were dislocated, and transport, marketing, and processing of cashew were disrupted (Finnegan 1992; CCL 1994).

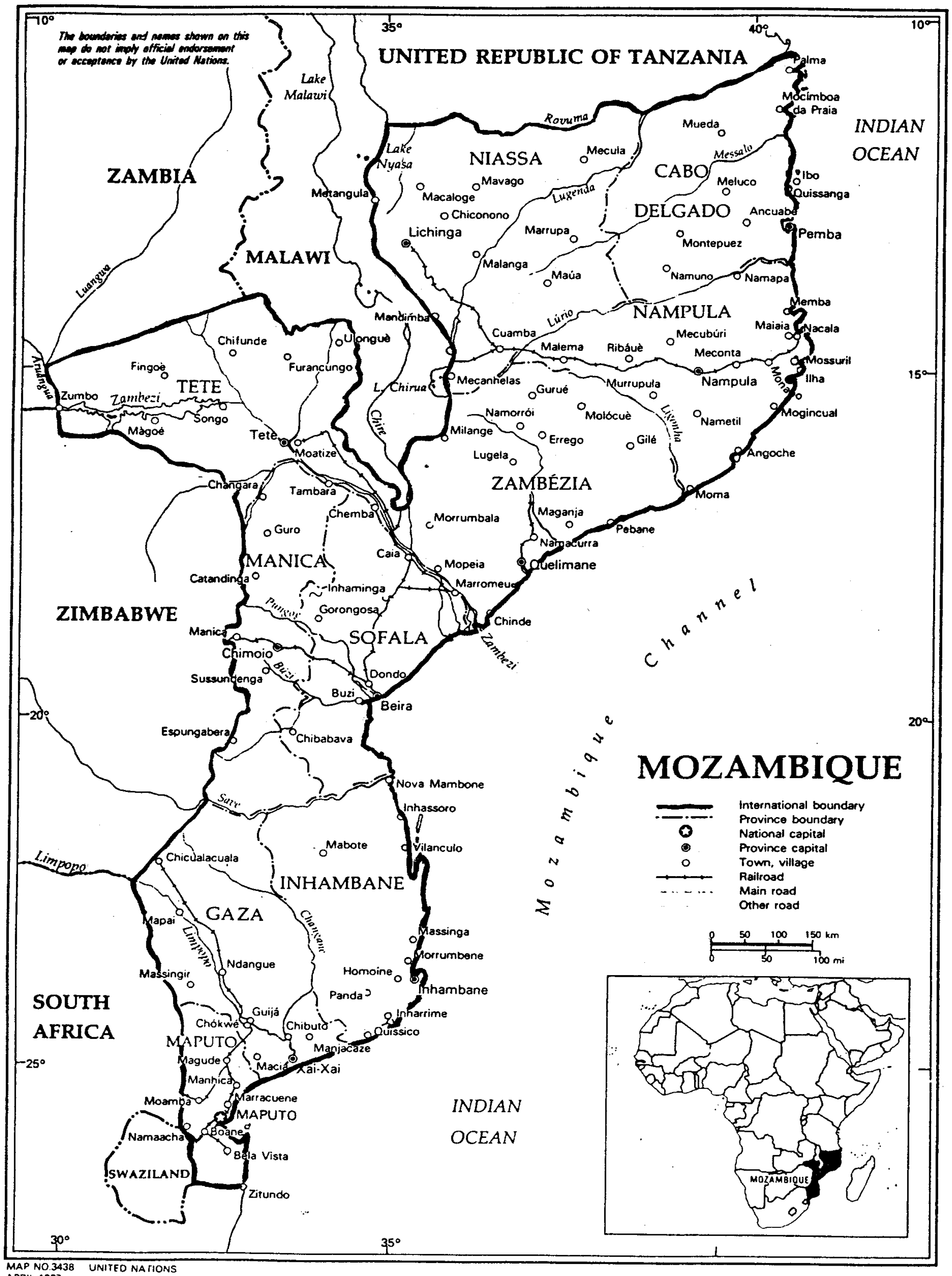
A recent national cashew tree population survey found very low numbers of trees less than 15 years old in all areas (CCL1994). Only 10–15 percent of the cashew tree population are in younger age classes (0–5, 6–10 years), with 20–30 percent between 16 and 25 years old, and 60–70 percent over 25 years of age (CCL 1994). A significant percentage of the younger trees that do exist appear to be self-seeded from the large stock of neglected adult trees (CCL 1994), meaning that their spatial placement either within an annual crop association or in a cashew grove is not optimized for an agroforestry system. While some studies note that production begins to decline after age 20 (FAO 1987; MOS/SST 1989) there is some disagreement as to the actual range in cashew tree productivity (CCL 1994). Throughout the cashew zone in Mozambique, very few trees are completely removed, in contrast to Tanzania and Kenya where farmers actively remove unproductive trees for use as firewood (CCL 1994). Thus a primary problem in Mozambique is the adoption (or postwar re-adoption) of tree replacement strategies and techniques, and hence a renewed role of agroforestry in natural resource management.

3. METHODOLOGY

In order to consider land conflict and how evidence operates for, and between smallholders, largeholders, and migrants, in 1996 social surveys were carried out (Unruh 1997) in two critical resource areas, and a control area in the northern part of the country. The idea was to compare the role of different forms of evidence (and customs and norms regarding evidence) in land dispute resolution.

The data for the study were gathered in the provinces of Nampula and Cabo Delgado in northern Mozambique (Figure 1). A social survey was carried out in 521 households in 21 villages, with villages distributed in three sets of seven villages each. Two of these sets were situated in agronomically endowed, or “critical resource” locations where fertile soils, perennial water, markets, infrastructure, and transport are fairly close together and thus are also locations most favored by large landholder interests. The third set of seven villages was dispersed within Nampula province in areas much less agronomically endowed, and not in critical resource areas. This third set acts as a control.

Figure 1—Study data in the provinces of Nampula and Cabo Delgado in Northern Mozambique



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Villages for the control set were selected based on their location in less agronomically favored areas in Nampula province. Households within villages were selected according to a stratified random sampling, whereby all households of each village were divided according to their relationship with a large landholder interest (cotton producers in this area) and then randomly selected. Smallholder proximity to cotton production is the largest source of smallholder versus largeholder land conflict in Nampula and Cabo Delgado (Tanner 1996). For control villages, households were stratified according to their participation and nonparticipation in a CARE oil seeds project, and randomly selected. The decision to participate in the oil seeds project in a village was left to the household.[1] Although this choice, and the subsequent stratification, are not directly relevant to the present land tenure study, this subsample adequately represents households in noncritical resource areas.

4. CRITICAL RESOURCE AREAS AND THE CONTROL SET

Tables 1, 2, and 3 provide a look at some of the more relevant differences among the three sets of villages. Generally, those occupying the critical resource areas (especially Montepuez) are in a more constrained and difficult situation regarding land tenure. Migrants numbers are higher, land conflicts and loss due to conflicts are more

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[1] This was part of a larger study dealing with land tenure and food security, as these related to largeholder cotton interests that operated in these areas.

problematic, agricultural investments (such as field bunding, fertilizer, and fences) are lower, but the number of years of education, surprisingly, is higher (Table 1). In general high values for tenure security are more frequent in the control set, while the critical resource sites have fewer respondents who are tenure secure (Table 2). Conflict resolution between smallholders using the customary tenure regime is regarded as more “unjust” in critical resource areas, as is land conflict resolution between smallholders and largeholders using the formal system (Table 3).

Table 1—Summary of selected variables for the control set and critical resource areas

	Village sets[1]		
Variables	Control set	Monapo	Montepuez
		(percentage)	
Share of migrants	10	23	73
Reports that smallholders lose land in the area	23	34	88
Perception that land conflicts are a problem	64	91	92
Perception that arrival of outsiders to obtain land is a problem for the community	16	39	66
		(summed years for household)	
Education	1.4	6.5	7.4
Average number of			
Land conflicts	0.21	0.53	0.49
Farm investments	5.5	5.2	2.4

Source: Unruh (1997).

1. Significant differences exist between village sets at the 0.05 level, with the exception of Monapo and Montepuez for “Perception of land conflicts as a problem”; and the control set and Montepuez for “Farm investments.”

Table 2—Tenure security for the three village sets

Tenure Security index	Control set	Monapo set	Montepuez set
Low: 8–15	10	27	50
Medium: 16–21	34	45	43
High: 22–30	56	28	7

Source: Unruh (1997).

a. Data is presented as the percentage of respondents within each set that fall within low, medium, and high measures for the tenure security index.

b. For land tenure security, an index was derived using 21 variables from the survey, including the general perception of land conflict (four variables); land loss and possibilities for losing land, including the role of title in land loss (eight variables); land lending (three variables); and investment in land (six variables). These variables were scaled, so that greater values indicate less presence and severity of land conflict, less land loss and preoccupation over land loss, more lending, and more investment. The values for the variables were added to give a scaled index for overall tenure security for each household. The index ranges from 8 to 30 with higher values indicating greater tenure security. Higher values are more frequent in the control, while the critical resource sites have fewer respondents that are tenure secure. Means for the tenure security index for the Montepuez (15.8) and Monapo (18.2) critical resource areas are significantly different from the control set (21.4) (and from each other) at the 0.05 level.

Table 3—Legitimacy of land dispute resolution for smallholders

Village set	Very just	Just	Unjust
Resolution between smallholders, using the customary system[1]			
Control	85	12	3
Monapo	59	38	3
Montepuez	29	53	17
Resolution between smallholders, using the statutory legal tenure system			
Control	52	43	4
Monapo	50	46	4
Montepuez	47	47	7
Resolution between smallholders and largeholders, using the statutory legal tenure system[1]			
Control	24	44	33
Monapo	14	31	55
Montepuez	13	17	71

Source: Unruh 1997.
Note: Data is expressed as a percentage of each village set's sample.
1. Values between village sets are significantly different at the 0.05 level.

CASHEW AGROFORESTRY TREES AS EVIDENCE

Trees and Land Tenure

In the developing world, economically valuable trees are among the most common and valuable forms of customary evidence for claiming "ownership" of land (Raintree 1987; Fortmann and Riddell 1985 and the references cited in these works for Africa, Asia, and Latin America). Numerous studies have looked at the role of economic or otherwise valuable trees in land tenure (Fortmann and Bruce 1988; Raintree 1987; Cohen 1993; Fortmann and Ridell 1985 and the references cited therein). Tree planting's role as powerful evidence for land claims is underscored by the restriction on tree planting by certain groups (such as women, tenants, and migrants) and the failure of agroforestry programs that do not take into account this important custom regarding valuable trees. Trees, by their enduring nature, can be evidence that lands in fallow are still "owned." This is important because land laws, including Mozambique's, can stipulate that land is declared "abandoned" if uncultivated for more than a certain number of years, which is frequently much shorter than an adequate fallow period.

In Mozambique, cashew tree tenure plays a large role in property rights institutions for smallholders, including land conflict resolution. Forces associated with the war and the "disconnect" between customary, migrant, and formal tenure have acted to put even greater weight on older cashew trees compared to other forms of evidence. There are important relationships between this evidence role and the continued adoption and maintenance of cashew agroforestry. The remainder of this section examines the relative importance of cashew trees as evidence; the subsequent two sections consider the two primary forces that shape the availability and legitimacy of cashew and other forms of evidence; and the final three sections look at cashew agroforestry's effect on property rights, factors important to the evolution of nonagroforestry evidence and institutions, and recent changes in the formal law to acknowledge forms of customary evidence.

Cashew Evidence in the Three Village Sets

For the three village sets in the study, the presence of cashew and other valuable trees is the single most important piece of evidence for defending or asserting rights to land, regardless of the average number of trees per smallholder. For the control, Monapo, and Montepuez samples, 86, 93, and 90 percent, respectively, indicated cashew trees as important evidence with respect to the occupation and "ownership" of land. These were the greatest percentages for any form of evidence (total of 30 forms) (Table 4). When asked whether having trees provided a "guarantee" against loss of land, the percentages were also quite high: 99, 99, and 94 percent for the control, Monapo, and Montepuez, respectively (Table 5). However the number of smallholders actually owning trees was much lower: 59, 69, and 16 percent of the control, Monapo, and Montepuez samples; and the average number of trees owned in the three samples was also low: 25, 39, and 3 for the control, Monapo, and Montepuez (Table 5). Thus while nearly all households consider trees as quite valuable evidence, many did not actually possess the evidence, and in Montepuez very few posses significant numbers of trees. One way to interpret this is that it may indicate the degree to which customs and norms that respect cashew trees as evidence are in place after the war, compared to other forms of evidence. The Montepuez village set is particularly noteworthy. While having the lowest percentage possessing trees and the lowest average number of trees per household, the percentage indicating this as important evidence is still quite high. Thus the Montepuez set illustrates that even in situations where institutions regarding property rights are most disrupted (Tables 1–3), the norms regarding agroforestry trees as legitimate evidence are nonetheless operative.

Thus, cashew agroforestry trees appear to provide strong evidence of claims to property, and legitimate evidence in dispute resolution. With property rights and tenure security strengthened by this evidence role of agroforestry trees, theoretically this would provide incentives to further invest in cashew agroforestry (adoption). However, as the following sections illustrate, several factors serve to complicate this investment significantly, with repercussions on property rights.

Table 4—Percentage of respondents mentioning social, cultural-ecological, and physical evidence, by village set

Evidence List	Control	Monapo	Montepuez
Social evidence			
Village elders	13	10	0
Local Leaders	25	10	0
Local organization	3	0	
Testimony of family	16	11	0
History of occupation	7	2	0
Knowledge of community area	3	0	0
Testimony of neighbors	36	45	3
History of economic trees	1	2	1
Cultural–Ecological Evidence			
Trails	4	3	1
Cemeteries	3	7	1
Location roads	4	0	0
Sacred areas	1	3	0
Ruins, old village	3	0	0
Economic trees	86	93	90
Tombs	15	7	0
Field boundaries	3	2	15
Location of old crops	0	0	1
Physical Evidence			
Local terrain differences	5	5	4
Very large trees	11	5	48
Location of mountains	4	6	5
Termite hills	5	5	28
Rivers	8	11	28
Soil type	31	26	61
Near cotton land	0	3	0
Boulders	1	5	1
Location of hills	0	1	8

Source: Unruh (1997).

Table 5—Summary of variables regarding agroforestry trees as evidence

Variables	Village sets: Control set	Monapo	Montepuez
Average number of trees per household	25	39	3
		(percentage)	
Agroforestry trees as important evidence	86	93	90
Plan to plant trees	32	25	10
Possess trees	59	69	16
Trees provide a "guarantee" of not losing land	99	99	94

Source: Unruh (1997).
Note: Average values for villages are significantly different at the 0.05 level for all three village sets in the category "Average number of trees per household," for the control set and Monapo in the category "Agroforestry trees as important evidence," and for Montepuez and the other two sites for the categories "Planning to plant trees" and "Possess trees."

5. THE WAR: DISLOCATION AND AGRICULTURAL DISRUPTION

The dislocations and disruptions attending the war have had significant impacts on the land tenure evidence "landscape" in two ways: 1) creating and maintaining an age-gap in agroforestry trees, and 2) making other forms of evidence less available and legitimate.

THE TREE AGE-GAP

Several interrelated forces connected to the war have operated, often in a mutually reinforcing way, to create and maintain a significant age-gap in cashew agroforestry trees. Perhaps most important was the direct effect of the dislocation of six million people on tree planting and the removal of older, nonproducing trees. Dislocatees (migrants) then residing on others' land were prevented from planting by their hosts because it would be seen as a land claim. Likewise, removing trees from such land would be seen as challenging the owner's claims. For dislocatees cultivating land of no clear ownership, the temporary nature of their residence deterred tree planting. For communities not dislocated, the war and resulting food security problems meant that the agricultural time horizons of many small scale producers were reduced considerably, effectively precluding tree planting with its expectation of production only after several years on land needed for much quicker producing annual crops. At the same time older trees near the end of production were not removed, as they frequently still provided small amounts of cashew for food insecure agriculturalists.

The village set with the greatest percentage planning to plant cashew trees in the coming year was the control, the sample with the lowest number of migrants from elsewhere and the greatest tenure security (Tables 4,1,2). The other two village sets fit this pattern, that is, as the percentage of migrants increases, the percentage of those intending to plant cashew trees decreases, as does tenure security (Tables 1, 2, and 4). With migration higher in Montepuez and cashew trees fewest, this may suggest why tenure security is lowest and perception of unjust dispute resolution is highest.

The frequency and severity of land conflict also influences the cashew age-gap. Key informant interviews in the three village sets revealed that smallholders in areas where conflicts are a large problem (Monapo and Montepuez, Table 1) are especially reluctant to remove older trees due to their greater evidence value (as indications of long-term occupation) over seedlings and saplings, which can be easily pulled up. An additional constraint to new tree planting is that as more smallholders lose land in the course of disputes (different from dislocation due to the war) they must then rent out or borrow land from other smallholders, again discouraging planting. In the overall context of cashew trees as evidence then, the tree age-gap has acted to shift emphasis (value) to older trees, primarily because this is what is most prevalent, and most meaningful as tree evidence. Migrants are most likely discouraged from removing trees as evidence, because the areas they occupy are relatively crowded, and include local community members. Thus, it would likely be known by whom the trees were cut, while the tree stump would attest to the fact that a tree once stood and had been cut. It would thus seem wiser for migrants to attempt borrowing or renting arrangements with local inhabitants, rather than attempt to overtly undermine their claims.

Availability of Nontree Evidence

The nature of dislocation during the war has meant that many agricultural areas were repeatedly occupied and abandoned at different times and by different groups. This has served to obscure, confuse and make less accessible or inaccessible many forms of evidence related to human occupation of the landscape. It also lessens social interaction regarding prewar arrangements of land ownership, loaning, renting, purchase, and so on. This is perhaps most notably the case where migrants currently comprise a significant proportion of the local population. The problematic postwar existence or availability of such forms of evidence not only has an influence on their legitimacy, but also on the comparative importance and legitimacy of other forms of evidence (agroforestry) that remain in place, and so it provides a much clearer indication of the history of occupation.

In order to ascertain differences in evidence availability among the three village sets, forms of evidence were first categorized as social, cultural-ecological, or physical. Social evidence is oral or testimonial evidence provided or confirmed by others in the community. It demonstrates occupation, and serves to tie individuals and households to local communities. Social evidence also corroborates other social, as well as physical and cultural-ecological, evidence. Cultural-ecological evidence is defined as the physical pieces of evidence that exist due to human activity on the landscape, such as agroforestry trees, current and old field boundaries, cemeteries, and so on. This evidence demonstrates occupation and corroborates social evidence and some other forms of cultural-ecological evidence. Physical evidence is defined as naturally occurring terrain features that are easily observed by anyone, and demonstrates familiarity with an area, but corroborates no other category of evidence.

These three categories of evidence vary considerably in their utility. In other words the interplay of social and cultural-ecological evidence will be much more meaningful than simply an individual's knowledge of where pieces of physical evidence (rivers, fallen trees, depressions, termite hills, and so on.) are located. Because knowledge of the location of naturally occurring terrain features is readily observed by anyone, it does not have the value of other evidence that lends itself to corroboration, and hence the building of an "argument." It is the combination of social evidence with cultural-ecological evidence that is most valuable in constructing an argument for a claim to land in a dispute. This is because social evidence ties individuals to communities, and cultural-ecological evidence corroborated by social evidence constitutes the connection between the physical signs of land occupation due to human presence, and the social aspects, which are bound up in cultural-ecological evidence (inheritance of land, networks of lending land, land transaction, and so on.). Such social evidence is at the heart of the definition of land tenure, which Middleton (1988) describes as "a system of relations between people and groups expressed in terms of their mutual rights and obligations with regard to land."

Table 4 compares the percentage of the village set samples favoring different forms of evidence within these three categories. What is most striking are the differences in social and physical evidence for the three village sets, but especially between the control set and Montepuez. Social evidence is largely lacking in the Montepuez set in favor of naturally occurring physical evidence, compared with the other two sets. This indicates the high preference for evidence that is available, even though such evidence is of reduced utility compared with other forms. Cultural-ecological evidence is essentially the same for the three sets, due to the large emphasis all sets place on agroforestry trees. However, there is a division within this evidence with regard to that evidence that ties individuals to community and land over the long-term (knowledge of and social attachment to tombs, cemeteries, sacred areas, village ruins, and so on) as opposed to shorter-term forms of cultural-ecological evidence (field boundaries, present crops, and so on). Subtracting agroforestry trees from the list of cultural-ecological evidence, respondents in Montepuez were more likely than those in other sites to cite evidence that demonstrates shorter-term occupation of an area (Table 4). If the control villages are the most "intact" communities, then it makes sense that social evidence and long-term cultural-ecological evidence are most prevalent there.

Overall, the ability of smallholders in Montepuez to build a good argument as to a land claim is compromised due to the lack of social evidence that can corroborate the existence of other social or cultural-ecological evidence. This is most likely because the majority in the Montepuez sample are recent migrants (Table 1), and thus do not have the same community/land connection or community cohesion as households within the control or the Monapo village sets. Of the migrants in the Montepuez set, only three (out of 94) households indicated some form of social evidence. Thus reductions in the availability of social evidence for populations with significant numbers of migrants appear to result in a shift favoring forms of evidence that are available—physical evidence and some cultural-ecological evidence—with the relative permanence of older agroforestry trees emerging as one of the most important and durable pieces of evidence available.

6. DIFFERENT APPROACHES TO LAND TENURE

The interaction of disparate approaches to land tenure in Mozambique influences the legitimacy of forms of evidence in dispute resolution. While the previous section looked at the influence of availability of evidence on shaping preferences for specific forms of evidence, the present section considers the influence of legitimacy of evidence on shaping evidence preferences across groups. In postwar Mozambique there are three different general approaches to land tenure: 1) customary, 2) statutory legal, and 3) migrant or “disrupted.” The latter approach is characterized by a comparative lack of social connections to community regarding land, and a higher value placed on naturally occurring physical forms of evidence in claims to land. Land disputes involving parties from the different tenure approaches can involve attempts to bring to bear forms of evidence that are regarded as legitimate and therefore respected (institutions) within a certain approach. But, if not respected by the opposing party (through enforcement or custom), then such forms of evidence are relatively unworkable. Violence aside, such a situation can then force the different parties, particularly the less powerful, to place increased value on evidence that is mutually legitimate.

For the customary (control) and largely migrant (Montepuez) groups in the study, there are only two forms of evidence for which both groups express a relatively high preference: soil type and agroforestry trees (Table 4), with soil type much less important for both communities compared with agroforestry trees. While similar data do not exist for largeholders (operating from the formal system), the land law in place at the end of the war acknowledged forms of smallholder evidence that demonstrates “occupation” (soil type does not), and explicitly disallowed social evidence. While crops and field boundaries are evidence of occupation, again, these have been severely disrupted during the war so as to be problematic for smallholders to connect with for purposes of evidence in a dispute, and these are less preferred (Table 4). Agroforestry trees, on the other hand, especially the older trees (indicating long-term or previous occupation) are evidence of occupation in the formal land tenure system and can signify a more direct and permanent connection to land for smallholders. Thus, agroforestry trees are the only remaining evidence for which there exist customs and rules (formal and informal) that pertain to them as evidence, not only within, but also between groups operating from the three different tenure approaches. As disputes between these three groups become common in certain areas, agroforestry trees, as mutually acceptable and respected evidence for defending rights to land, will shape dispute resolution to put much greater weight on this evidence.

All else being equal then, the actual presence of such evidence should influence the outcomes of disputes (land lost or not). While not comparable in every way, Monapo and Montepuez seem to support this. Relatively, both sets experience the same measures for value of trees as evidence, conflict number, and perception of land conflict as a problem (Tables 1 and 5). However the Monapo set, with many more cashew trees, indicates a much lower percentage believing smallholders lose land (Table 1), and higher percentages believing conflict resolution between smallholders and largeholders is less of a problem than conflicts between smallholders (Table 3). That the Monapo sample expresses greater tenure security (Table 2) also makes sense. One might speculate that the much larger presence of cashew trees in the Monapo area (Table 5), together with a greater presence of social evidence (not allowed in the Land Law, but in many cases connectable to trees) perhaps plays a substantial role in outcomes of land conflict.

Even in the presence of good evidence, conflicts are instigated for a variety of reasons, many stemming from poverty and instability in Mozambique, with migrants and largeholders alike seeking access to land in better areas with the hope of at least getting a crop from a piece of land before their claim is contested. While the incidence of conflict is perhaps not overly affected by the presence of cashew trees (Monapo has more cashew trees than Montepuez and less migrants, but also more conflicts), outcomes of disputes perhaps are resulting in greater tenure security. Comparisons between Monapo and Montepuez suggest that numbers of migrants and trees might not significantly affect incidence of conflict, but rather influence tenure security, investment in technology, and ideas regarding how "just" dispute resolution institutions are relying on whether legitimate evidence exists to address disputes.

7. THE TECHNOLOGY'S EFFECT ON PROPERTY RIGHTS INSTITUTIONS

There are two overall effects of cashew agroforestry on property rights in postwar Mozambique. First, the rules and customs regarding the link between agroforestry trees and land tenure have, in a postwar context, greatly facilitated (at no cost to the state) the coordination of defending and asserting rights to land, and hence land re-access and dispute resolution. This has helped to organize, nonviolently (and quite apart from intentionally implemented parts of the peace process) important aspects of property in a way that might not have occurred had there been no (or very few) agroforestry trees present in the postwar period. Thus the technology, or an aspect of it (older existing trees), has and continues to play an important role in the organization of property rights in the period of recovery. The existence (and comparative importance) of respected customs and norms regarding the connection between agroforestry trees and land, in an otherwise chaotic postwar tenure environment, holds considerable potential as a starting point for the evolution or re-formation of additional institutions regarding property rights. Of significant potential here, especially over time, are forms of social evidence connectable to cashew trees, that is, corroborating testimony regarding lending, renting, and purchase of tree harvests, and times of planting and maintenance. Also of some potential are forms of cultural-ecological evidence attesting to short-term occupancy, such as field boundaries, location of crops, and so on, which could, over time, be used to derive social evidence regarding these.

The second effect of agroforestry trees as evidence on property rights has to do with the adoption and maintenance of cashew agroforestry as these intersect with the formidable tree age-gap. The failure to adopt, or re-adopt, tree replacement strategies due to the high value placed on older trees as evidence will eventually result in a decrease in this evidence as the older trees die out, with impacts on the overall technology (loss of agroforestry, as opposed to adoption) and property rights. With decreasing numbers of trees, their availability as forms of evidence would eventually reach a point where the set of customs and norms that pertain to trees as evidence would begin to disintegrate. Very high value will continue to be placed on older trees unless other forms of evidence become available and legitimate, and institutions pertaining to these are able to evolve and deliver in terms of tenure security. The derivation of other forms of evidence, possessed by and legitimate to smallholders, and at the same time legitimate in the formal land tenure system and able to compliment agroforestry trees, would likely amplify the number and kind of meaningful forms of evidence and relieve some of the comparative importance of agroforestry trees; thus allowing the adoption (or re-adoption) of practices necessary for agroforestry as an NRM technology. For the control sample, even without customary social forms of evidence regarded as legal, there is a wider array of evidence available and legitimate (Table 4). This is also the set where the greatest planting goes on and where the smallest percent indicated that cashew trees are an important form of evidence (Table 5). Thus, while cashew trees are always expected to be an important form of evidence for the control (it is not significantly different from Montepuez in terms of importance) its comparative importance is less than for the other sets. This is due to the wide array of other available evidence as well as the proportionately smaller number of largeholders competing for land in the control area, thus enabling greater consensus on the legitimacy of customary evidence. For the three samples, the increasingly wide range of different forms of social and cultural-ecological evidence (from Montepuez to Monapo to the control set) parallels the percentage believing dispute resolution and tenure security between smallholders is more "just" (Tables 2 and 3).

In addition to the tenure relationship with tree replacement, there is a potentially significant market disruption effect on replacement strategies. With market and transport infrastructure considerably damaged during the war, the ability of commercial interests to purchase needed quantities of cashew over an adequately large area, and process, and transport shipments for export and urban consumption, has been much reduced. As a result, the economic incentive to smallholders to replace older trees in order to attain economically viable levels of production has likewise no doubt decreased. However, the relative importance of an economic incentive to replacement versus a tenure benefit to nonreplacement is difficult to determine. Presumably, if market and transport infrastructure were optimally in place in the post-war period, there would be some increase in replacement of trees. However with cashew trees—the primary form of existing evidence to land claim in many areas—it is perhaps unlikely that replacement would occur to the extent that such evidence is significantly jeopardized because the potential loss of land (and trees) would likely be a priority economic consideration over any incentive to increasing cashew production on land that may be lost. This may be especially important as cashew is usually the most common tree found on smallholder agricultural land in the country’s cashew belt, and non-native economic tree species can have a stronger evidence value than native, naturally occurring trees. However over time, as other evidence becomes available and legitimate, the role of market incentives to tree replacement is likely to increase, provided the marketing infrastructure is recovering.

The two effects of cashew agroforestry on property rights (assisting in the organization of land re-access, and the potential disintegration of this same evidence and associated institutions along with the technology itself) perhaps highlight a broader point about the relationship between technology adoption and property rights. In Mozambique, the nature of this relationship is not a static, entirely predictable one, but rather is necessarily influenced by a wider sociopolitical context that can influence the trajectory of this relationship. As this context changes, so can the nature of the relationship.

8. FACTORS IMPORTANT TO THE EVOLUTION OF NONAGROFORESTRY EVIDENCE AND RELATED INSTITUTIONS

LEGITIMACY

The evolution of institutions that pertain to other forms of customary evidence (social, cultural-ecological) first faces a legitimacy problem with the formal tenure system. Customary evidence is largely not legitimate within the formal system, and the statutory system is less than legitimate to many smallholders, especially for dispute resolution. The incorporation of customary forms of evidence into the formal land tenure system (land law) is a fundamental step in making such evidence legitimate within the formal system, and the formal system legitimate to smallholders. This would act to increase the value of such evidence among smallholders, especially in the problematic conflicts with largeholders who operate from the formal tenure system. For dispute resolution institutions to effectively operate between customary (including migrant) and formal tenure systems it must be realized that it is easier to modify national land legislation to accommodate evidence legitimate within the customary system, than it is to legislate out of existence customary norms and rules regarding land tenure (Bruce et al. 1994), in an attempt to replace the customary tenure system with the formal, so that everyone is "playing by the same rules." This is not to suggest that the details of land tenure in all customary systems should be incorporated into formal law (an impossible task), but rather that the themes and tenets that embody these and make them operable, such as community membership, testimony, local leadership, history of occupation, present use, and use of in-place dispute resolution institutions for intra-community disputes, be recognized by statutory law.

On the other hand, continued conflicts with largeholders in which smallholders lose land because the formal system does not regard customary evidence as legal would increase the number of smallholders having to move off land, resulting in the loss of important social and cultural-ecological evidence wherever they end up as migrants, thereby acting to stagnate the evolution of evidence and their institutions. Adoption of agroforestry could then become more difficult as those dislocated from land will likely, if they continue to farm, be unable to plant trees on rented or borrowed land.

Legitimacy of the formal system from the smallholder viewpoint is also an issue. Smallholders residing in critical resource areas, with a much greater exposure to largeholders, believe that land dispute resolution between large and smallholders is more unjust than do those in the control sample (bottom third of Table 3). That the primary problem in land dispute resolution involving the formal system is between small and largeholders, and not between smallholders, is supported by the differences in the response of “unjust” between utilization of the formal tenure system to resolve conflicts between smallholders, versus between smallholders and largeholders (Table 3). For Montepuez, 64 percent more of the sample believed the formal system was “unjust” when the dispute was between small and largeholders, as compared with use of the formal system for resolving disputes between smallholders. For Monapo, this difference was 51 percent, and for the control set, 29 percent. For dispute resolution between smallholders using the formal system, approximately half of the samples from both critical resource areas believed this to be “very just” which is comparable to the control. Thus, there exists both an opportunity and a problem regarding formal, legal land dispute resolution. The opportunity is that smallholders do believe the formal system has legitimacy, and this could be built upon. This would increase the legitimacy of the formal system for smallholders and incorporate the much needed “customs and controls” of communities in enforcement of decisions. The problem is that the same system (formal) is problematic when the dispute is between small and largeholders—acting to detract significantly from the opportunity.

AVAILABILITY

The evolution of institutions regarding customary forms of evidence also faces an availability problem. The war has disrupted much in the way of institutions regarding commonly accepted social and cultural-ecological evidence for smallholders, especially for those who are now migrants. To a large degree, this is because the availability of the evidence itself was disrupted. Time will be necessary to both increase the availability of evidence and re-make local institutions pertaining to this evidence. The re-formation of these will be variable over time and space, and in some areas will require considerable time. For areas with significant numbers of migrants (Montepuez), the question of availability of evidence will be more critical than for areas with fewer migrants (Monapo) or for established communities with very few migrants (control set). Making forms of customary evidence (especially social forms) legal in the formal tenure system will have less of an impact, or a much delayed impact on groups that do not have this evidence significantly available. In the Mozambique case, customary evidence regarded as legal will clearly be of greater assistance to communities such as the control areas and Monapo, as opposed to areas such as Montepuez, where forms of social evidence are much less available. However, to the degree that customary forms of evidence are made legal in the national tenure system, one could imagine that the time necessary for the evolution or re-evolution of institutions even in areas such as Montepuez would very likely be shortened.

COMMUNICATION

Inclusion of customary evidence in statutory legal codes, however, will have little meaning to small-scale agriculturalists if the parameters of the new statutory legal environment are not known at the local level, and if smallholders do not have the capacity to engage the new legal environment. Additional work (key informant interviews) in Mozambique indicated that while smallholders can perceive the statutory legal system to be unjust in dispute resolution with largeholders, they are unaware of the precise nature of the statutory legal framework regarding use and access of land resources, including dispute resolution. At the same time, largeholder and commercial interests are also often unaware of important aspects of the legal environment with regard to disputes and their resolution. District level officials are frequently unaware of current and new legal tenets, and there is extremely limited capacity on the part of the government to diffuse this information outside the provincial capitals. Even the capacity to “inform only” from the province to the district, and especially within the district is extremely weak and in many cases nonexistent. The incapacity of the district level to deal with basic land issues is an important impediment to smallholders’ ability to take advantage of any legal environment (current or changed). Thus, dissemination of information regarding legal tenets from the national capital through several layers of formal and informal land administration is a fundamental aspect of the evolution of effective institutions regarding legal forms of customary evidence. The two critical resource areas show a certain potential in this context. With significantly more education than the control site (Table 1), dissemination of important aspects of the Land Law might be taken advantage of more quickly by this group, especially given the breakdown of important customary forms of evidence, community connection, and notions of how “just” the customary system is in dispute resolution between smallholders, compared with the formal system.

9. HAS THIS HAPPENED?

Responding to the land tenure issues of the postwar period, the Mozambican Interministerial Land Commission, backed by technical support, took the lead in formulating a revised national land policy and land law for Mozambique. Activities of the Land Commission over the previous five years included research on a number of important topics, local to national debates and discussions, workshops, and three national conferences on land issues, with discussions of land conflict resolution playing a prominent role in these. On July 31, 1997, after two weeks of parliamentary debate, the National Assembly approved a new Land Law.

The key changes regarding conflict resolution adopted as articles in the revised Law indicate

- Acceptance of nonwritten forms of customary evidence, such as oral testimony, to defend claims to land
- Explicit granting of land use rights to rural smallholders through occupation (without prejudice or inferiority compared with rights received by formal written title)

- Mandatory local community participation in the formal titling process
- Ability to register land in the name of the local community

Efforts are underway in Mozambique to encourage domestic and international NGOs to play a role in bringing about local understanding of the revised Land Law through communication of relevant aspects of the revision. This is done by a coordinated effort to engage in two primary activities. The first is to take on the much-needed role of communicating important aspects of the revised Law to the district levels. Second, NGOs, in their areas of activity, and with greater knowledge of both the formal legal structures and the smallholder communities they work with, are able to act as advocates to numerous communities, to "walk them through" dispute resolution with largeholders, while smallholders continue to learn about the new legal environment. These two aspects of national land policy reform in Mozambique (inclusion of customary evidence, and communication of the revised law to the provincial, district and local village levels) have the potential to encourage the evolution of land dispute resolution institutions associated with an amplifying menu of legitimate evidence.

Direct information on the impact of the revised Land Law is not available due to the recent nature of the changes. But what is expected is that smallholders, with an ability to present their own evidence that is customarily legitimate, yet legal within the formal system, will increasingly be able to participate in dispute resolution with largeholders, resulting in a greater ability to retain access to land. Making social forms of evidence legal may have the effect of encouraging smallholders to derive and value such evidence where it does not now exist (Montepuez) or is weak (Monapo). This could eventually result in an expansion of the kinds of available evidence and associated institutions, like that which exists in the control community. Increasing tenure security in this way may then take some of the pressure off older agroforestry trees as the sole evidence that is available and respected by different groups. This in turn could result in the employment of the tree replacement strategies important to full adoption and maintenance of cashew agroforestry.

Incorporation of customary land tenure evidence into formal legislation creates a new framework for interaction between the customary and formal tenure systems. Largeholders will perhaps be more willing to “cut a deal” with communities over use of resources if it is widely known that customary evidence in a land dispute has formal legal standing. Overall, inclusion of customary evidence in formal legal codes is likely to have the effect of increasing community control over the resources on which they depend.

10. CONCLUSION

The nature of legitimate evidence in land dispute resolution plays a fundamental role in the land tenure security necessary for adoption of natural resource management technologies. In postwar Mozambique, forces associated with the conflict have served to alter the availability and legitimacy of evidence to put significant evidence value on cashew agroforestry trees. The widespread presence of cashew on smallholder land allows these trees to provide evidence of land ownership, and constitute legitimate evidence for dispute resolution. As a result, cashew agroforestry as an NRM technology has strengthened property rights and heightened tenure security, a uniquely valuable service in the chaotic postwar period. With such value placed on agroforestry trees, further investment in cashew would seem the logical choice. However several forces serve to discourage investment in cashew planting.

- The high evidence value placed on agroforestry trees, together with a comparative lack of other evidence of equal value, means that older, nonproducing agroforestry trees are not removed to make space for planting cashew in tree-farm associations, or cashew groves.
- With close to half of the national population dislocated during the course of the war, the presence of migrants on land claimed by others is a common occurrence. Migrants are prevented from planting cashew due the role of tree planting in claiming land and because the duration of their tenure tends to be shorter.
- The war has created significant uncertainty over who owns what in Mozambique, increasing the probability of disputes and decreasing the incentives to invest further in cashew planting.
- The lack of connection between formal and customary land tenure systems has increased the likelihood of land disputes between smallholders and largeholders, particularly in critical resource areas. The resulting uncertainty is aggravated by power distributions that favor commercial and largeholder interests hence lending greater legitimacy to statutory law regarding administration of land. Smallholders therefore

can experience greater expectations of land loss, resulting in decreased incentives to invest in technologies such as cashew agroforestry.

Such a set of opposing forces regarding the role of cashew agroforestry trees as evidence for land claims reveals important aspects about the adoption of NRM technologies. With number of migrants highest and number of cashew trees lowest in Montepuez, this may explain lower measures of tenure security, and perceptions of unjust dispute resolution; however Monapo has a greater number of land conflicts than Montepuez despite a higher average number of cashew trees per person, fewer migrants, and greater tenure security. This may suggest that numbers of trees and migrants do not affect the incidence of conflict significantly, but they do affect tenure security, investment in technologies, and perceptions of the "justness" of dispute resolution institutions. Thus, incidence of conflicts may not necessarily significantly weaken tenure security, provided that forms of evidence widely perceived to be legitimate (such as cashew agroforestry trees) are available to resolve disputes.

With little alternative forms of evidence available that are as widely legitimate as cashew trees, there exists the risk that continued nonremoval of older trees coupled with little planting of new trees would result in fewer trees in the future. However, recent legislative revision by the Mozambican government has resulted in a formal land law that incorporates, to a significant degree, customary forms of evidence. This presents the possibility of "valuing" alternate forms of customary evidence in land dispute resolution, and widening the array of legitimate evidence available for smallholders. While too soon to determine, this may have the effect of decreasing the near singular importance of cashew trees as evidence, and hence an important constraint to cashew tree replacement as an important aspect of full adoption of the agroforestry technology.

REFERENCES

Bruce, J.W., S.E. Migot-Adholla, and J. Atherton. 1994. The findings and their implications: Institutional adaptation or replacement? In *Searching for tenure security in Africa*, ed. J.W. Bruce and S.E. Migot-Adholla. Dubuque, Iowa: Kendall/Hunt Publishing Co.

CCL (Capricorn Consultants Limited). 1994. *National cashew tree population survey, final report*. Nairobi: Capricorn Consultants Limited.

Cohen, S.E. 1993. *The politics of planting: Israeli-Palestinian competition for control of land in the Jerusalem periphery*. Geography Research Paper No. 236. Chicago: University of Chicago Press.

Finnegan, W. 1992. A complicated war. Los Angeles: University of California Press.

Food and Agriculture Organization of the United Nations (FAO). 1987. *The cashew industry in Mozambique*. Rome.

Fortmann, L., and J. Bruce. 1988. *Whose trees? Proprietary dimensions of forestry*. Boulder, CO: Westview Press.

Fortmann, L., and J. Riddell. 1985. *Trees and tenure: An annotated bibliography for agroforesters and others*. Madison and Nairobi: Land Tenure Center and ICRAF.

Galli, R. 1992. Who will rehabilitate agriculture in the post-war period? Unpublished manuscript.

Lauriciano, G. 1995. Socio-economic. *Mozambique Inview*. Maputo: Mediacoop.

Middleton, J. 1988. Forward. In *Land and society in contemporary Africa*, ed. R.E. Downs, and S.P. Reyna . Hanover: University Press of New England.

Moll, P. 1996. *Call for prompt action on the Mozambique draft bill on land*. World Bank Mozambique land brief position paper. Maputo: World Bank.

Raintree, J.B. 1987. *Land, trees, and tenure*. Madison and Nairobi: Land Tenure Center and ICRAF.

Tanner, C.R. 1996. Personal communication. FAO representative to the Land Commission, Ministry of Agriculture, Maputo.

Unruh, J.D. 1997. Post-conflict recovery of African agriculture: Critical resource tenure in Mozambique. Ph.D. diss., University of Arizona.

USAID (US Agency for International Development). 1996. *Mozambique: Country strategic plan FY 1996-FY 2001*. Maputo: USAID Mozambique Mission.

USCR (U.S. Committee for Refugees). 1993. *World refugee survey*. Washington, D.C.

Willett, S. 1995. Ostriches, wise old elephants and economic reconstruction in Mozambique. *International Peacekeeping* 2:34–55.

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CAPRi WORKING PAPER NO. 13

BETWEEN MARKET FAILURE, POLICY FAILURE AND "COMMUNITY FAILURE": PROPERTY RIGHTS, CROP-LIVESTOCK CONFLICTS AND THE ADOPTION OF SUSTAINABLE LAND USE PRACTICES IN THE DRY ZONE OF SRI LANKA

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March 2001

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ABSTRACT

Using the case of the semi-arid zone of Southern Sri Lanka as an example, the paper shows that crop damages caused by grazing livestock can constitute an important obstacle to the adoption of available technologies for more sustainable land use. The paper considers crop damages as an externality problem and shows that the classical solutions to externalities—the neo-liberal, the interventionist solution and the communitarian solution—cannot be applied in the Sri Lankan case due to market failure, government failure and "community failure." The paper discusses collective action and bargaining between organized interest groups as an alternative solution and analyses the conditions which make such a solution work. The paper concludes that - in the Sri Lankan case - a decentralized system of government, a preferential voting system creating incentives for politicians, an institutionalized negotiation platform, and the facilitating role of intermediaries favored this solution.

CONTENTS

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Regina Birner and Hasantha Gunaweera

1. INTRODUCTION

In the semi-arid zone of Southern Sri Lanka, conflicts over crop damages caused by grazing livestock constitute an important obstacle to the adoption of more sustainable land use practices. They affect the shift from slash-and-burn agriculture to irrigated farming and to agro-forestry. At first sight, crop damages may appear as a technical problem, but they have an institutional dimension as well. They are a manifestation of an underlying conflict between crop farmers and livestock keepers for property rights in land. For three reasons, this problem is an interesting case for studying the relations between property rights, collective action and technology adoption: First, solving the problem involves collective action at different levels: among the crop farmers and the livestock farmers themselves and between these groups. Second, the case illustrates the decisive role of the political and administrative system in which the groups interact. Third, the problem is not unique to Sri Lanka. It is rather universal in certain phases of agricultural development, especially in areas where both crop and livestock farming are ecologically feasible. The problem typically arises when increasing population pressure induces the expansion of crop farming and, consequently, land resources used for pastoral livestock keeping become scarce (Birner 1999).

The paper is organized as follows: The study methodology is outlined in Section 2. Section 3 discusses the emergence and relevance of crop damages by grazing livestock as an obstacle to the adoption of more sustainable land use practices. Section 4 examines the difficulties of reaching a solution in the presence of market failure, government failure and “community failure.“ Analyzing the process currently observed in the research region, Section 5 shows how collective action within a given political and administrative arena may lead to a solution. Conclusions are drawn in Section 6.

2. DESCRIPTION OF THE STUDY SITE AND METHODOLOGY

This study is based on empirical data collected in the Hambantota District of Sri Lanka, which is mainly located in the Dry Zone, which receives less than 1270 mm rainfall. Land use in this zone is characterized by the co-existence of two land use systems, which differ considerably in their intensity: (1) irrigated paddy cultivation, mostly in irrigation and settlement projects, which have been established in Hambantota District since the last century, and (2) slash-and-burn agriculture on the non-irrigated land resources, which traditionally includes fallow periods and in Sri Lanka is referred to as *chena* cultivation. Vegetables and fruits are cultivated to a small extent on the plots adjoining the houses, which are referred to as home gardens. Wasteland, fallow land, and the paddy land after harvesting has traditionally been used for keeping of cattle and buffalo in an extensive free-grazing system.

Two empirical data sources are used for this paper: (1) a research project on livestock development conducted from 1994 to 1995 in selected villages of the Hambantota District and (2) a survey carried out from 1995 to 1998 by a committee nominated to develop a proposal for a solution to the problem of crop damages caused by livestock. The 1994/95 research project applied the methodology of a comparative village case study, which included eight villages in the Dry Zone section of Hambantota District. Four villages were selected from areas settled in the last century and four from areas settled in the period between the 1950s and the 1990s. In each group, two villages were situated within major irrigation schemes and the other two in non-irrigated areas.

Research methods included a review of the household statistics available at the village level, a survey of all livestock keeping households in the selected villages (207 households), participant observation over a period of twelve months in one of the selected villages, interviews with crop farmers affected by crop damages caused by livestock, and interviews with representatives of the agencies involved in settling conflicts concerning crop damages. Information on technology development was also provided by major development agencies in the district and by the Department of Agriculture. Information on the political frame conditions was obtained through informal interviews with local politicians and the observation of the election campaigns for the Provincial Council, Parliamentary and Presidential elections in 1994.

The second data source of this paper, the survey carried out from 1995 to 1998 by the committee mentioned above completely covered one selected Agrarian Services Division of the district, which was particularly seriously affected by the problem of crop damages. The committee reviewed the secondary data maintained by different government institutions and by the livestock farmers' organization of the respective Division. Primary information was obtained from 45 key informants involved in the settling of conflicts concerning crop damages. During the process of developing, negotiating and implementing the proposal for a solution to the problem of crop damages, the committee collected information on the discussion process taking place within the organized interest groups and on their interaction with administrative and political decision-makers.

LAND TENURE AND LAND USE IN THE RESEARCH REGION

In the traditional settlement areas of the research region, paddy lands and home gardens are typically held as formal private property. In the irrigation and settlement projects constructed after the enactment of the Land Development Ordinance of 1935, farmers hold individual use rights in paddy lands and home gardens. The only transfer right is the right to bestow, which is limited to handing down the land intact to a single heir. This regulation led to a clear stratification of the rural households in those holding comparatively large parcels of paddy land and those without paddy land (see Tables 1 and 2).

Table 1—Land tenure in the dry zone of Hambantota District

Division	Households owning land	Households owning paddy land	Average size of paddy holdings	Average size of upland owned[a]
	(number)	(percent)	(acres)	(acres)
Hambantota	8,795	39.6	2.36	1.62
Tissamaharama	8,010	34.4	2.94	1.50

Source: DCS (1984: 25)

Note: Data are taken from the 1982 census of agriculture, the last available census data which provide information on tenure of paddy holdings.

[a]Data on chena cultivation on state-owned land were not collected in this census.

Table 2—Distribution of paddy land

	Percentage of households owning					
Division	< 1acre	1-2 acres	2-3 acres	3-4 acres	4-5 acres	> 5 acres
Hambantota	12.0	26.1	28.1	23.0	4.8	6.0
Tissamaharama	5.4	16.5	31.5	19.8	9.9	17.0

Source: DCS (1984, 25)

Note: Data are taken from the 1982 census of agriculture, the last available census data which provide information on tenure of paddy holdings.

Paddy land is an important status symbol and access to more than two acres in the research region is commonly considered as sufficient to secure the livelihood of a household throughout the year.

Except for the home gardens, the non-irrigated land resources in the research region are almost exclusively formal state land. These land resources are widely used both for slash-and-burn agriculture (*chena* cultivation) and for livestock rearing. Since the enactment of the Crown Lands Encroachment Ordinance in 1840, *chena* farmers have had to obtain cultivation permits from the local administration. Due to environmental concerns, cultivation permits are nowadays hardly issued at all in the research region. Chena farming is nevertheless widely practiced (see Table 3) and tolerated by the authorities, because in non-irrigated areas, the majority of the rural households depend on chena cultivation for their livelihood. In the eight villages surveyed in 1994/95, the average cultivated area was 2.1 acres per household.

Table 3—Area cultivated with other crops than paddy[a]

Division	All parcels cultivated with other crops than paddy[b]			Home gardens[c]
		total area	average size	
	(Number)	(Acres)	(Acres)	(Number)
Hambantota	5,951	6,093	1,02	4,032
Sooriyawewa	7,415	9,303	1,25	3,617
Tissamaharama	11,639	9,617	0,83	8,913
Lunugamwehera	5,889	5,463	0,93	4,105

Source: DCS (1992/93, 5)

Note: This table includes four divisions, because both the Division of Hambantota and Tissamaharama have been divided since the 1982 census.

[a]The census did not distinguish between state-owned and privately owned land. However, according to information collected from the Divisional Secretariats in Hambantota and Tissamaharama, almost the entire upland cultivation area that is not allocated to home gardens is state-owned.

[b]For this survey, a parcel was defined to be a piece of land cultivated singly or jointly, irrespective of legal ownership (DCS, 1992/93, 2).

[c]The major definition criterion for the home garden was the dwelling house.

Due to low productivity and a considerable risk of crop losses, most of the *chena*-cultivating households have to hire out labor or find other additional income sources in order to secure their livelihood. Notwithstanding, these households are referred to herein as "*chena* farmers." Most chena farmers in the surveyed villages were ranked below the poverty line, which the government defined for the implementation of poverty alleviation programs.

After the harvest, paddy lands and *chena* lands are traditionally used as grazing resources for cattle and buffalo. Fallow *chena* lands and other land resources not used for crop cultivation are used for grazing, as well. The livestock owners claim that they have customary rights to use these lands for grazing. Interviews with key informants and participant observation revealed that the owners of the larger herds kept outside the village were successful in excluding newcomers and outsiders from using these land resources for rearing cattle and buffalo. However, they have not developed specific regulations to limit the herd sizes and control the stocking rate. The distribution of cattle and buffalo ownership in the research region is highly skewed. In the villages included in the 1994/95 survey, only 5.6 percent of all households kept cattle, 1.2 percent kept buffalo and 0.8 percent kept a combination of both. The average herd size was 33 animals for cattle and 67 for buffalo. Of the cattle (buffalo) keeping households 43 (6) percent kept less than 10 animals and 20 (47) percent kept more than 60 animals. In the Division covered by the 1995-98 surveys, approximately 75 percent of the livestock owners keeping more than ten animals are organized in a cattle farmers' association, which has 150 members. 35 percent of the members keep between 100 and 250 animals and 18 percent keep more than 250. The average herd size is 158 animals per member.

Herds below ten animals are typically kept at the homestead of the owners, while the larger cattle and buffalo herds are kept outside the village in a free-grazing system. During the paddy cultivation seasons, these herds are traditionally shifted to more remote areas. Crop damages are mostly caused by larger herds kept outside the village, which are typically owned by rather affluent families. All cattle and buffalo keeping households included in the 1994/95 survey which owned more than ten animals also cultivated paddy land and, in addition, many engaged in trade, renting out agricultural machinery, money lending, etc. In the research region, the social status of this group is documented by the respectful use of a special Sinhalese term—*Gambaraya.* For convenience, the term " livestock owners" is used herein to refer to households that keep herds of cattle and buffalo of more than ten animals outside the villages and are therefore involved in the problem of crop damages.

3. CROP DAMAGES BY LIVESTOCK AS AN OBSTACLE TO TECHNOLOGY ADOPTION

The problem of crop damages caused by livestock as an obstacle to technology adoption can be placed into the framework of the theory of induced innovation (Boserup 1981; Hayami and Ruttan 1985). Both the system of slash-and-burn agriculture (*chena* farming) and the system of large-scale cattle and buffalo rearing emerged under the conditions of low population density. Accordingly, these systems are non-labor intensive and employ extensive land use. Both systems have come under pressure due to the rapidly increasing population in the Dry Zone section of Hambantota District. The population density almost doubled from 106 to 204 persons per square km between 1971 and 1994.[1] As land in irrigation and settlement projects must not be divided in the course of inheritance, the members of the second generation of the settlers who do not inherit paddy land are either forced to apply for land in new irrigation and settlement projects or to engage in *chena* cultivation on the non-irrigated land resources. Consequently, reduced fallow periods and increasing soil degradation in the non-irrigated areas are a common phenomenon in the research region, as elsewhere in the Dry Zone of Sri Lanka. In the early 1980s, more than half of the *chena* plots in the research region were already cultivated without fallow period (ILO 1984). The cultivation practices have, however, not been adapted to the reduced fallow periods and the interviewed farmers frequently reported declining yields.

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[1] Calculated according to information from the Statistical Branch of the District Secretariat, Hambantota, 1994.

Since the 1980s, public research institutions in Sri Lanka have increasingly been engaged in the development of technologies, which allow the shift from *chena* cultivation to more sustainable permanent land use systems. The focus has been placed on the development of alley cropping systems (Keerthisena 1995), on the introduction of drought-resistant fruit and timber trees into the upland farming systems of the Dry Zone (Gunasena 1995), and on moisture conservation techniques such as contour bounds with hillside ditches (Handawela 1995). The interviewed representatives of the agencies promoting alternatives to chena cultivation generally reported a low rate of adoption and addressed crop damages caused by the free-grazing cattle and buffalo herds as a major reason. The records from two projects illustrate the problems of adoption.

One foreign-funded project was started in 1993 as a participatory technology development program, involving 15 women farmers' groups representing 312 households in all. Fourteen of the 15 groups identified the establishment of fruit trees in their home gardens and on the land they used for *chena* as technology to be developed. The following trees were identified by the groups for on-farm testing: banana, papaya, lime, orange, mango, pomegranate, cashew and wood apple. Two hundred eighty-six households agreed to participate in the on-farm trials. The group discussions held to identify potential constraints led to the conclusion that the trials were only feasible if the plots were fenced with barbed wire. Otherwise, the household members would have to watch the plots day and night to prevent damages by free-grazing cattle and buffalo. In *chena* cultivation, permanent observation during the whole production cycle of approximately four month is the usual practice to protect the crops from damages by livestock. The participants considered this practice, which draws heavily on the households' labor resources, as not applicable for perennial crops. The traditional fencing material, dry branches of thorny shrubs growing on areas under bush fallow, has increasingly become scarce due to the reduced fallow periods mentioned above. Calculations by the project showed that the use of barbed wire would increase the costs of establishing 0.5 acres of a typical recommended combination of fruit trees from Rs. 440 to Rs. 2,680. For comparison, the daily labor wage during the peak season was Rs. 135. In view of the high initial capital requirements and the high maintenance costs of barbed wire fences, the program was not considered economically viable for small-scale farmers and was, therefore, not implemented. The year before, the project had for similar difficulties stopped a program to introduce an agro-forestry system based on *Gliricidia* and wood apple trees grafted with oranges. The records of the project show that the problem of crop damages was discussed as the major obstacle to the development of upland cultivation in 111 of 124 village-level meetings held within the period from 1995 to 1998. It became obvious that a practicable solution could not be found at the project level.

The second example refers to the Kirindi Oya Irrigation and Settlement Project (KOISP), the major irrigation project in the region. It illustrates the difficulties to introduce new crop farming practices even without a tree component. As an alternative to *chena* farming, KOISP promoted the planting of other field crops than paddy (chilies, ground nuts, onions, green gram, cowpea) within the irrigation tracts during the minor cultivation season, when the irrigation water was not sufficient to grow paddy. In 1990, 232 ha were cultivated with the above-mentioned crops, corresponding to only 12 percent of the targeted extent of 2,000 ha (HARTI 1995). A situation analysis study by HARTI identified the danger of crop damages as a major obstacle, next to lack of water and insect attacks. As shown in Table 4, for all crops except onions, the farmers reported crop damages by animals as the major constraint to productivity.

Table 4—Constraints to productivity in crop production

Tpye of constraints	Chillie	Ground nut	Onion	Green gram	Cowpea	Total
			(number of farmers)			
Lack of water	14	3	25	-	-	42
Insect attack	37	-	5	5	2	44
Lack of quality seed	5	-	-	-	-	14
Damage by animals	72	23	14	6	11	121
Unsuitability of soil	12	2	10	-	-	52
Total	140	28	53	11	13	246

Source: HARTI (1995: 26)

Almost all farmers reported that they had to take care of the crops throughout the cultivation cycle day and night (HARTI 1995). The study concluded that cultivation of small plots under different areas was not practicable because of the probability of crop damages by animals, especially cattle (HARTI 1995). As a possible solution, the study recommended to cultivate large blocks that are easier to protect. However, the farmers in the KOISP project also have problems to protect paddy from crop damages by livestock, even though paddy is cultivated in large blocks. The project impact evaluation study of KOISP assessed the problem of crop damages in paddy and concluded, “The conflict between cattle owners and paddy farmers has become one of the major problems of the project, threatening its sustainability“ (IIMI 1995).

THE LIVESTOCK OWNER’S PERSPECTIVE

The problem of crop damages by grazing livestock is closely related to increasing population density, which has led to competition between crop and livestock farming for land. Following the argumentation of McIntire et al. (1992), one can assume that crop-livestock competition only occurs after the expansion of crop farming has reached the point at which grazing grounds available during the cropping season become scarce. Until this point is reached, the expansion of crop farming usually increases the potential for livestock farming because crop by-products, especially stubble, improve the fodder availability during the dry season. In the research region, the point at which competition occurs was probably reached during the middle of the 1980s. In the first phase of the above-mentioned KOISP project, which was completed in 1986, an area of 8,800 ha was developed for cultivation. This is more than the total area under all major irrigation schemes that were developed in the area during the entire colonial period (IIMI 1995; Irrigation Department 1975). Moreover, KOISP is situated in an area that traditionally served as a major grazing ground for the cattle and buffalo herds during the cropping season, a fact which contributes to the problem of crop damages. Even though individual cases of crop damages were already recorded during the colonial period (Woolf 1983), the reports by the interviewed persons provide evidence that the incidence of crop damages increased considerably during the last decade. The problem mostly affects the new irrigation scheme, as mentioned above, but also the non-irrigated areas to which the livestock owners now shift their animals during the cropping season since they had to make way for KOISP. The interviewed administrators of villages in the surroundings of KOISP, which rely mostly on non-irrigated cultivation, reported between 150 and 200 cases of crop damages per season. The damages are usually caused by cattle and buffalo herds owned by persons who reside in the traditional paddy cultivation areas. As the livestock owners protect their own crops (see Section 4), these areas are less affected by livestock. The interviewed village administrators reported less than five cases per season.

The interviews with the livestock keepers showed that they consider the expansion of crop cultivation, especially under KOISP, as a violation of their traditional property rights in these land resources. Therefore, they are reluctant to take measures to prevent crop damages caused by their herds. The livestock owners do not continuously herd their animals throughout the day, and they paddock only the calves during the night. They still practice the traditional system that emerged under low population density when herding was not necessary in order to prevent crop damages. There are obvious economic incentives not to change the prevailing system: continuous herding would decrease the return to labor due to increased labor input and because paddocking the herds during the night time would reduce feed intake, thus affecting milk yields and growth rates.

4. POTENTIAL SOLUTIONS FOR CROP-LIVESTOCK CONFLICTS

The crop damages caused by livestock can be considered as an external effect of the prevailing livestock farming system. In the theoretical literature, three major approaches to solve the problems caused by externalities can be distinguished: a "neo-liberal solution," an "interventionist solution", and a "communitarian solution." The following sections examine to which extent each theoretical position can be applied to the problem of crop damages in the research region.

THE NEO-LIBERAL SOLUTION

The neo-liberal solution to problems caused by externalities can be expressed by the Coase Theorem, which holds that a clear specification of private property rights is a sufficient solution to the problem of externalities. In the absence of transaction costs, voluntary bargaining between individual agents will, according to the theorem, lead to an efficient outcome, regardless of how property rights are initially assigned (Coase 1960). Interestingly, Coase used exactly the problem of crop damages caused by livestock to illustrate his argument. In his example, Coase assumed that a cattle-raiser and a neighboring crop farmer trade for property rights regulating crop damages. Depending on how the liability for crop damages is defined, they trade either for the crop farmer's right to compensation or for the cattle farmer's "right to damage the crops." Coase showed that, whichever way the liability is defined, the trade will lead to an efficient allocation of the land resources according to the comparative advantage of crop and livestock production. The "Coase Theorem" requires no state intervention to solve externality problems because a market in which property rights are traded solves the problem. The idea that even property rights can be allocated efficiently through the market mechanism fits well into neo-liberal economic reasoning and explains to a large extent the popularity of the Coase Theorem in mainstream economics (Medema 1994).

To judge the applicability of the neo-liberal solution in the Sri Lankan case, it is useful to consider two major assumptions on which the Coase Theorem is based:

- the absence of transaction costs, and
- the irrelevance of equity questions.

ad (1): Coase (1960) pointed out that his argumentation only holds if there are no costs involved in carrying out market transactions (transaction costs are zero). Coase (1960) left no doubt that he considered this assumption an unrealistic one. In the Sri Lankan case considered here, individual bargaining between crop and livestock farmers would certainly involve transaction costs because each crop farmer would have to strike a deal with several livestock farmers in order to protect his crops. Otherwise, the crop farmers would have to organize themselves, which also involves transaction costs.

ad (2): Coase (1960) mentions that his argument does not take questions of equity into account. However, it is obvious that the assignment of property rights and the bargaining for them alters the distribution of wealth and income of the parties concerned. In the Sri Lankan case, the current distribution of wealth and income between the livestock keepers and the *chena* farmers is already rather unequal. As indicated above, the livestock owners belong to the upper stratum of the village society, while the *chena* farmers usually live below the poverty line. Even if the right to compensation for crop damages is assigned to the *chena* farmers, the social barriers created by the difference in status, wealth, caste and education make it unlikely that *chena* farmers and livestock keepers could enter any individual bargaining process as equal partners.

Further implicit assumptions of the Coase Theorem are also unlikely to apply: the assumption of perfect knowledge of one another's production and profit or utility functions, and the assumption that agents strike mutually advantageous bargains in the absence of transaction costs (Hoffman and Spitzer 1982).

As major assumptions of the theorem do not apply, it does matter how the property rights are initially assigned. So long as there are transaction costs and information costs, as well as social and class barriers between the parties concerned, private bargaining for property rights may either not take place at all or it may not lead to an efficient outcome. Therefore, the idea of the Coase Theorem that a market mechanism for the exchange of private property rights can solve externality problems is not applicable in the Sri Lankan case. In this sense, one can speak of a "market failure."

THE INTERVENTIONIST SOLUTION

State intervention is the other classical answer to the problem of externalities. In principle, different types of state intervention are conceivable as measures to deal with the problem of crop damages. In the following, four instruments will be discussed which differ in the level of state intervention and in the degree to which they can be enforced at the local level:

- a Pigouvian tax on cattle and buffalo,

- regulations that make the herding of the animals compulsory and prohibit stray animals,
- regulations that forbid livestock keeping in cropping areas, and
- regulations that assign the liability for crop damages to the livestock farmers and include provisions to enforce this liability by state intervention.

ad (1): The Pigouvian tax is generally judged to be superior to other instruments of state intervention on efficiency grounds, but this instrument is difficult to implement in the case under consideration. Besides the problem of determining the appropriate tax level, which internalizes the external costs caused by the crop damages, the implementation of such a tax is affected by difficulties to record the exact number of animals kept by the individual livestock owners.

ad (2): A legal regulation which requires that livestock farmers herd their animals had already been established in the case under consideration. According to the Cattle Trespass Acts No. 12 of 1941 and No. 24 of 1949, the local administrative authorities such as municipal and town councils have the right to catch all animals in the area under their administration which are not herded and demand a fine from the owner. A similar provision was included into the Agrarian Services Act No. 58 of 1979, which applies to the land resources in irrigation schemes and to other cultivated land held as formal private property. These formal legal regulations have so far hardly been enforced by any municipal or town council or by any village administrator in the research region. The interviewed administrative officers mentioned potential conflicts with livestock owners as a major reason.

As will be discussed in Section 5 in more detail, the attitude of the administration concerning the enforcement of these regulations plays a key role in solving the problem of crop damages.

ad (3): A legal regulation which forbids keeping grazing livestock in cropping areas already existed in the case under consideration. According to the Agrarian Services Act, the paddy farmers within one irrigation tract fix at their seasonal meeting a date for the start of the cultivation and the livestock owners are required to move their herds out of the paddy cultivation areas before this date, otherwise they can be fined by the village administrator. In the traditional paddy growing areas, this regulation was fairly well enforced. The livestock owners had a strong incentive to comply with the regulation because they often had their own paddy lands situated in the respective irrigation tracts. Difficulties to enforce this regulation arose, however, in the more recently established irrigated areas, such as KOISP, to which the livestock owners traditionally used to move their animals during the cropping season.

ad (4): The assignment of the liability for crop damages to the livestock farmers was also established in the Sri Lankan case. This regulation, too, was affected by enforcement problems. According to the Agrarian Services Act, each crop cultivator with formal property rights in the land he cultivated had the right to seize an animal “trespassing“ on his land and detain it until a compensation for the crop damages was paid. The crop cultivator had to inform the village administrator, who had to assess the crop damages and to inform the livestock owner. In case the livestock owner failed to pay, the Commissioner of Agrarian Services was entitled to sell the seized animals by public auction and pay the compensation out of the proceeds of the sale. The Agrarian Services Act did not require that crop cultivators fence their land in order to be entitled to claim compensation. In general, the regulations of the Act can be interpreted as an attempt of the state to reduce the transaction costs of the crop farmers involved in enforcing their private property rights in land, because (1) the Act unconditionally passed on the liability for crop damages to the livestock farmers and (2) the Act shifted the efforts involved in claiming compensation to the local administration. According to the Act, all the crop farmer had to do was to seize the animal and inform the village administrator.

However, the crop farmers had considerable problems to enforce this formal right to compensation since: (1) according to the estimation of the interviewed village administrators, the crop farmers were in one third of the cases not able to seize the animals causing the damage; (2) for technical reasons, the appropriate assessment of the damage was difficult and turned out to be a major cause of social conflict in the villages; and (3) the provision of the Act to auction the animals if the livestock owner failed to pay was not practical because the livestock farmers acted in solidarity and did not buy animals at such auctions. Therefore, such auctions were hardly held at all.

The Agrarian Services Act did not apply to *chena* farmers because they did not hold formal property rights to the land on which they grew crops. They could, however, claim compensation for crop damages on the basis of the general legislation which protected their rights to the actual crops. The jurisdiction acknowledged that *chena* farmers were—according to the principle of *fructus industrialis*—the owners of the crops they grew. On this basis, they were granted the right to compensation, but they had to seek the assistance of the police and, if this was not successful, file a case in court. As several visits to the police were necessary to deal with a single case, this procedure involved considerable transportation costs and resulted in the loss of whole working days, which was difficult to bear during the cultivation season. For the *chena* farmers, there were also social barriers to contacting policemen and advocates. Due to such reasons, none of the three police stations in the research area recorded more than ten reports of crop damages in *chena* fields per year, although the number of such cases in a single *chena*-based village easily exceeded 100 per season. Not a single case for compensation for crop damages by livestock had been filed in court by *chena* farmers during the last years.

In conclusion, as the discussion of this section shows, none of the potential instruments of state intervention which could internalize the external costs caused by the crop damages was effectively enforced at the local level. In this sense, one can speak of a “government failure.“

THE COMMUNITARIAN SOLUTION

In view of government failures and market failures, a third approach to solve externality problems has received increasing attention in economics: informal institutions such as social norms which are enforced by local communities, herein referred to as a “communitarian solution.“ One can distinguish two types of “communitarian solutions“ to problems caused by externalities: (1) traditional social norms or other informal institutions which have emerged over time at the local community level for a variety of reasons, and (2) institutional arrangements which have been specifically created by the members of the respective community to solve the crop damage externality problem. This section deals only with the first type of solution. The second type is dealt with in Section 5.

In the case under consideration, traditional social rules to deal with the problem of crop damages have indeed evolved, but they have been considerably weakened during the last decades. The interviews revealed that the livestock owners traditionally used to pay compensation for crop damages to *chena* farmers, even though they were not formally required to do so. The payment of compensation was embedded in a traditional patron-client relationship between the livestock owners and the *chena* farmers. The livestock farmers usually owned paddy land on which the *chena* farmers worked as hired laborers. The livestock owners also interacted as money lenders and traders with the *chena* farmers. The payment of compensation by the livestock owners was considered as a deed of mercy rather than as the fulfillment of a right held by the *chena* farmers. The village community played a role as well, since there was publicly disapproval if a relatively rich livestock owner refused to pay compensation for the crop damages suffered by a comparatively poor *chena* farmer.

The weakening of the social rule to pay compensation can be related to the dissolution of the traditional patron-client relationship. The mechanization of paddy cultivation since the 1960s reduced the dependence of the livestock owners on the labor resources of the *chena* farmers. The emergence of semi-formal credit organizations in the villages promoted by NGOs, development projects and the government reduced the dependence of the *chena* farmers on the livestock owners as money lenders. In addition, many *chena* farmers are descendants of settlers who emigrated during the last decades from other regions of the country, because they received paddy land in irrigation projects. These *chena* farmers have never established personal relations to the livestock owners. Moreover, the livestock owners feel that both the settlers in the irrigation projects and their descendants who engage in *chena* cultivation are invading their traditional grazing rights. Therefore, they do not perceive that they have any social obligation to pay compensation for crop damages occurring in these areas.

In conclusion, traditional social norms have become defunct with the dissolution of patron-client relationships and new informal rules, based on voluntary co-operation, are not likely to evolve in a society that is stratified by unequal access to resources, separated by different caste affiliation, and fragmented due to ongoing immigration. To characterize such cases in which informal regulations are not likely to work, Ellickson (1991) has introduced the concept of “social imperfections“—an analogy to the concept of market imperfections. One could also draw a parallel to the concept of market and government failure, and speak of a “community failure“ in this case.

5. COLLECTIVE ACTION AND BARGAINING AS A SOLUTION

The preceding section has shown that the three classical solutions to problems of externalities did not work in the case under consideration because of market failure, government failure and “community failure.“ This section discusses an alternative solution: collective action and bargaining between organized groups with the participation of state authorities. Such a process is currently going on in the research region. The politicians and the local administration act as advocates of the *chena* farmers. Under the mediation of an appointed committee, they bargain with the organized livestock farmers for the following “deal“: The livestock farmers commit themselves to avoid crop damages. In exchange, they receive formal reserved pastureland where they can keep the animals during the cropping season.

This process combines elements of all three classical solutions: the bargaining aspect of the Coase solution; the involvement of the state, which characterizes the interventionist solution; and the engagement of the local communities, which is the essence of the communitarian solution. The following analysis deals with the conditions under which a combination of these elements can possibly overcome the failures of the three classical solutions. For this purpose, the process which is currently going on in the research region is analyzed as a process of institutional change which is driven by the interaction of different interest-groups within a given political and administrative arena. In the first step, the interest groups involved and their organizational capacity are examined. In the second step, the political and administrative institutions and actors involved are analyzed. In a third step, the bargaining process taking place in the research region is examined and a model solution is discussed, which has been developed for one Agrarian Services Division.

THE INTEREST GROUPS INVOLVED AND THEIR ORGANIZATION

Three potential interest groups may be distinguished: the paddy farmers, the *chena* farmers and the livestock owners. The organizational capacity of the potential interest groups is characterized by the classical problem of collective action described by Olson (1965). To analyze the organizational capacity of the respective interest groups, one can apply the transaction costs concept of the New Institutional Economics. The transaction costs influence what Davis and North (1971) call the "perception and organization lag"— the time that is required to perceive the potential profits from a new institutional arrangement and organize an interest group. Drawing on the argumentation of Davis and North (1971), one can assume that the lag will be shorter:

- the smaller is the number and the greater is the socio-cultural homogeneity of persons who compose the relevant interest group,
- the larger are the expected net benefits, the closer (in point of time) are these benefits, and the greater is the degree of certainty with which the expected costs and benefits are known,
- the lower is the risk aversion and the time depreciation of the potential members,
- the longer is the menu of known institutional alternatives to the present situation,

- the better is the access of the potential members to the communication and transportation infrastructure, and
- the greater is the possibility to redirect an already existing organization or to pursue the interests within an existing organization.

In the research region, the livestock keepers have organized themselves during the 1980s in three formally registered organizations, which are united in one umbrella organization. According to the factors listed above, the organizational capacity of the livestock farmers can be explained by the fact that they represent a comparatively small and socially homogenous group of comparatively wealthy people with easy access to means of transportation and communication. Moreover, the livestock farmers had an “institutional alternative“ which they pursued: the formal ownership of pastureland where crop farming was not allowed and where they could keep their animals during the cropping season. Another factor which is not included in the above list also played a role: the charismatic leadership provided by one livestock owner who served as the secretary of one of the three livestock farmers’ organizations and as the general secretary of the umbrella organization.

The paddy farmers are formally organized in Farmers’ Associations for the purpose of irrigation management. In contrast to the case of the livestock farmers, the organization of the paddy farmers is strongly supported by state authorities, especially the Agrarian Services Department, which even organized the relevant meetings. In the irrigation projects, membership is compulsory. Therefore, the paddy farmers had in principle the possibility to pursue their interests with regard to the problem of crop damages within these already existing organizations. However, in the new areas of the KOISP project area, where crop damages in paddy were important, the paddy farmers' organizations were not well functioning, despite state support. As the settlement project was still new, the heterogeneity of the settlers in terms of caste and origin was particularly pronounced. Moreover, widespread disputes among the settlers over the boundaries of the allocated paddy lands, along with some absentee owners, were obstacles to the creation of solidarity.

The *chena* farmers in the research region were hardly organized at all to pursue their common interests with regard to the problem of crop damages. Recalling the factors listed above, this can be attributed to their relatively large number, their socio-cultural heterogeneity (different origin and caste affiliation, etc.) and their comparatively low income, which implies a high time depreciation and risk aversion. The fact that the *chena*-based villages were poorly connected to the communication and transportation infrastructure also reduced the organizational capacity of the *chena* farmers. Moreover, the *chena* farmers were not in a position to pursue their interests in already existing organizations, even though many of them were members of various organizations such as semi-formal credit societies or village groups created in connection with the implementation of poverty alleviation programs. None of these organizations was directly related to *chena* farming and the organizations usually included members such as laborers or craftsmen who were not interested in *chena* farming at all. Moreover, the village groups of these organizations were highly dependent on external "social mobilizers." The experience in the research region has shown that the village groups usually stopped functioning when the respective program was terminated and the social mobilizers withdrew. Furthermore, unlike the livestock owners, they did not know of an institutional alternative to the present situation. Their experience had only shown that all measures taken so far had not been effective in solving the crop problem.

THE POLITICAL-ADMINISTRATIVE SYSTEM

To understand the role of ”the state“ in the bargaining process in the research region, it is useful to conceptualize the state as a system of political and administrative institutions that create an incentive structure for politicians and bureaucrats and influence the bargaining power of the interest groups identified above. Sri Lanka’s political and administrative system can be characterized as a comparatively stable democracy which allows changes in the party or coalition in power by democratic elections. Since the introduction of a Provincial Council system in 1987, which was part of a decentralization package designed to solve the ethnic conflict, political representation in Sri Lanka involves three levels: the parliament, the directly elected provincial councils, and—at the local level—the Pradeshia Sabhas, town councils and municipal councils. The members of all these bodies are elected according to a proportional system of representation and a preferential system of voting. This election system creates a particularly strong incentive for the individual candidates to care for the interests of the voters in their district. The system also results in a high politicization even among the rural population and in widespread clientelism, patronage and populist policies (Dunham and Kelegama 1997; Moore 1997). In order to secure votes, politicians have an incentive to induce the local administration to implement development programs and policies beneficial to their voters. The electoral districts are coterminous with the administrative districts and their administrative resources, which facilitates the co-operation of politicians at all levels with the local administration. In addition, “District Political Authorities“ were created in order to accelerate the process of development at the district level and involve grass-root level organizations in local planning and project implementation (Warnapala 1997). Under the present system, the District Development Committees (DDC), which is chaired by elected politicians, continue to pursue these goals.

The political and administrative system influences the comparative power of the interest groups involved. As the *chena* farmers represent the largest number of voters, their interests have to be addressed by politicians of any party if they want to win elections or stay in power. The fact that the *chena* farmers are not organized certainly limits their ability to articulate their interests. Nevertheless, the political system described above, which implies a close direct relation between the voters and the political candidates, leaves room for the expression of interests even for groups which are not formally organized. This is especially the case during election campaigns. By continuously addressing the crop damages problem in meetings with politicians, the *chena* farmers were obviously able to make the politicians and the local bureaucracy aware of the urgency of the problem. Moreover, the politicians and the local administration have been kept informed about the problems faced by development projects promoting new crop farming technologies, as described in Section 2. Although they tend not to get involved in direct political advocacy, development project and NGO staff can be important in channeling information about issues confronted by *chena* farmers to local administrations, which serve as project implementing agencies. Interviews with politicians and local administrators showed that they consider the problem of crop damages as a serious obstacle to the agricultural development in the region.

In contrast to the case of the *chena* farmers, the political power of the livestock farmers rests mainly on their ability to organize themselves effectively and act as a political pressure group. Since their number is comparatively small, their political influence cannot be based on the votes they represent. However, due to their high degree of organization, they are well prepared for lobbying activities and their representatives are able to communicate directly with political and administrative decision-makers. Moreover, due to their comparatively wealthy status, the livestock keepers are able to support the election campaigns of political candidates. Due to these factors, the politicians have an incentive to find solutions that take the interests of the livestock farmers into account.

The paddy farmers represent more votes than the livestock farmers do and, as described above, they are organized, too. However, crop damages are not very prominent in the lobbying activities of the paddy farmers' organizations. Other aspects of paddy cultivation, especially the distribution of irrigation water and the farm gate price of paddy, appear to be of greater relevance for the paddy farmers as an interest group. This can be related to the fact that only the paddy farmers in the new irrigation and settlement projects are severely affected by livestock-related crop damages. As has been outlined above, they are less efficiently organized than the paddy farmers in traditional areas are.

THE PROCESS OF NEGOTIATING A SOLUTION

Until the early 1990s, the strategy of the administration, especially of the Department of Animal Production and Health, was to convince the livestock farmers to switch to a more intensive system of livestock keeping, involving improved breeds, systematic fodder management, feeding of concentrates, etc. This was seen as an incentive for the livestock owners to reduce their herd sizes voluntarily. It was popular among the administration and the politicians to consider this strategy as an appropriate solution to the problem of crop damages because it would not involve major conflicts with the livestock owners. The interviews showed that a more intensive system of livestock keeping was considered as a necessary “modernization“ of the prevailing system, which was often characterized in a pejorative way as “semi-domesticated.“ However, even though the Department offered extension services as well as subsidies for breeding animals, concentrates, establishment of fodder plots, etc., the livestock farmers did not show any interest in adopting the proposed innovations. Their reluctance to adopt more labor- and capital-intensive technologies can be attributed to economic incentives. As outlined in Table 5, the present extensive system of keeping large herds is competitive in terms of its return to labor and capital. The intensification promoted by the administration aimed at improving the return to land without taking into consideration the—potentially negative—impact of the proposed techniques on the return to capital and labor.

Table 5—Farm enterprise income from cattle keeping

Item	Small herds	Medium herds	Large herds
Total herd size (number of animals)	5	30	100
Gross output			
from milk (Rs.)	3,470	16,240	89,390
from cull animals and stock increase (Rs.)	3,760	16,210	67,600
Total (Rs.)	7,230	32,450	156,990
Total costs[a] (Rs.) (without imputed labour and capital costs)	2,130	15,010	69,150
Enterprise income I (Rs.) (without imputed labour and capital costs)	5,090	17,440	87,830
Fixed capital (Rs.)	9,460	48,630	224,100
Enterprise income II (Rs.) (with imputed capital costs, without imputed labour costs)	4,050	12,090	63,780
Input of labour (man-days)	216	231	552
Enterprise income I per man-day[b] (Rs.)	24	76	159
Enterprise income II per man-day (Rs.)	19	52	114
Enterprise income I in relation to fixed capital[c] (percent)	54	36	39

Source: Birner (1996)
[a]Variable and fixed costs including infrastructure depreciation.
[b]The daily labor wage in paddy cultivation during the peak season was Rs. 135.
[c]The interest rate in the formal bank sector was in the range beween 20 and 25 percent.

One can assume that, as long as the livestock farmers bear relatively low opportunity costs of land—which is the case in the present system—their incentive to adopt the proposed technologies and reduce their herd sizes will remain low. In addition, intensive systems of cattle and buffalo farming are generally discouraged in Sri Lanka by an unfavorable relation of the prices for milk and concentrates.

In the 1990s, it became obvious that the strategy of the Department of Animal Production and Health to convince the livestock owners to voluntarily reduce their herd sizes had failed. At the same time, the problem of crop damages gained momentum due to the increasing population density and the expansion of crop cultivation. The three election campaigns of 1994 with their numerous meetings at the village level provided an excellent forum for the *chena* farmers to launch complaints concerning the crop damage problem. In 1995, the above-mentioned District Development Committee (DDC), which is chaired by a Member of Parliament elected for the district, decided to attend to the problem. The DDC organized a large special meeting to which representatives of the livestock farmers' organizations, the paddy farmers' organizations, NGOs, development projects and the local administration were invited. The *chena* farmers did not participate, because they had no organizations and, therefore, no representatives who could claim to speak for them. However, the interests of the *chena* farmers were expressed by the Member of Parliament who chaired the meeting and by members of the administration. As the number of participants was too large to start a negotiation process immediately, a special committee was nominated which should negotiate a solution. This committee can be considered as an intermediary or facilitator in the bargaining process. It comprised two Sri Lankan counterparts of a foreign-funded agricultural development project and one entrepreneur from the agribusiness sector.

In the past, the livestock owners had already demanded that the government allocate land to them as exclusive pasture. This demand was forwarded to the government during the planning period of the above-mentioned KOISP. As a result, the government identified in 1986 an area of 445 hectares to be declared as exclusive pastureland. However, these land resources were not officially handed over to the livestock farmers' organizations. In the Agrarian Services Division most seriously affected by the problem of crop damages, about 75 percent of the livestock owners who keep more than ten animals were organized in the cattle owners' association responsible for this area. In essence, the committee negotiated between this association and the DDC as the relevant political and administrative decision-making unit.

The members of the livestock owners association who together keep approximately 23,800 heads of cattle and buffalo demanded an extension of the land area of 445 hectares which was identified as pastureland in 1986, because this area was obviously not sufficient to maintain the herds of all members during the cropping season. The bargaining problem arose from the fact that the available land resources in the region were not sufficient to maintain the total number of animals kept by the association without reducing the land available for *chena* farming. To reduce this conflict of interests between the livestock owners' association and the *chena* farmers, the committee proposed (1) to declare an area as reserved pastureland where the incidence of *chena* farming was particularly low and (2) to improve the carrying capacity of these land resources by technical measures. The pastureland proposed by the committee covers an area of 2,000 hectares, including the 445 hectares identified in 1986. The suggested improvement measures include the rehabilitation of land resources which had been destroyed by gem mining, the restoration of existing tanks (small earthen reservoirs) and the construction of additional tanks, the introduction of water conservation methods, and the establishment of improved pasture and fodder trees. The committee estimated that even if these measures were taken, only half the number of animals currently kept by the members of the livestock owners' association could be maintained in the proposed pastureland throughout the cropping season. Therefore, the problem of crop damages could only be solved if members of the association committed themselves to take measures to prevent crop damages outside the proposed pastureland, including a reduction of the herd sizes.

One may ask why the livestock owners' association entered into a bargaining process at all under these rather unfavorable conditions. The major incentive probably came from signals of the politicians that they could induce the local administration to enforce the stray cattle legislation, if no agreement was reached. This threat was credible, because the politicians had a strong incentive to prove that they were able to solve the problem of crop damages after they had publicly given the issue a high priority by involving the DDC. As the local administration participates in the DCC, they also have an incentive not to create the image of being incapable of solving problems of high priority. Moreover, the interviews implied that the attitude of the local administration towards the livestock and the *chena* farmers had gradually changed in favor of the latter group during the last decade. By implementing poverty alleviation programs such as the Janasaviya program or the 15,000 villages project, the local administrators had developed a more direct relationship to this group. Moreover, the local administrators had experienced that many project activities in the crop farming sector in which they were involved were doomed to fail because of the crop damages problem.

The livestock owners knew that, if the administration enforced the stray animals legislation, they would have to reduce their herd sizes and take measures to prevent crop damages without receiving pastureland in return. The committee proposed an additional incentive to convince the association to agree to the proposal: it suggested that the livestock owners' association itself, and not a state agency, should manage the proposed area of 2,000 hectares of pastureland. The association should receive formal permanent use rights in the proposed pasture area and be in charge of the implementation of the proposed upgrading activities. The Norwegian-funded Hambantota Integrated Rural Development Project and USAID agreed to provide technical and financial support for this purpose.

As an appropriate organizational structure, the committee suggested a company with limited liability formed by the members of the livestock owners' association. The livestock owners' association accepted the proposal in a special meeting after a highly controversial discussion, as did the DDC. The administration promised to enforce the stray cattle legislation in case the livestock farmers failed to fulfill their commitment to prevent crop damages. Obviously, the credibility of this commitment by the administration plays a crucial role for the implementation of the proposal, because it represents the only threat which can prevent the livestock owners from free riding on the proposed solution, that is to receive the pastureland without fulfilling the commitment to prevent crop damages. As mentioned above, the administration has its own incentives to keep its commitment and, in addition, the local politicians have—due to the reputation effect—an incentive to induce the administration to keep its commitment. At the time of terminating the research in 1998, the livestock owners' organization had already registered a private company with limited liability as required by the proposal. The local administration was in the process of surveying the respective land resources in preparation for the official transfer of the property rights in the proposed pastureland.

It remains to be seen whether the proposed solution will eventually solve the problem of crop damages. On the one hand, the proposal involves considerable potential. Unlike earlier approaches, it was negotiated with a view to balancing the various interests, and the parties involved gave their explicit consent. Moreover, the proposal includes an institutional innovation: the arrangements proposed for the management of the pastureland in the form of a private company. On the other hand, the successful implementation depends on a number of critical factors: the possibilities of enforcement crucially depend on the willingness of the local administration to enforce the stray animal legislation if the livestock owners do not comply with the provisions of the proposal. The incentive of the politicians to exercise pressure on the administration mainly depends on the political weight which they attach to the loss of reputation occurring in case they cannot solve the crop damages problem after placing it on the political agenda. It also depends on the extent to which the voting power of *chena* farmers carries weight in comparison to the lobbying efforts and election campaign support provided by the livestock farmers. Moreover, to be sustainable in the long run, the utilization of the proposed pastureland has to be economically viable without subsidies: this remains a major a challenge—both from the organizational and from the technical point of view.

6. CONCLUSIONS

The study of *chena* farmers and livestock owners in the Hambantota District of Sri Lanka allows one to draw several conclusions on the relation between property rights, collective action, and technology adoption. The first conclusion concerns the relation between property rights and the adoption of innovations, the development of which has been induced by economic forces such as changing price relations of land and labor. In accordance with the induced innovation hypothesis, the increasing population density in the research region led to the development of innovations, which allowed for use of increasingly scarce land resources in a more efficient way. Due to the goals and interests of the organizations which promoted these innovations, the new technologies were not only designed to use scarce land resource more intensively, but also to enhance environmental sustainability and raise the income of the most disadvantaged land users, the *chena* farmers. The organizations promoting these technologies managed to remove major "traditional constraints" to technology adoption by providing infrastructure and information and by organizing semi-formal credit societies. However, the concentration of traditional informal rights in grazing resources in the hands of the livestock owners and poor enforcement of formal property rights held by crop farmers under increasing population pressure and competition for land resulted in crop damages by livestock, which prevented the adoption of more sustainable land use practices. It can be concluded that induced technical change may require institutional change such as a redistribution of property rights and greater incentives to enforce rights as crucial prerequisites. In such situations, institutional change has causal priority over technical change for determining the path of agricultural development.

The case study also supports the conclusion that a redistribution of property rights, which makes more efficient land use possible, is not simply induced by a change of the economic conditions such as increased population density. The case study rather shows that due to market failures, government failures and "community failures," none of the classical solutions to solve problems of externalities could be applied. Thus, the case considered here contradicts the "efficiency theory" of institutional change, which is reflected in Demsetz's (1967) hypothesis that "Property rights develop to internalize externalities when the gains of internalization become larger than the cost of internalization." The case study is rather an illustration for North's (1990) view that "Institutions are not necessarily or even usually created to be socially efficient; rather they, or at least the formal rules, are created to serve the interests of those with the bargaining power to devise new rules."

One can conclude from the case study that the bargaining power of the potential interest groups involved in institutional change crucially depends on their capacity to organize themselves and act collectively in order to pursue their interests. The comparative bargaining power is also strongly influenced by the political and administrative system in which the different interest groups interact. In the case under consideration, the resource users who were most disadvantaged by the prevailing property regime were also those with the lowest organizational capacity: the *chena* farmers. This can be considered as a dilemma because exactly these resource users would have had to pursue a change in the prevailing property regime in order to make a more efficient, equitable and sustainable land use possible.

In the Sri Lankan case, the political system of a functioning democracy, a decentralized form of government and a preferential system of voting created an incentive for the politicians and for the local administration to act as advocates of the *chena* farmers. A platform to start a negotiation process was already institutionalized. Members of a donor-funded project and a private sector institution were able to play a facilitating role. Due to this combination of factors, a process of institutional change could be induced in spite of the low organizational capacity of the *chena* farmers. Such favorable conditions are not enjoyed in many developing countries. What has been achieved due to the comparatively favorable conditions was the development of a model solution, which is now in the process of being implemented.

However, this solution has been developed without the active participation of the *chena* farmers themselves. While the traditional patron-client relationships between *chena* farmers and livestock owners had been dissolved, the *chena* farmers had become clients of the politicians and the local administration. One could argue that in the case under consideration, active participation of the *chena* farmers in the bargaining process might not have changed the result. However, in cases where the political and administrative frame conditions are less favorable, active participation of the groups which are disadvantaged under the current distribution of property rights may be essential to induce institutional change which leads to more efficient, equitable and environmentally sustainable resource use. For such cases, the case study supports a further conclusion. The analysis has shown that the New Institutional Economics and the theory of collective action can well explain why the organizational capacity of the *chena* farmers was so low that they could not enter the bargaining process directly. By drawing attention to the relevance of direct communication, reputation, trust and reciprocity, the theory of collective action can also explain how collective action can be achieved and sustained among individuals who have symmetrical interests and access to resources (Ostrom 1998). However, the New Institutional Economics and the theory of collective action are less well equipped to deal with issues of power, and answer the question of how collective action can be induced between groups which have unequal access to resources and which are divided by social barriers of status and wealth. Historical evidence shows that one factor plays a prominent role for turning socially and economically disadvantaged groups into actors of institutional change: the vision that they are—in spite of their disadvantaged position—able to change the present situation, if they act collectively. Creating this vision has much to do with charismatic leadership and ideology. To both factors, the New Institutional Economics and the theory collective action still have remarkably little to say.

REFERENCES

Birner, R. 1999. The role of livestock in agricultural development—Theoretical approaches and their empirical application in the case of Sri Lanka. Aldershot: Avebury.

Boserup, E. 1981. Population and technological change—A study of long-term trends. Chicago: Chicago University Press.

Coase, R.H. 1960. The problem of social cost. Journal of Law and Economics 3 (October): 1-44.

Davis, L.E., and D.C. North. 1971. Institutional change and American economic growth. London: Cambridge University Press.

Demsetz, H. 1967. Toward a theory of property rights. American Economic Review 57 (2): 347–373.

DCS (Department of Census and Statistics). 1984. Sri Lanka census of agriculture 1982—Hambantota District report (Smallholding Sector). Colombo.

________. 1992/93. Agricultural crops and livestock 1992/93—Hambantota District preliminary report. Colombo.

Dunham, D., and S. Kelegama. 1997. Does leadership matter in the economic reform process? Liberalization and governance in Sri Lanka. World Development 25 (2): 179–190.

Ellickson, R.C. 1991. Order without law—How neighbors settle disputes. Cambridge: Harvard University Press.

Gunasena, H.P.M., ed. 1995. Multipurpose tree species in Sri Lanka—Development of agroforestry systems. Proceedings, Sixth regional workshop on multipurpose trees, Kandy, Sri Lanka, 17–19 August, 1995.

Handawela, J. 1995: Role of agroforestry in stabilisation of upland rainfed farming in the South Eastern Dry Zone of Sri Lanka. In Multipurpose tree species in Sri Lanka—Development of agroforestry systems, ed. H.P.M. Gunasena. Proceedings, Sixth regional workshop on multipurpose trees, Kandy, Sri Lanka, 17–19 August, 1995.

HARTI (Hector Kobbekaduwa Agrarian Research and Training Institute). 1995. Production and marketing of other field crops in the Kirindi Oya Project area. Research Study No. 91. March 1995. Colombo.

Hayami, Y., and V.W. Ruttan. 1985. Agricultural development—An international perspective. 2nd ed. Baltimore and London: The John Hopkins University Press.

Hoffman, E., and M.L. Spitzer. 1982. The Coase theorem: Some experimental tests. Journal of Law and Economics 25 (April): 73–98.

IIMI (International Irrigation Management Institute). 1995. Kirindi Oya irrigation and settlement project—Project impact evaluation study. Volume II (Final Report). Colombo.

ILO (International Labour Organisation). 1984. Employment and income generation in agriculture in the District of Hambantota, Sri Lanka. Colombo.

Irrigation Department. 1975. Register of irrigation projects in Sri Lanka. Colombo: Ceylon Printers.

Keerthisena, R.S.K. 1995. Fifteen years of research on alley cropping at Mahailluppallama—Review. In Multipurpose tree species in Sri Lanka: Development of agroforestry systems, ed. H.P.M. Gunasena. Proceedings, Sixth regional workshop on multipurpose trees, Kandy, Sri Lanka, 17-19 August, 1995. Sri Lanka: Peradeniya.

McIntire, J., D. Bourzat, and P. Pingali. 1992. Crop-livestock interaction in sub-saharan Africa. Washington, D.C.: The World Bank.

Medema, S. 1994. The myth of the two Coases: What Coase is really saying. Journal of Economic Issues 27 (March): 208–26.

Moore, M. 1997. Leading the left to the right: Populist coalitions and economic reform. World Development 25 (7): 1009–1028.

North, D.C. 1990. Institutions, institutional change and economic performance. Cambridge: Cambridge University Press.

Olson, M., Jr. 1965. The logic of collective action—Public goods and the theory of groups. Cambridge, Massachusetts: Harvard University Press.

Ostrom, E. 1998. A behavioral approach to the rational choice theory of collective action. American Political Science Review 92 (1): 1–22.

Warnapala, W.W.A. 1997. Provincial politics in Sri Lanka—An analysis of the Southern Provincial Council election 1994. New Delhi: Navrang.

Woolf, L. 1983. Diaries in Ceylon, 1908-1911—Records of a colonial administrator, being the official diaries maintained by Leonhard Woolf while Assistant

Government Agent of the Hambantota District, Ceylon. 2nd ed. Dehiwala, Sri Lanka: Tisara Prakasakayo.

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EPTD DISCUSSION PAPER NO. 49

ORGANIZATIONAL DEVELOPMENT AND NATURAL RESOURCE MANAGEMENT: EVIDENCE FROM CENTRAL HONDURAS

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November 1999

ABSTRACT

The determinants of local organizational density and the impacts of local and external organizations on collective and private natural resource management decisions are investigated based on a survey of 48 villages in central Honduras. Factors positively associated with local organizational development include the presence of external organizations, population level, moderate population growth, lower population density, the presence of immigrants, distance from the urban market, literacy and coffee production. Local organizations are found to contribute to collective action to conserve resources, while government organizations appear to displace it, though not in all cases. The findings suggest that external organizations can play a catalytic role in fostering development of local organizations and emphasize the importance of improved understanding of the roles of local organizations, in order to enhance complementarity and minimize competition between these different agents in promoting sustainable development.

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ORGANIZATIONAL DEVELOPMENT AND NATURAL RESOURCE MANAGEMENT: EVIDENCE FROM CENTRAL HONDURAS

John Pender and Sara J. Scherr

1. INTRODUCTION

In recent years a consensus has begun to emerge regarding the importance of local institutional and organizational development in developing countries as a necessary complement to economic, social and political development. Numerous observers have hailed the increased role for local organizations and other elements of civil society in the wake of structural adjustment policies and declining government budgets in many developing countries (Farrington and Bebbington 1993; de Janvry and Sadoulet 1993; Uphoff 1993; Nugent 1993).

Local (or "grassroots") organizations, defined in this paper as non-governmental organizations (excluding private firms operating for profit) governed and operating at the village level or below (Uphoff 1993), have been claimed to offer numerous advantages favoring rural development (Farrington and Bebbington 1993).[1] These include increasing economic efficiency where private markets fail; increasing the effectiveness of government and non-government programs by involving local people in the design and implementation of such programs; reducing poverty in rural areas by responding to the needs of the rural poor; empowering rural people by increasing their role in decision processes that affect their lives; and improving management of natural resources by

[1] Uphoff (1986) distinguishes organizations, defined as "structures of recognized and accepted roles", from institutions, defined as "complexes of norms and behaviors that persist over time by serving collectively valued purposes". There are many examples of organizations that are not institutions (for example, a particular law firm), institutions that are not organizations ("the law"), and organizations that are institutions (the Supreme Court). We follow Uphoff's distinction in this paper.

helping to foster collective action to manage externalities or common property resources (Baland and Platteau 1996; Rasmussen and Meinzen-Dick 1995; Uphoff 1986). Although substantial work has investigated some of these claims, drawing comparative conclusions about these issues from much of the literature is difficult because of the idiosyncratic nature of many of the case studies that are reported, lack of a representative sampling frame, measurement of different variables in different studies, and lack of use of rigorous statistical procedures to test hypotheses about the impacts of key variables (Rasmussen and Meinzen-Dick 1995).[2]

The present study represents a modest effort to address some of these shortcomings through a study of the development of local organizations and their impacts on natural resource management (NRM) in a representative sample of villages in central Honduras. The issues of local organizational development and natural resource management are critical in Honduras. Local organizational development is relatively limited in most of rural Honduras, and problems of resource degradation—including deforestation, watershed degradation, soil erosion, soil fertility decline, water scarcity and water contamination—are increasingly critical as population continues to grow rapidly in the fragile hillsides of the country (Pender and Durón 1996). However, new opportunities have arisen as a result of declining central government presence in rural areas, increased authority of local governments, and greater presence of non-

[2] The seminal work of Esman and Uphoff (1984) is an exception to this generalization, although the method of selection of their case studies limits the ability to generalize from their findings, as the authors note.

governmental organizations (NGOs) since the early 1990s (Durón and Bergeron 1995). Now is thus an opportune time to study organizational development in Honduras.

In this study, we do not focus on organizational function or performance, but rather on the determinants and impacts of local organizational presence. We focus on voluntary local organizations, which are the dominant form of local organization in the region. In contrast to some recent literature, we emphasize that local organizational development may affect private NRM decisions as well as affecting collective action to manage resources.

2. CONCEPTUAL FRAMEWORK

The conceptual model for this study draws upon the theory of induced institutional innovation (Hayami and Ruttan 1985; North 1990). This theory posits that institutional innovation is induced by changes in relative factor prices or other changes in the net benefits of innovation, and that such innovation influences farmer decisions and can thus have feedback effects on the disequilibria that stimulated the change. In our case, we hypothesize that organizational innovation responds to changes in the factors influencing the costs and benefits of organizational activity. Although organizations and institutions are not identical, we posit that a similar process of induced change applies to organizational development as to institutional change.[3] As in the case of institutional change, the process of induced organizational development is not likely to be automatic, occurring whenever the aggregate benefits of change exceed the costs, because of the

[3] Many of the changes discussed by North and Hayami and Ruttan involve organizational as well as institutional change.

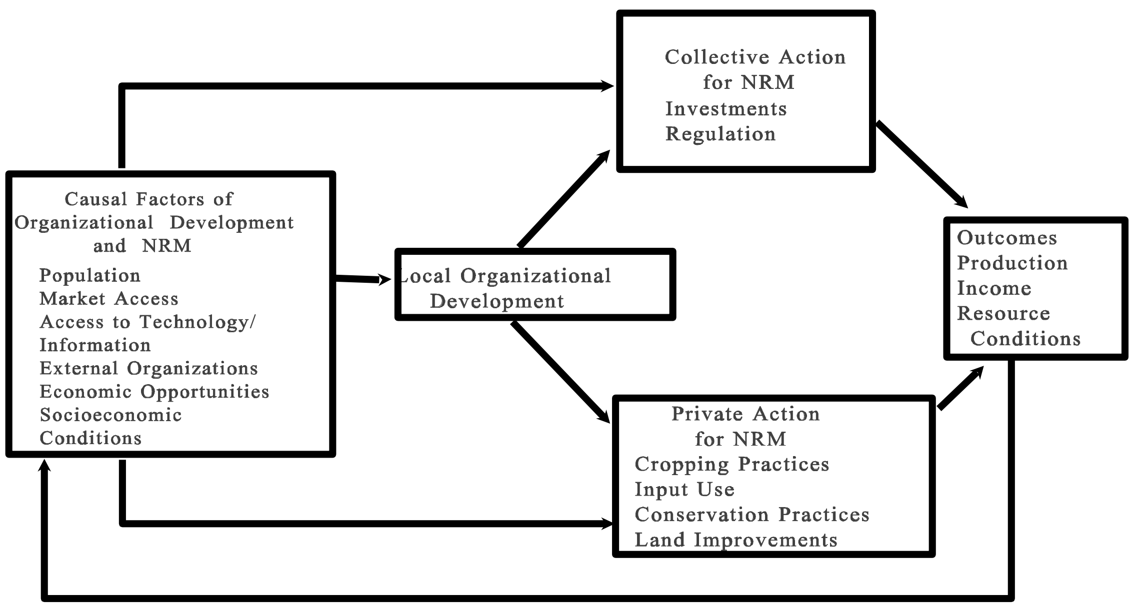
high degree of uncertainty about the benefits and costs, the need for collective action to attain the benefits, and the presence of high fixed costs and other indivisibilities that may cause the process to be path-dependent (North).

In our conceptual framework, changes in factor endowments, market access, economic opportunities, access to technology, interventions by external programs and organizations, local natural resource and socioeconomic conditions and other factors affecting the benefits and costs of organizational activity are hypothesized to induce local organizational change (Figure 1). Development of local organizations can influence natural resource management (NRM) by affecting collective or private actions. Collective action affecting NRM may include community regulation to address externalities, or collective investments to improve common lands, protect the watershed, or otherwise achieve collective benefits. Private actions affecting NRM may include adoption and/or adaptation of new agricultural technologies; intensification of use of factors of production; investments in land or other resource improvements on private land; adoption of soil and water conservation and organic fertility management practices.[4] Both collective and private action affecting NRM may be influenced by a large number of factors other than organizational development; including many of the factors that influence organizational development itself. These factors include access to infrastructure, information, local knowledge, risk, factors of production (land, labor, capital), wealth, and the physical/technical factors that determine local comparative advantage (rainfall, soil types, etc.) (McCullough et al. 1998). Changes in NRM as

[4] Some of these investments may also occur on common or private lands through collective action where collective benefits arise.

determined by collective and private actions lead to changes in outcomes within the village, including impacts on agricultural production, incomes, and resource conditions. These changes in outcomes may influence the costs and benefits of organizational activity, as well as affecting the returns to collective and private action directly, and thus have feedback effects on the process of organizational development and NRM.

Figure 1 Conceptual framework



3. RESEARCH METHOD

We investigated the determinants of local organizational development and the impacts of organizational development on collective and private action affecting NRM using data collected from a survey of 48 villages in the central hillsides region of Honduras. The central region was defined to include all *municipios* (analogous to counties) of the department of Francisco Morazan except two lowland valley communities, and five adjacent hilly *municipios* in the department of El Paraiso.

The central region is relatively homogeneous in terms of topography and climate, while it includes substantial variation in population density, access to markets, and agricultural practices.[5] Over 90% of the region is on hillsides and the climate is generally sub-humid tropical, with annual rainfall ranging from 1000 to 2000 mm. Rural population density averaged 25 persons/km.^{2} in 1988, though it ranged from as low as 9 to as high as 87 in some municipalities. Many villages in the region lack access to roads, requiring up to a half-day by foot or pack animal to reach from the nearest road. Although soils are generally of poor quality and thin and natural pastures are limited, crop and livestock production are the main sources of rural livelihood.

There are serious resource degradation and poverty problems in the region. About half of the region is still covered by pine forest, though nearly one-fifth of the area has been deforested since the 1960s. Soil erosion is a serious problem, with estimated erosion rates in the region ranging from 22 to 46 tons per hectare per year, causing economic losses of as much as 700 Lempiras ($60) per hectare per year (World Bank,

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[5] The region is described in detail in Pender and Durón (1996).

1991). Other major resource and environmental concerns include declining forest quality, soil fertility depletion, watershed degradation, water pollution caused by agrochemicals and other factors, and air pollution caused by forest fires and agricultural burning. Poverty is severe; more than 40% of children were malnourished and more than half of households lack access to potable water or health services in 1991.[6]

STUDY SAMPLE

The villages surveyed were selected by a stratified random sample of 48 of the 325 rural *aldeas* (villages) in this region (excluding Tegucigalpa, the urban center of the region and the capital of Honduras). The stratification was based on 1974 population density of the *municipio* (municipality) in which each *aldea* was located (more or less than 30 persons per km.^{2}) and the distance of the *municipio* county seat to Tegucigalpa (more or less than 60 km.). Twelve *aldeas* were selected from each stratum, and all of the *aldeas* selected participated in the study.[7] We over-sampled high population density *municipios* to obtain sufficient variation in population density in the sample.

SOURCES OF DATA

The sources of information used for the study included a community-level questionnaire administered with groups of typically 15 to 20 respondents, participatory resource mapping, data from the 1974 and 1988 population census, and maps of

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[6] Based on data from the Fondo Hondureño de Inversión Social for the municipios in the central region, excluding Distrito Central, which is dominated by Tegucigalpa.

[7] Of the 31 *municipios* in the central region, 12 (representing 153 *aldeas*) were classified as low population density/close to Tegucigalpa, 11 (101 *aldeas*) were classified as low density/far, 4 (31 *aldeas*) as high density/close, and 4 (40 *aldeas*) as high density/far.

topography, climate, soils and other geographical features of Honduras. The questionnaire explored community members' perceptions about the current state and changes since 1975 in agriculture and NRM (including private and collective action), the factors causing or conditioning these changes (including organizational presence), and some of the consequences of these changes for agricultural production, human welfare and natural resource conditions.[8] The questionnaire included a census of all of the organizations that had worked in the aldea since 1975 and descriptions of the activities of those that were involved in NRM. Complete information on organizations was obtained for only 40 of the communities, so these are used as the basis for the analysis in this paper.[9] The participatory mapping identified *aldea* boundaries (needed to compute village area and population density). The census data provided information on population and some indicators of access to social services, literacy and poverty.

In the respondent groups, we sought to obtain representation of people of different ages, gender, and from different neighborhoods in each village. Unfortunately, however, women were under-represented in the group of respondents in most communities, probably for cultural reasons. This may have reduced the availability and quality of information related to women's organizations (such as housewives' clubs) and activities in which women are more commonly involved. However, according to the respondents

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[8] The questionnaire and details on the implementation of the survey are provided in Pender and Scherr (1997).

[9] Information on the extent of participation in local organizations was collected but was not sufficiently complete to be used in the analysis. Nearly all of the organizations mentioned in the organization census were organizations that still exist in the communities. It is possible that there was under-reporting of organizations that have ceased to exist, though further data collection would be needed to verify that.

(including the women respondents), women are generally less involved than men in most of the agricultural and resource management activities discussed in this paper, so the bias in the results reported here related to under-representation of women may not have been large.

ANALYSIS

We investigated the determinants of local organizational presence and the impacts of organizational presence using econometric analysis, supported by qualitative information from the survey. The variables included in these regressions and the hypotheses about the impacts of explanatory variables are discussed in a later section. In all regressions, the coefficients and standard errors were corrected for sampling weights, stratification, and the total number of communities in the central region (StataCorp 1997). The results are thus representative of the region as a whole. Standard errors were estimated using the Huber-White estimator, and are thus robust to general forms of heteroskedasticity (White 1980).

The "pathways of development" found in the region, were included as explanatory factors in the analysis (along with other factors).[10] A development pathway is defined as a common pattern of change in livelihoods and resource management, and thus represents a particular set of economic opportunities and constraints (Pender, Scherr, and Duron 1999). Using data on occupations and changes in occupations and land use since the mid-1970s, six pathways of development were identified. Basic grain (maize, beans and sorghum) production is the most or second most important occupation in all but one of

[10] The explanatory factors and hypotheses concerning their impacts are discussed later in the paper. Here, we introduce the concept of development pathways, since this is used in the next section.

the sample communities. Other factors were therefore more determinate in distinguishing the pathways. The pathways include villages where 1) basic grain production is the dominant economic activity and has been expanding during the past 20 years ("basic grains expansion pathway"), 2) basic grains production is the dominant economic activity though production has been stagnant or declining ("basic grains stagnation pathway"), 3) horticultural (mainly vegetable) production has increased and has become the first or second most important activity ("horticultural expansion pathway"), 4) coffee production has increased and is the first or second most important activity ("coffee expansion pathway"), 5) forestry activities are the first or second most important activity ("forestry specialization pathway"), and 6) non-farm employment has increased and become the first or second most important source of income ("non-farm employment pathway").[11]

4. LOCAL ORGANIZATIONS AND NRM IN CENTRAL HONDURAS

ORGANIZATIONAL PRESENCE

Rural organization in the central region has historically been poorly developed. Factors that may have contributed to this include poverty, low population density, poor communications infrastructure, political and economic marginality, a tradition of dependence on government organizations, and the relative lack of ethnic differentiation in

[11] In almost all of the basic grains expansion and stagnation communities, livestock production is the second most important activity. All of these pathways are described and analyzed in detail in Pender et al. (1999).

the region.[12] In the 1970s, most organizations were the local offices of national ministries or programs. Local people organized themselves mainly for marketing coffee, pine resin and processed forest products.

Externally-governed organizations, defined as organizations governed at a level above the *aldea* (village), continue to dominate the landscape. Many national government organizations are directly involved in technical assistance related to agriculture and NRM, and water and forest management. Other agencies have indirect effects on NRM through infrastructure, social investment, education, and nutrition and health programs. External NGOs proliferated in the region during the 1980s and early 1990s, with the withdrawal of government social and technical assistance programs, increased availability of international funding, new attention to local environmental concerns, and new philosophies of decentralization and local action for public services, including NRM (Miranda 1997). Over 20 externally-directed NGOs were operating there in 1997.

The density of locally-governed community organizations averages about seven organizations per community (similar to the average number of externally-governed organizations) (Table 1). Of these, nearly 40% are involved to some extent in agricultural or natural resource management activities, although not usually as their primary or original mandate. All are voluntary organizations.

[12] The ethnic composition of the central region is predominantly *ladino* (mixed indigenous/European). Some sociologists hypothesize that rural organizations are more likely to form where there are readily identifiable ethnic or social groups, such as indigenous groups. We are grateful to Stephen Sherwood for this suggestion.

Table 1 Organizational presence in Central Honduras

Mean number of organizations per village (Robust Standard Errors in Parentheses)[a]

Type of Organization	Total Number per Village	Number involved in NRM
Government organization	4.2	2.7
	(3.1)	(1.8)
External NGO	2.3	1.8
	(2.0)	(1.7)
Local NGO	7.1	2.6
	(2.8)	(2.3)

[a] Means and standard errors corrected for sampling weights, stratification, and finite population.

The "*patronato*" has official status as the primary local decision making body at the village level, and exists in almost all villages. *Patronatos* are involved in NRM activities such as repair and construction of drinking water systems, and forest protection, management or establishment in public areas or near water sources. Water committees are relatively common (found in over 60% of villages), and are responsible for maintaining and protecting drinking water systems. Parent associations are common (in over three-fourths of villages), and are mainly involved in school improvements, sometimes including tree planting. Church groups are very common, but they are not often involved in NRM activities, though some have been involved in reforestation, guarding forests, and education about safe use of water. Various types of cooperatives and work groups are found in a few communities, mainly in the non-farm and coffee pathways. A few student and school groups undertake reforestation. A few communities have local chapters of indigenous councils or other civic and social groups.

ORGANIZATIONAL ACTIVITIES IN NRM

Organizations in the central region commonly play three roles in natural resource management:

- Service or support to local farmers and residents in managing privately held natural resources (for example, to improve agricultural production and conservation);
- Collective investment in common property resources (e.g., community forest management, reforestation, building and repairing water systems, run-off control); and
- Regulation of local natural resource use and management by individuals and groups (e.g., watershed and forest protection, water distribution, forest management).

Organizational activities related to common property resources have only recently begun to shift from protection (reducing degradation) to improvement (rehabilitating degraded land or enhancing the quality of existing resources), while organizational activities related to private farm resources is shifting slowly from production to conservation. The greatest concern sparking voluntary collective action has been protection of water resources for local consumption. Local people were also willing to organize to protect forest resources where these are important economically or to protect local watersheds. Similar efforts were uncommon for soil conservation. Local people acted mainly through existing organizations, although new temporary coalitions arose in a few cases to address perceived emergencies.

Support for Local Farmers in NRM

Externally-managed organizations have played a pivotal role in the introduction and dissemination of new agricultural, conservation, livestock and forestry technologies in the central region, both through direct extension and indirectly through diffusion and local information systems. Municipalities were active in no-burning campaigns. Many external agencies provided inputs and services—for example, technical extension, inputs, bank credit or forest micro-enterprise support—through specially organized farmer groups, but these typically disbanded when services were discontinued. Some farmer cooperatives and work groups are supported by outside agencies or supra-local farmer organizations, which provide access to production technology, agricultural inputs, credit, or marketing services for particular commercial products (coffee, resin, sugar, wood products). Most spontaneous diffusion of new NRM practices has occurred through individual, rather than collective, action.

Collective Investment

Collective investment in natural resources is only incipient in the Central region. Most activities are organized by *patronatos*, local water committees, the municipality, or special projects partially financed externally; the major local input is labor. Group action was reported mainly for road maintenance or for building and maintaining potable water systems, which occurs in nearly all communities (Table 2). This reflects the local priority for activities with high near-term benefits. There has been little collective investment in irrigation systems; rather, inexpensive ditch and hose irrigation has been established by individual farmers close to either natural water sources or the new drinking water systems.

Table 2 Collective investments by communities in Central Honduras

Type of Investment	Percentage of Communities Investing[a]
Road maintenance	91.7
Constructing/maintaining potable water system	87.5
Controlling runoff	20.8
Investments on common land (mainly tree planting)	10.6
Collective investments on private land	4.2

[a] Percentages corrected for sampling weights and stratification.

About one-fifth of the region's communities have organized to control water drainage or runoff, by planting trees near water sources or building stone walls. Field visits suggested that these were constructed principally to protect other infrastructure investments, such as roads or water tanks, or to avoid mass movement of soil. All tree planting was organized by local schools, while stone walls were constructed by community members after damage had occurred (Durón 1998). External organizations were involved in only a few of these cases (promoting tree planting near water sources).

Only a tenth of all communities worked collectively on common land improvements, mainly tree-planting.[13] In one case, an external organization had catalyzed the effort by offering food for work to plant trees. All other cases were

[13] "Common land" refers to national or municipal land that has not been allocated for private use. Such land is mainly used as forest land in the region.

organized by members of the community through the school or *patronato*. Collective investments on private land (e.g., drainage construction or maintenance) are even more rare.

Local Regulation of Natural Resources

Until recently, rural people have had limited legal control over natural resources other than private cropland. The national Forestry Law of 1974 gave control over forest resources on both public and private lands exclusively to the state. Much of the land was national or municipal land subject to restrictions on their use and sale, although most farmers had relatively secure tenure. In the 1990s, the legal and institutional context for local organization for NRM changed considerably. The Law of Modernization and Development of Agriculture (LMDSA) of 1992 led to the withdrawal of many national government services and market controls. Agrarian reform land was given full legal status as privately titled land. The Forest Law of 1993 returned many of the rights of commercial use and access to timber and forests to private landowners, local communities and municipalities,although usually subject to some rules for resource protection. Although the area of national or municipal lands had declined in many communities, they were still present in two thirds of our survey communities in 1996; Jurisdictional conflicts are common on such lands.

Local knowledge and interpretation of the new rules varies greatly. The resulting set of norms actually imposed locally to address externalities in NRM thus varied, sometimes reflecting local priorities as much as actual legislation. In 1996, fewer than half of communities in our survey with municipal or national lands restricted rights of outsiders. A quarter prohibited agricultural cultivation on those public lands; few had grazing restrictions. The priority environmental concerns reflected in regulations were water supply and quality. A third of communities with public lands reported having local restrictions on the use of water from those lands. Water restrictions included granting priority for human consumption and prohibitions on contamination. Many forest regulations also serve to protect water resources. While fewer than half of the communities with public land reported restricting fuelwood collection, most restricted pole and timber extraction (requiring cutting permits, or prohibiting clearing around water sources). A few communities regulate or prohibit pine resin collection.

Regulations are occasionally enforced directly by the national forest, water or other agencies, but in most cases enforcement is the responsibility of the municipality (or its locally-based representative) or the local *patronato*.[14] In cases involving problems caused by community members, there are usually attempts to first deal with externality problems informally. If there is no response, then officials or a community group approach the person; the next step is to bring the matter to the attention of the municipal representative. Continued intransigence would lead the community to raise their concerns to higher municipal authorities or a national public agency, and/or begin legal proceedings. For externalities caused by people from outside the *aldea*, the initial approach by community members is followed by recourse to the municipality and the public agencies. Formal complaints are uncommon. It is unclear whether this is due to few violations, the effectiveness of informal mechanisms, reluctance to impose sanctions,

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[14] In some cases, private organizations are contracted to manage protected areas.

questions as to the legitimacy or effectiveness of the formal mechanisms, or other reasons.

One would expect to find more dependence on non-local authorities for regulatory enforcement in conditions where local people are affected by few locally important externalities, where external authorities are actively present, or where the problems are caused by outside groups (or powerful individuals) over whom local authorities have no effective jurisdiction. By contrast, one would expect to find more dependence on local authorities where management practices are perceived to generate significant local externalities.

These expectations appear consistent with observed differences in enforcement of rules among the different development pathways. In the basic grains expansion and non-farm employment pathways, all enforcement was reported to be by outside agencies. In the former, this can be explained by the relatively low level of externalities of importance to local people, as a result of relatively low population density and resource pressures. In the latter, it may be explained by the greater presence of national agencies and large externalities caused by outsiders. In the horticultural pathway, most problems are resolved by the municipality, or otherwise by outside agencies; this may reflect the low level of local organizational development in this pathway. In the coffee and forestry pathways, the main actors are local organizations (e.g., forestry coops) and outside agencies. In the relatively densely populated basic grains stagnation pathway, with large local externalities, local and municipal authorities were the principal enforcers of natural resource rules.

5. ECONOMETRIC ANALYSIS

DETERMINANTS OF ORGANIZATIONAL DENSITY

Variables and hypotheses

The dependent variables in the analysis of local organizational development was the number of local organizations existing in the community at the time of the survey, and the number involved in NRM activities. These are obviously only very rough measures of organizational development and abstract from many important issues such as organizational performance, sustainability, intensity of activity, etc. We were not able to obtain satisfactory measures of such aspects of organizational development given the extensive nature of the survey and the limited time we were able to spend in each village (half a day). More intensive research is needed to study these issues.

Least squares regression was used to investigate the determinants of organizational presence. The explanatory variables included in the regressions were the number of external organizations that have worked in the village, the population of the village in 1974, population density in 1974, population growth rate (between 1974 and 1988) and growth rate squared, distance of the village from Tegucigalpa, distance to the nearest road, adult literacy rate in 1974, the percentage of the 1974 population born within the *municipio*, and dummy variables representing the different pathways of development identified by the survey.[15]

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[15] Summary statistics for all variables used in the regression analyses are reported in the Appendix.

Because they may be endogenous to the process of organizational development, predicted values of the population growth rate, the population growth rate squared, and development pathway variables were used in the regressions.[16,17] The presence of external organizations also may be endogenous, since it could have been influenced by local organizational development. There is also the potential for omitted variable bias to cause a spurious correlation, if unobserved factors were responsible for both local and external organizational presence. We were not able to use an instrumental variables approach to correct for these problems, since any variable that influences development of external organizations may also directly affect local organizational development. Thus, the number of local and external organizations may be correlated not because external organizations stimulate local organizational development, but because local organizations attract external organizations, or because both local and external organizational development are stimulated by other, unobserved factors.

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[16] The variables used to predict the population growth rate and growth rate squared include all of the other explanatory variables, plus dummy variables for whether the community had access to a road in 1975, whether road access had been obtained since 1975, and the proportions of households having access to water, sanitation, electricity or radio in 1974. The development pathway dummy variables were replaced by predicted probabilities from a multinomial logit regression of pathway determinants (this regression is reported in Pender et al. 1999). The explanatory variables for the pathways include mid-point altitude of the village, average number of rainfall days, 1974 population density, distance to Tegucigalpa, distance to the nearest road, and whether a technical assistance program had worked in the village.

[17] For technical reasons, the standard errors could not be corrected for the fact that predicted values were used in the regressions in this study. We are not aware of analytical formulas to correct the standard errors for the complex two-stage regressions used (e.g., including predicted probabilities from a multinomial logit model for an ordered probit model in a second stage regression). Given the small number of observations per stratum, bootstrapping does not appear justifiable. We examined the robustness of our findings to use of actual vs. predicted values and to exclusion of the pathway variables; the robustness of the findings is discussed later in the paper.

The explanatory variables may affect the benefits or costs of organizational development. A higher population level is expected to positively affect the demand for organizations, but may also increase the cost of organizing. Controlling for population level, population density represents the scarcity of resources and geographic proximity of village households, both factors that may increase organizational density. Greater scarcity of resources may lead to greater demand for organizations to help allocate and conserve resources (such as water user associations) (Scherr and Hazell 1994); while closer proximity of households is expected to reduce the transactions costs of organizational development (Mumtaz 1995). On the other hand, resource scarcity may increase potential conflict and thus undermine the ability to establish and maintain effective organizations to regulate use of natural resources.[18]

We also include the population growth rate and the square of the population growth rate to reflect the impact of immigration or emigration.[19] Where the population growth rate is unusually low this is likely due to emigration, while an unusually high growth rate is likely due to immigration. In both cases, lower stability of the community population may reduce the ability to achieve collective action in organizational development (Rasmussen and Meinzen-Dick 1995; Baland and Platteau 1996; Bardhan

[18] It may be that resource scarcity induces organizational or institutional development only after a threshold level of resource damage has been realized (Scherr and Hazell 1994; Otsuka and Place forthcoming). One way to test for this is to include higher order polynomial terms (e.g., population density squared). Unfortunately, the correlation of population density squared with population density in our sample is very high (0.94), limiting our ability to identify such nonlinear effects. Regressions including both population density squared and population density as explanatory variables resulted in both variables being statistically insignificant.

[19] The correlation between population growth rate and growth rate squared is 0.81.

1993; Ostrom 1990). Thus we expect an inverted U-shaped relationship between population growth and organizational development, with a positive effect of growth rate and negative effect of growth rate squared.

The percentage of the village born within the *municipio* reflects the absence of immigrants, and may be related to the social proximity of village members, presence of relations of trust and potential for social sanctions, all of which may determine the ability to achieve collective action in forming and maintaining organizations (*Ibid.*). On the other hand, the presence of immigrants may increase the demand for organizations to manage potential conflicts or increase awareness of opportunities for organizational development. Thus this variable may have mixed effects.

As with migration, market integration may undermine the ability to attain collective action, since community members may have more "exit" options where markets are more integrated (*Ibid*.). On the other hand, greater access to markets may increase the demand for some kinds of organizational development related to economic opportunities, unless entry of private firms or state intervention displace the need for such development (Bebbington et al. 1996; Uphoff 1986). Market access may also influence organizational development by affecting village members' access to information and knowledge of alternative organizational forms, as well as by affecting economic opportunities. Thus the expected impacts of measures of market access, including distance to Tegucigalpa and distance to a road, are ambiguous.

Education and literacy may affect organizational development. Education may increase awareness of opportunities for organizational development and the ability of individuals to organize (Meinzen-Dick 1997; Bebbington et al. 1994; Esman and Uphoff

1984). More educated individuals may have a longer-term perspective due to greater access to credit or greater ability to save (Pender 1996). Where a high proportion of a community is literate (compared to a moderate percentage as in the less literate communities in the sample), this may indicate less heterogeneity in terms of wealth or social status, which may favor collective action as argued by many authors (Ostrom 1990; Tang 1992; Bardhan 1993); though the negative impact of wealth heterogeneity is disputed by Baland and Platteau (1996). On the other hand, education may increase the awareness of exit options of community members and thus tend to undermine collective action. More educated people may have higher opportunity costs of their time, so they may be less prone to participate in collective action. Thus the net impact of education is theoretically ambiguous.

The presence of external organizations in the village can also have mixed effects. On one hand, such organizations may be catalysts for local organizational development and help to strengthen the capacity of local organizations (Farrington and Bebbington 1993; Esman and Uphoff 1984; Ostrom 1990; Thomas-Slayter 1992). On the other hand, such external influences may compete with or undermine local organizations, by reducing the need for local collective action (Thomas-Slayter 1992; Thomas-Slayter 1994).

The different pathways of development may have different implications for organizational development. We expect greater demand for economic organizations such as producer associations, credit groups and cooperatives where cash crop production is occurring, as in the horticultural and coffee expansion pathways, than in the basic grains pathways (Uphoff 1986). On the other hand, the higher incomes associated with such commercial pathways may undermine organizational development by causing people to have a higher opportunity cost of their time, increased exit options from their communities, or greater social heterogeneity. Thus the net impact of development pathways on organizational development, as with most other factors, cannot be determined *a priori*, but is an important empirical issue.

Cultural, ethnic or religious heterogeneity, distribution of assets or income are also factors that could affect the costs and perceived benefits of organizing. Lack of variation in ethnic and religious makeup of the study communities prevented inclusion of these variables in the analysis, however. We were not able to obtain information on asset or income distribution so could not include this in the analysis.[20]

Results

The regression results for organizational density are reported in Table 3. Local organizational density is positively associated (at the 10% level) with the presence of external organizations, population level, distance from the urban market and adult literacy; and negatively associated with rapid population growth, the percent of the community born in the *municipio*, and the basic grains expansion and forestry pathways. The number of local organizations involved in NRM activities is positively associated with the number of external organizations involved in NRM activities, population level, adult literacy and the coffee expansion and non-farm employment pathways; and negatively associated with population density and the forestry pathway.

[20] In our study design, we intended to use information on land distribution from the agricultural census of Honduras, but this information could not be obtained.

The robustness of these findings was explored in regressions using actual rather than predicted population growth rate and pathway dummies, and excluding the pathways.[21] Almost all of the coefficients significant at the 5% level in Table 3 have the same sign and are significant at the 5% level in these other regressions.[22] In addition, we find support for the hypothesized inverted U-shaped relationship between population growth and organizational development in these additional regressions, with a significant positive coefficient of population growth rate and a significant negative coefficient of growth rate squared. Based on the estimated coefficients, the maximum predicted number of local organizations occurs at a population growth rate of 4.0% per year in the first regression and 3.3% per year in the second regression. These population growth rates are well within the range of population growth rates in the sample (see Appendix), indicating that the turning point of the inverted-U relationship occurs within the sample.

These results generally support the theory of induced organizational development, particularly as regards the positive impact of population level, which we expected to be associated with the demand for organizations. Interestingly, however, land scarcity (as measured by population density) does not appear to induce organizational development, and in fact is negatively associated with organizational involvement in NRM. This suggests that the greater potential for conflict over resources caused by resource scarcity may undermine organizational development. The results also suggest that interventions

[21] Regression results available from the authors.

[22] The exceptions are the coefficient of basic grains expansion in the first regression, which is negative and significant at the 10% level when actual values are used; and the coefficient of the forestry pathway in both regressions, which is insignificant in the first regression and positive and significant in the second regression.

by external programs and organizations have promoted local organizational development in central Honduras, though this is subject to the possibilities of reverse causality or omitted variable bias mentioned above. We know from qualitative evidence that in some cases external agencies have promoted local organizational development (Durón 1998); for example, efforts by an externally funded forestry project (MAFOR) to promote forest management cooperatives.

The greater presence of local organizations in communities further from Tegucigalpa supports the argument that greater market access may undermine local organization by increasing community members' alternatives to participation in such organizations. There may also be greater intensity of government involvement in communities closer to the capital city (even controlling for the number of external organizations involved), which would tend to substitute for local organization. We did not find the same impact of proximity to Tegucigalpa for the presence of local organizations involved in natural resource management, perhaps because the types of services provided by the government do not substitute well for the natural resource management functions of these local organizations.

The positive association between literacy and local organizational presence supports the hypothesis that more educated people may be more aware or more able to take advantage of opportunities for organizational development. More educated people may also be more receptive to encouragement from external organizations to organize.

The negative association between the percentage of village members born in the *municipio* and local organizational density is interesting. This suggests that immigration increases the demand for formal organizations or that immigration helps villages become more aware of opportunities for local organizational development. However, there appears to be a diminishing impact of immigration on organizational development (shown by the negative coefficient of the square of the population growth rate).

We found some impact of the pathways of development on organizational development, though some of the effects were not robust to the specification (see footnote 21). The most robust finding with regard to the pathways is that the presence of local organizations involved in NRM is greater in the coffee than basic grains pathways. The greater presence of organizations involved in NRM in coffee communities may be due to several factors, including the effort by external organizations to promote local organizations in such areas, the greater economic value of resources in coffee communities, and common concerns about pollution problems caused by coffee processing. The latter two possibilities are consistent with the hypothesis of induced organizational development.

Table 3 Determinants of local organizational presence

Least Squares Regression (Robust Standard Errors in Parentheses)[a, b]

Variable	Total Number of Local Organizations	Number of Local Organizations involved in NRM[c]
Number of external organizations[c]	0.1976**	0.1443*
	(0.0833)	(0.0807)
1974 population	0.002173***	0.002254***
	(0.000722)	(0.000491)
1974 population density	-0.00675	-0.03850***
	(0.00871)	(0.00822)
Population growth rate, 1974-88[b]	0.380	0.154
(percentage)	(0.230)	(0.331)
Population growth rate squared[b]	-0.0475**	-0.0235
	(0.0190)	(0.0247)
Distance to Tegucigalpa (km.)	0.0248**	-0.0055
	(0.0108)	(0.0135)
Distance to nearest road (km.)	-0.0256	0.213
	(0.0821)	(0.154)
Rate of adult literacy in 1974	0.0459*	0.0818***
(percent)	(0.0234)	(0.0213)
Percent of 1974 population born in	-0.0629**	0.0038
the *municipio*	(0.0258)	(0.0289)
Basic grains expansion[b]	-2.775**	-0.115
	(1.059)	(2.037)
Horticultural expansion[b]	0.774	2.368
	(1.633)	(1.840)
Coffee expansion[b]	1.268	2.513***
	(0.866)	(0.876)
Forestry specialization[b]	-4.618***	-3.869***
	(1.390)	(1.339)
Non-farm employment[b]	1.077	1.667*
	(0.865)	(0.934)
Intercept	5.827	-3.593
	(3.425)	(3.800)
Number of observations	39	38
R^b	0.825	0.742

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.

[a] Coefficients and standard errors adjusted for sampling weights, stratification, and finite population.

[b] Predicted values are used for population growth rate, population growth rate squared, and the pathway dummy variables. Standard errors are not adjusted for use of predicted values. The variables used to predict the population growth rate and growth rate squared include all of the other explanatory variables, plus dummy variables for communities that had access to a road in 1975 and for communities that gained road access since 1975, and the proportions of households having access to water, sanitation, electricity, or radio in 1974. Pathway probabilities are from a multinomial logit regression using as explanatory variables mid-point altitude, average number of rainfall days, 1974 population density, distance to Tegucigalpa, distance to the nearest road, and whether a technical assistance program had worked in the village.

[c] For the regressions of determinants of the number of local organizations involved in natural resource management (NRM), the number of external organizations involved in NRM is the first explanatory variable.

DETERMINANTS OF COLLECTIVE INVESTMENT AFFECTING NRM

Variables and hypotheses

The community survey asked specifically about whether community members had invested collectively in efforts to control runoff, such as by planting trees and constructing stone walls or ditches; and whether they had invested collectively in improvements to common lands, such as by planting trees or shrubs in community forests or fencing common areas.[23] Because it may have been difficult for respondents to distinguish these questions, for econometric analysis we combined the responses into a single variable representing collective action relating to NRM (a "yes" to either question was treated as a yes, a "no" to both questions treated as a "no"). We also collected information on local rules for managing forests, water, and common lands (discussed previously in Section 4), but this information is not suitable for econometric analysis.

A probit model was used to investigate the determinants of collective action relating to NRM. Most of the explanatory variables used in the regressions for determinants of local organizational density were included in this regression, since organizational development also involves collective action and thus is affected by many of the same factors. We included the number of government organizations and the number of external non-government organizations (NGOs) as separate variables, to investigate whether these different types of external organizations have different impacts. We also included the predicted number of local organizations from the regressions discussed in the preceding section as an explanatory variable. It is arguable that all

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[23] The questionnaire did not investigate the intensity or frequency of these activities, only whether they had occurred.

organizations, and not only those involved in NRM activities, may influence collective action related to NRM by affecting the level of "social capital" in the village. Thus in one regression we consider the total numbers of external and local organizations as explanatory variables, and in another we consider the number involved in NRM activities. The models were not estimable when the development pathway variables were included; so these were excluded.[24]

We expect that local organizational density will contribute to the possibility of collective investment, whether or not the organizations are directly involved in natural resource management. This is because the presence of local organizations may increase social interactions and the possibility of enforcing agreements based on the multiplex relationships among community members (Baland and Platteau 1996; White and Runge 1995). Our expectations about the effects of other variables on collective investment are similar to our expectations about their impact on local organizational development, since local organizational development itself requires collective action, as discussed above.

Results

Interestingly, we find that the presence of local organizations involved in NRM activities is positively related to collective action (statistically significant in one specification), while the number of government organizations is negatively associated with collective action (significant in both) (Table 4). In one specification, we find that land scarcity is associated with less collective action, consistent with the finding of less

[24] When too many regressors were included in the model, the model predicted the outcomes perfectly, and not all coefficients could be estimated. This is a common problem in estimating binary probit models with a small data set.

Table 4 Determinants of collective action to control runoff or improve common land

Probit Regression (Robust Standard Errors in Parentheses)[a, b]

Variable	Total Number of Organizations as Explanatory Variables[c]	Organizations Involved in NRM as Explanatory Variables[c]
Number of local organizations[b, c]	0.343	0.843**
	(0.413)	(0.333)
Number of government Organizations[c]	-0.538***	-0.519**
	(0.157)	(0.208)
Number of NGOs[c]	0.809*	0.050
	(0.428)	(0.245)
1974 population	0.00223	-0.00066
	(0.00197)	(0.00117)
1974 population density	-0.0527***	-0.0030
	(0.0137)	(0.0162)
Population growth rate, 1974-88[b] (percentage)	1.210**	0.343
	(0.564)	(0.425)
Population growth rate squared[b]	-0.456**	-0.220*
	(0.192)	(0.119)
Distance to Tegucigalpa (km.)	-0.0717**	-0.0122
	(0.0287)	(0.0141)
Distance to nearest road (km.)	0.013	-0.210
	(0.356)	(0.146)
Rate of adult literacy in 1974 (percent)	-0.0342	-0.0660**
	(0.0396)	(0.0316)
Percent of 1974 population born in the *municipio*	-0.0685	-0.0325
	(0.0526)	(0.0329)
Intercept	10.51	6.83
	(7.65)	(4.70)
Number of observations	39	38

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.

[a] Coefficients and standard errors adjusted for sampling weights, stratification, and finite population.

[b] Predicted values are used for number of local organizations, population growth rate, and population growth rate squared. Standard errors are not adjusted for use of predicted values. Predicted values for number of local organizations are based on the regressions in Table 3. Predicted values for population growth rate and growth rate squared are determined as explained in footnote b, Table 3.

[c] In the first regression, the total number of local organizations, government organizations, and NGOs are the first three explanatory variables. In the second regression, the numbers of these organizations involved in NRM are the explanatory variables.

organizational activity related to NRM. As in the case of organizational development, we find an inverted-U relationship between population growth and collective investment (though this is significant in only one specification).[25] Villages more distant from Tegucigalpa are less likely to engage in collective action (significant in one specification), while higher literacy rate is negatively associated with collective action (in the other specification).

We investigated the robustness of these results, using actual rather than predicted levels for the number of local organizations, population growth rate and growth rate squared. All of the coefficients significant at the 5% level in Table 4 are the same sign and significant in these other regressions, except the coefficient of literacy rate in the second regression (insignificant). In addition, we find statistically significant support for a positive effect of population, an inverted-U relationship between population growth and collective action, and a negative effect of distance to roads on collective action in these regressions.

Overall, these results confirm the importance of organizational presence, demographic factors and market access as factors influencing the potential for collective action. Local organizations appear to promote collective action while external government organizations appear to displace it. It may be that external government organizations substitute for local collective action, or they may simply choose to work in problem communities where local collective action is not occurring. Even if they do

[25] The maximum predicted probability of collective investment occurs at a population growth rate of 1.3% per year in the first regression and 0.8% per year in the second. These rates are well within the range of population growth rates of the sample.

displace local collective action, the net impact of external government organizations on collective action depends on indirect effects (via their contribution to development of local organizations) as well as direct effects. Based on the magnitude of the coefficients in Tables 3 and 4, the direct effects appear to outweigh the indirect effects, however, so that external organizations tend to reduce collective action on balance.

Qualitative information from the community survey indicates that in most cases, collective action to manage runoff or improve common lands occurred through local initiative, though in some cases, external organizations were involved (Durón 1998). Thus, external organizations do not always displace local action and in some cases promote it. Furthermore, co-involvement of external organizations and local organizations in constructing and maintaining potable water systems and roads was very common (Ibid.). Thus, the extent to which external organizations displaced local collective action appears to depend greatly on the type of collective action. For drinking water systems and roads, external organizations specialized in providing capital inputs and technical expertise, while expecting local communities to provide complementary labor inputs. The different comparative advantages of external and local organizations in providing these different kinds of complementary inputs explains the motive for the high degree of co-involvement of external and local organizations in such activities; and the large benefits of these activities to the recipient communities explains the near universal achievement of collective action in these cases. By contrast, collective action to protect natural resources by planting trees, etc. likely requires less technical or capital inputs from external agents and provides smaller perceived benefits to the community.

As with local organizational development, population growth appears to promote collective action, though rapid population growth may undermine it as a result of less stability of the population. Population density appears to undermine collective action, also consistent with its impact on local organizational development.

Unlike the case with local organizational development, proximity to the urban market appears to promote collective action. This may be because of greater intensity of effort in such areas by external programs seeking to promote collective action in more accessible communities. Since local organizations also favor collective action, the net impact of proximity to the urban market on collective action depends on indirect effects (via its impact on local organizational development) as well as direct effects. Based on the magnitude of the coefficients in Tables 3 and 4, the direct effect appears to outweigh the indirect effect, so that communities closer to Tegucigalpa are predicted to have greater collective action.

DETERMINANTS OF PRIVATE ACTION AFFECTING NRM

Variables and hypotheses

The variables reflecting private actions affecting NRM include the extent of use of various cropping practices (fallow, burning, irrigation), purchased inputs (chemical fertilizer, insecticides, herbicides, improved seeds), annual conservation or fertility management practices (contour planting, green manures, minimum tillage, mulch, incorporation of crop residues, use of cow manure or chicken manure), and land improving investments (terraces, live barriers, stone walls, drainage ditches, trees). These variables were measured as an ordinal index from 0 to 6 (0 = no farmers use the practice, 1 = a few (less than 10%), 2 = minority, 3 = about half, 4 = majority, 5 = almost all (more than 90%), 6 = all). We used ordered probit regressions to estimate the impacts of the explanatory variables on farmers' likelihood of adopting different practices.[26]

The explanatory variables included in these regressions include the number of local organizations (predicted), number of government organizations and number of NGOs involved in NRM activities in the village, population density, distance of the village from Tegucigalpa, distance to the nearest road, literacy rate, and the (predicted) development pathways. These variables reflect many of the factors hypothesized by McCullough et al. (1998) to affect private technology choice, including access to infrastructure (distance to a road), access to information (presence of external organizations, distance to Tegucigalpa, literacy), credit (proxied by development pathways and literacy rate), labor/land endowment (population density), physical/technical conditioning factors determining comparative advantage (determinants of predicted pathways of development), and collective action (presence of local organizations). Household and plot level data and time-series data would be needed to adequately incorporate some of the other factors, such as risk, property rights, prices, and wealth.

There are too many dependent variables reflecting private NRM decisions to discuss hypotheses specific to each one. We focus here on the expected impacts of organizations. Government and NGO technical assistance organizations are expected to have increased adoption of practices they have been promoting, such as various conservation practices, while reducing use of some traditional practices that they have discouraged, such as burning. The presence of local producer associations may favor

[26] Ordered probit is a simple generalization of a standard binary probit model allowing for multiple ordered categories, estimated by maximum likelihood. See Amemiya (1985) or other advanced econometrics texts for a detailed explanation.

adoption of more modern commercial practices, such as adoption of irrigation and purchased inputs, to the extent that they help farmers obtain access to information about such technologies or access to inputs and credit (Uphoff 1986).

Results

The effects of organizations on cropping practices and use of inputs are mixed. Local organizations are associated with greater use of burning, chemical fertilizer, chicken manure and mulching, but less use of insecticides or plowing in of crop residues (Tables 5, 6 and 7). Government organizations are associated with greater use of insecticides, plowing in of crop residues, and terracing, and less use of fallow, burning and mulching. NGOs are associated with greater use of fallow, minimum till, plowing in of crop residues, and live barriers, and less use of chemical fertilizers and chicken manure.

The robustness of these findings was investigated using regressions including actual rather than predicted values of the number of local organizations and the pathway variables, and regressions excluding the pathways. Most of these results were found to be robust.[27]

It is difficult to simply characterize such complex results, but it appears that NGOs and government organizations have a tendency to promote more labor intensive practices and investments such as terracing, live barriers, and plowing in of crop residues, while local farmer organizations help to promote more immediately profitable and less

[27] The non-robust exceptions were the positive association between NGOs and fallow, the negative association between NGOs and chemical fertilizer use, the negative ld association between government organizations and mulching, and the positive association between government organizations and terracing.

labor intensive methods such as use of chemical fertilizer and chicken manure. The differential association of local and government organizations with burning practices is an example of this; where local organizations are more prevalent, burning is more common, whereas government organizations inhibit use of burning. The fact that government organizations discourage burning is not surprising, given that it is government policy to prevent agricultural burning. The positive association of burning with local organizations is somewhat surprising. This finding probably does not mean that local organizations promote burning; rather, government organizations may be less actively involved (even if present) in areas where local organizations are well developed, so the discouraging effects of government presence may be lower.

Table 5 Determinants of cropping practices

	Ordered Probit Regressions (Robust Standard Error in Parentheses)[a]						
Variable	Continuous cropping	Burning	Irrigation	Fertilizer	Insecticide	Herbicide	Improved Seeds
Number of local organizations affecting	0.260*	0.749***	0.036	0.432**	-0.498***	0.200	-0.553
NRM[b]	(0.150)	(0.138)	(0.144)	(0.183)	(0.123)	(0.138)	(0.361)
Number of government organizations	0.318**	-0.706***	-0.043	-0.083	0.838***	-0.235	0.723
affecting NRM	(0.153)	(0.160)	(0.157)	(0.183)	(0.164)	(0.180)	(0.457)
Number of NGOs affecting NRM	-0.368***	-0.166	0.156	-0.376***	0.0271	-0.237*	0.386
	(0.127)	(0.133)	(0.113)	(0.108)	(0.1178)	(0.121)	(0.238)
1988 population density (persons/km[b])	0.0172**	-0.0122	-0.00142	-0.00171	0.00246	-0.00416	-0.00113
	(0.0077)	(0.0077)	(0.00594)	(0.00495)	(0.00543)	(0.00584)	(0.00876)
Distance to Tegucigalpa (km.)	0.0295***	0.0306***	0.0194	-0.0118	0.0302***	0.0174	-0.0014
	(0.0096)	(0.0103)	(0.0117)	(0.0115)	(0.0097)	(0.0142)	(0.0138)
Distance to nearest road (km.)	0.0631	0.0558	-0.0857	-0.2353***	-0.0652	0.1639**	-3.594
	(0.0917)	(0.1147)	(0.0903)	(0.0698)	(0.0734)	(0.0721)	(2.996)
1988 adult literacy rate (percent)	-0.0250	0.0363**	0.0018	-0.0350**	0.0218	-0.0327**	-0.0347*
	(0.0217)	(0.0150)	(0.0161)	(0.0163)	(0.0167)	(0.0135)	(0.0192)
Basic grains expansion[c]	-1.478*	-3.899***	-0.528	4.979***	1.023	-1.712**	-11951***
	(0.855)	(0.960)	(1.010)	(0.776)	(0.970)	(0.789)	(4047)
Horticultural expansion[c]	1.782*	-5.444***	3.726***	3.027***	4.756***	-1.387*	5.891***
	(0.968)	(1.103)	(1.327)	(0.990)	(1.010)	(0.767)	(1.603)
Coffee expansion[c]	-1.985**	-3.550***	-1.291*	2.554***	0.913	-0.761	3.238***
	(0.877)	(0.800)	(0.754)	(0.624)	(0.878)	(0.682)	(1.160)
Forestry specialization[c]	6.497***	-5.996***	-1.308	2.171	-0.308	2.899*	4.934*
	(1.891)	(1.326)	(1.730)	(1.560)	(1.840)	(1.630)	(2.555)
Non-farm employment[c]	-0.576	-1.259	0.072	-2.095***	2.171**	-1.114	5.046**
	(0.868)	(0.935)	(0.816)	(0.770)	(0.983)	(0.899)	(1.910)
Number of observations	37	36	37	38	37	37	38

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.
[a] Coefficient and standard errors corrected for sampling weights, stratification, and finite population.
[b] Predicted number of organizations, based on results of regressions reported in Table 3.
[c] Predicted pathway probability, based on the same multinomial logit regression reported in footnote b of Table 3.

Table 6 Determinants of annual soil conservation/organic fertility management practices

	Ordered Probit Regressions (Robust Standard Error in Parentheses)[a]						
Variable	Contour Planting	Green Manure	Minimum Till	Mulching	Plowing in Crop Residues	Cow Manure	Chicken Manure
Number of local organizations affecting	0.309	0.250	0.051	0.511***	-0.369**	0.077	1.182***
NRM[b]	(0.250)	(0.185)	(0.190)	(0.123)	(0.152)	(0.167)	(0.308)
Number of government organizations	0.106	0.282	0.163	-0.259**	0.602***	0.126	0.149
affecting NRM	(0.155)	(0.181)	(0.167)	(0.123)	(0.199)	(0.158)	(0.192)
Number of NGOs affecting NRM	-0.175	0.314	0.329*	-0.185	0.341**	-0.072	-0.965***
	(0.205)	(0.195)	(0.177)	(0.119)	(0.128)	(0.109)	(0.226)
1988 population density (persons/km[b])	-0.00855*	-0.00481	-0.01112	0.00681	-0.00611	0.00158	0.00750
	(0.00447)	(0.00690)	(0.00749)	(0.00414)	(0.00499)	(0.00566)	(0.00610)
Distance to Tegucigalpa (km.)	-0.0943***	-0.0363*	-0.0514**	-0.0058	-0.0569***	-0.0315	-0.0378*
	(0.0209)	(0.0212)	(0.0214)	(0.0123)	(0.0149)	(0.0210)	(0.0223)
Distance to nearest road (km.)	0.342**	0.117	0.644**	0.1438	0.091	0.263**	-20.22***
	(0.131)	(0.159)	(0.268)	(0.0948)	(0.191)	(0.118)	(2.64)
1988 adult literacy rate (percent)	-0.0048	-0.0410*	-0.0080	-0.0241**	0.0265	0.0111	-0.0187
	(0.0133)	(0.0220)	(0.0174)	(0.0117)	(0.0169)	(0.0166)	(0.0188)
Basic grains expansion[c]	-1.857*	-1.396	-2.311	-0.929	-23.888***	-2.963***	6.785**
	(0.973)	(1.765)	(2.236)	(1.287)	(8.194)	(0.691)	(3.331)
Horticultural expansion[c]	-3.735***	-7.870*	-2.961	-1.388	-1.302	-2.674**	-2.937
	(1.209)	(3.905)	(1.894)	(1.079)	(0.990)	(1.085)	(2.124)
Coffee expansion[c]	0.441	1.050	1.827	0.462	-1.476*	-0.622	0.245
	(0.765)	(1.152)	(1.245)	(0.483)	(0.768)	(0.793)	(1.013)
Forestry specialization[c]	5.288***	-0.021	-1.138	-3.671	0.080	-0.279	-0.747
	(1.839)	(1.898)	(2.074)	(3.405)	(1.334)	(1.270)	(2.039)
Non-farm employment[c]	-3.783***	-2.536*	-1.264	-1.657**	-1.705**	-2.179*	-1.232
	(1.242)	(1.370)	(1.526)	(0.724)	(0.726)	(1.109)	(1.314)
Number of observations	37	38	38	38	36	38	38

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.
[a] Coefficient and standard errors corrected for sampling weights, stratification, and finite population.
[b] Predicted number of organizations, based on results of regressions reported in Table 3.
[c] Predicted pathway probability, based on the same multinomial logit regression reported in footnote b of Table 3.

Table 7 Determinants of land improving investments

Variable	Terraces	Live Barriers	Stone Walls	Drainage Ditches	Trees
	Ordered Probit Regressions (Robust Standard Error in Parentheses)[a]				
Number of local organizations affecting NRM[b]	0.148	-0.168	-0.032	-0.131	0.1442
	(0.169)	(0.145)	(0.215)	(0.192)	(0.0918)
Number of government organizations affecting NRM	0.316**	0.061	-0.024	0.147	0.0610
	(0.144)	(0.111)	(0.189)	(0.159)	(0.0894)
Number of NGOs affecting NRM	-0.043	0.230**	0.237	0.051	0.0744
	(0.152)	(0.111)	(0.145)	(0.125)	(0.1140)
1988 population density (persons/km[b])	0.00408	0.01071	00.01579**	0.00259	0.01115**
	(0.00698)	(0.00893)	(0.00669)	(0.00609)	(0.00552)
Distance to Tegucigalpa (km.)	-0.0209*	-0.0273***	-0.0121	-0.0345**	0.01162
	(0.0118)	(0.00899)	(0.0119)	(0.0130)	(0.00826)
Distance to nearest road (km.)	0.2055**	-0.0416	0.0426	0.0938	-0.1751**
	(0.0919)	(0.0771)	(0.0765)	(0.0999)	(0.0756)
1988 adult literacy rate (percent)	0.0024	-0.0091	-0.0041	-0.0112	-0.0088
	(0.0140)	(0.0134)	(0.0167)	(0.0150)	(0.0134)
Basic grains expansion[c]	-0.956	1.058	-0.719	1.087	1.795**
	(0.795)	(0.844)	(0.754)	(1.185)	(0.718)
Horticultural expansion[c]	1.972**	-2.605**	-3.286***	-1.143	-0.147
	(0.821)	(1.070)	(1.199)	(1.128)	(0.638)
Coffee expansion[c]	1.553*	1.733	-2.235***	0.771	0.051
	(0.865)	(1.167)	(0.819)	(0.829)	(0.712)
Forestry specialization[c]	2.760*	-0.079	-0.433	3.017	-0.553
	(1.462)	(1.183)	(1.296)	(1.833)	(1.596)
Non-farm employment[c]	-0.171	-1.044	-1.970**	-0.776	-0.887
	(0.768)	(0.808)	(0.910)	(1.098)	(0.579)
Number of observations	38	38	38	37	38

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.
[a] Coefficient and standard errors corrected for sampling weights, stratification, and finite population.
[b] Predicted number of organizations, based on results of regressions reported in Table 3.
[c] Predicted pathway probability, based on the same multinomial logit regression reported in footnote b of Table 3.

6. CONCLUSIONS AND IMPLICATIONS

With regard to the determinants of local organizational development in central Honduras, the main findings of this study are that population growth contributes to organizational development at low levels of growth but has a diminishing and possibly negative effect at high growth rates, that proximity to the urban center reduces local organizational presence, and that the presence of immigrants appears to favor local organizational development. Local organizational development related to NRM is positively associated with larger population levels but negatively with population density (land scarcity), and positively associated with education levels and expansion of coffee production.

With regard to the impacts of local organizations on NRM, we find mixed results. Local organizations involved in NRM contribute to collective investment in NRM and assist in regulating use of common property resources and dealing with externalities (the *patronatos* are particularly important for establishing and enforcing these regulations), though these roles vary substantially across the development pathways. Local organizations have mixed impacts on farmers' private decisions to adopt resource conservation measures; in some cases being associated with less adoption of such measures, such as no-burn practices and plowing in crop residues. This may be because such conservation measures are of lower priority to many farmers than activities that generate greater income in the near term and which may substitute for conservation practices (such as use of chemical fertilizers rather than organic methods).

In contrast to the impacts of local organizations, we find that external government organizations seem to displace collective investment in NRM, though they promote other kinds of collective investment such as construction and maintenance of water systems and roads. External organizations have a stronger impact on promoting adoption of some labor-intensive conservation measures (such as no-burn, plowing in crop residues, and terracing) on private cropland. Some government organizations also play an important role in enforcing regulations or managing externalities, including the *municipios* in general and national level organizations in forestry communities (in combination with local organizations). NGOs are also important in promoting some conservation practices, such as plowing in crop residues and use of live barriers.

In a broad sense, the findings support the theory of induced organizational development, particularly the positive impact of population level and coffee production on local organizational presence. However, they also suggest that land scarcity and very rapid population growth may undermine the ability for organizational development to keep pace with population, or the ability to achieve collective action for NRM.[28] In many communities (most notably rapidly developing horticultural expansion communities), local organizational development is still very limited, despite (or perhaps because of) very rapid population growth, improvements in road and market access, and increases in demand for credit and other services. This suggests that local organizational development may be unable to respond to very rapid change.

[28] Negative impacts of a rapid population growth rate (as opposed to a high population level) on NRM due to lags in institutional adjustment have been hypothesized by several authors (see for example Templeton and Scherr (1997) and references cited therein).

The positive association between external and local organizational presence suggests that external organizations are playing a catalytic or complementary role in many cases, though the effort still may be insufficient to fulfill the demand where the pace of change is very rapid. On the other hand, the negative impact of external organizations on collective investments in NRM suggests that caution is warranted when such organizations do intervene in local communities, to be sure that they are facilitating and not undermining local initiative. External organizations appear to be essential to promote soil conservation measures on private farmland.

Both external organizations and local organizations can play important and complementary roles in fostering more sustainable and productive use of natural resources. The challenge for policy makers and program managers is to identify and exploit cases where synergies exist between external and local organizational development (such as providing complementary inputs into infrastructure development or in regulating resource use and externalities), to be cautious about intervening in a way that displaces local initiative (such as displacing local collective investments), and to focus effort on activities that have significant social benefits but are not being addressed adequately by private action (such as many conservation measures). Given the possibilities of unexploited complementarities or unintended competition between the actions of external organizations and local organizations, increased investment by external actors in understanding the extent and roles of local organizations could yield substantial benefits.

It is important to recognize that the opportunities for and constraints upon efforts to meet this challenge may vary substantially from place to place, depending upon local economic opportunities, population pressure, and other factors. This study focuses on a situation of relatively low level of economic development and low population density. One might expect to find similar results in similar conditions elsewhere, while in more developed or densely populated conditions substantially different relationships between organizational development and natural resource management may exist. As our conceptual discussion emphasized, most determinant factors have theoretically ambiguous impacts, which can only be determined through careful empirical research. Such research on organizational development is still relatively limited. It is hoped that this paper will encourage further efforts to disentangle the causes and effects of local organizational development in different circumstances, and help policy makers to consider such issues when considering how to target their efforts to promote more sustainable agricultural development.

APPENDIX

Summary statistics of variables used in the regressions

Variable	Number of Observations	Mean[a]	Robust Standard Error[a]	Minimum	Maximum
Number of local organizations	40	7.10	2.77	2	15
Number of local organizations involved in NRM	40	2.60	2.34	0	9
Number of government organizations	45	4.22	3.08	0	13
Number of government organizations involved in NRM	45	2.73	1.75	0	6
Number of external NGOs	40	2.25	2.02	0	9
Number of external NGOs involved in NRM	40	1.77	1.72	0	8
Whether collective investment to control runoff or improve common land occurred	47	0.30	0.46	0	1
Index of proportion of households using[b]:					
Continuous cultivation	45	3.84	1.58	0	6
Burning to prepare fields	46	2.87	1.53	0	6
Irrigation	46	0.70	0.96	0	4
Fertilizer	48	2.50	1.75	0	6

Variable	Number of Observations	Mean[a]	Robust Standard Error[a]	Minimum	Maximum
Insecticide	47	2.96	1.76	0	6
Herbicide	47	2.72	1.72	0	6
Improved seeds	48	1.33	1.98	0	6
Contour planting	47	1.55	1.73	0	5
Green manure	48	0.48	0.74	0	2
Minimum tillage	48	0.92	1.37	0	4
Mulching	48	1.40	1.77	0	5
Plowing in crop residues	46	1.37	1.74	0	5
Cow manure	48	0.94	1.21	0	4
Chicken manure	45	0.82	1.27	0	4
Terraces	48	1.29	1.50	0	4
Live barriers	48	1.85	1.57	0	6
Stone walls	48	2.02	1.68	0	6
Drainage ditches	47	1.09	1.28	0	4
Tree planting	48	1.69	1.64	0	5
Village population—1974	47	652	422	46	1903

Variable	Number of Observations	Mean[a]	Robust Standard Error[a]	Minimum	Maximum
Population density—1974 (persons/km[b])	47	37.5	33.4	4.0	170.2
Population density—1988	47	46.9	43.5	5.0	223.0
Annual population growth rate, 1974-88	47	1.97	2.72	-2.68	14.81
Distance to urban market (km)	48	67.7	31.9	5	160
Distance to nearest road (km)	48	1.6	3.5	0	16
Percentage of literate adults, 1974	47	51.0	16.3	18.9	81.7
Percentage of literate adults, 1988	48	56.1	21.0	13.1	90.0
Percentage of 1974 population born in municipality	47	90.4	9.2	57.0	99.8
Basic grain expansion pathway	48	0.10	0.31	0	1
Basic grain stagnation pathway	48	0.31	0.47	0	1
Horticultural expansion pathway	48	0.10	0.31	0	1
Coffee expansion pathway	48	0.21	0.41	0	1
Forestry specialization pathway	48	0.06	0.24	0	1
Nonfarm employment pathway	48	0.21	0.41	0	1

[a] Means and standard errors corrected for sampling weights, stratification, and finite population.
[b] Index values: 0 = none; 1 = less than 10%; 2 = less than half; 3 = about half; 4 = more than half; 5 = more than 90%; 6 = all.

REFERENCES

Amemiya, T. 1985. *Advanced econometrics*. Cambridge: Harvard University Press.

Baland, J-M. and J-P. Platteau. 1996. *Halting degradation of natural resources. Is there a role for rural communities?* Oxford: Clarendon Press.

Bardhan, P. 1993. Analytics of the institutions of informal cooperation in rural development. *World Development* 21(4): 633–639.

Bebbington, A.J., D. Merrill-Sands, and J. Farrington. 1994. *Farmer and community organizations in agricultural research and extension: Functions, impacts and questions.* Overseas Development Institute (ODI) Agricultural Administration (Research and Extension Network) Network Paper 47. London: ODI.

Bebbington, A.J., J. Quisbert, and G. Trujillo. 1996. Technology and rural development strategies in a small farmer organization: Lessons from Bolivia for rural policy and practice. *Public Administration and Development* 16: 195–213.

Boserup, E. 1965. *The conditions of agricultural growth*. New York: Aldine Pub. Co.

de Janvry, A. and E. Sadoulet. 1993. Market, state, and civil organizations in Latin America beyond the debt crisis: The context for rural development. *World Development* 21(4): 659–674.

Durón, G. 1998. The influence of external organizations in the collective management of resources in Honduras. M.A. thesis, School of Development Studies, University of East Anglia, U.K.

Durón, G. and G. Bergeron. 1995. *Las politicas sectoriales agricolas y ambientales y su impact en las laderas de Honduras*. Documento presentado en el Seminario Taller "Las Politicas Sectoriales y su Efecto en el Manejo de los Recursos Naturales en Areas de Lader en Honduras," 11-13 de Septiembre, 1995, Tegucigalpa, Honduras.

Esman, M.J. and N.T. Uphoff. 1984. *Local organizations: Intermediaries in rural development*. Ithaca: Cornell University Press.

Farrington, J. and A. Bebbington. 1993. *Reluctant partners? Non-governmental organizations, the state and sustainable agricultural development*. London and New York: Routledge.

Hayami, Y. and V.W. Ruttan. 1985. *Agricultural development: An international perspective*. Baltimore: Johns Hopkins University Press.

McCulloch, A.K., R. Meinzen-Dick, and P. Hazell. 1998. Property rights, collection action and technologies for natural resource management: A conceptual framework. Mimeo. Washington, D.C.: International Food Policy Research Institute.

Meinzen-Dick, R. 1997. Farmer participation in irrigation: 20 years of experience and lessons for the future. *Irrigation and Drainage Systems* 11: 103–118.

Miranda, B. 1997. Arreglos institucionales para el desarrollo sostenible de las laderas de America Central. In *Desarrollo agricola, sostenibilidad de recursos naturales y reduccion de la pobreza en America Latina: El papel de las regiones de laderas*, eds. O.Neidecker-Gonzales and S.J. Scherr, pp. 125-142. Feldafing: DSE.

Mumtaz, S. 1995. The demographic determinants of "successful" village cooperatives. *The Pakistan Development Review* 34 (4 Part II): 609–617.

North, D.C. 1990. *Institutions, institutional change and economic performance*. Cambridge: Cambridge University Press.

Nugent, J.B. 1993. Between state, markets and households: A neoinstitutional analysis of local organizations and institutions. *World Development* 21(4): 623–632.

Ostrom, E. 1990. *Governing the commons: The evolution of institutions for collective action*. Cambridge: Cambridge University Press.

Otsuka, K. and F. Place. Land tenure and natural resource management: Forest, agroforest, and cropland management in Asia and Africa. Baltimore: Johns Hopkins University, forthcoming.

Pender, J. 1996. Discount rates and credit markets: Theory and evidence from rural India. *Journal of Development Economics* 50: 257–296.

Pender, J., S.J. Scherr, and G. Durón. 1999. *Pathways of development in the hillsides of Honduras: Causes and implications for agricultural production, poverty, and sustainable resource use*. Environment and Production Technology Division Discussion Paper No. 45. Washington, D.C.: International Food Policy Research Institute.

Pender, J. and S. J. Scherr. 1997. Community survey of hillside development patterns in the central region of Honduras. Environment and Production Technology Division. Washington, D.C.: International Food Policy Research Institute. Mimeo.

Pender, J., and G. Durón. 1996. *Pathways of development in the central hillsides of Honduras: 1970s - 1990s*. Environment and Production Technology Division, International Food Policy Research Institute, Washington, D.C. Mimeo.

Rasmussen, L.N. and R. Meinzen-Dick. 1995. *Local organizations for natural resource management: Lessons from theoretical and empirical literature*. Environment and Production Technology Division, Discussion Paper No. 11. Washington, D.C.: International Food Policy Research Institute.

Scherr, S.J., and P.B.R. Hazell. 1994. *Sustainable agricultural development strategies in fragile lands*. Environment and Production Technology Division, Discussion Paper No. 1. Washington, D.C.: International Food Policy Research Institute.

StataCorp. 1997. *Stata statistical software: Release 5.0*. College Station, TX: Stata Corporation.

Tang, S.Y. 1992. *Institutions and collective action: Self-governance in irrigation systems*. San Francisco: ICS Press.

Templeton, S. and S.J. Scherr. 1997. *Population pressure and the microeconomy of land management in hills and mountains of developing countries*. Environment and Production Technology Division, Discussion Paper No. 26. Washington, D.C.: International Food Policy Research Institute.

Thomas-Slayter, B.P. 1992. Implementing effective local management of natural resources: New roles for NGOs in Africa. *Human Organization* 51(2): 136–143.

________. 1994. Structural change, power politics, and community organizations in Africa: Challenging the patterns, puzzles and paradoxes. *World Development* 22(10): 1479–1490.

Uphoff, N. 1986. *Local institutional development: An analytical sourcebook with cases*. West Hartford: Kumarian Press.

________. 1993. Grassroots organizations and NGOs in rural development: Opportunities with diminishing states and expanding markets. *World Development* 21(4): 607–622.

White, A.T. and C.Ford Runge. 1995. The emergence and evolution of collective action: Lessons from watershed management in Haiti. *World Development* 23(10):1683–1698.

White, H. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 48: 817–838.

World Bank. 1991. Honduras: Environmental Agenda. Mimeo. Washington, D.C.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the Swiss Development Cooperation and the InterAmerican Development Bank for this research. We are grateful to the study team—Guadalupe Durón, Fernando Mendoza, Carlos Duarte, Juan Manuel Medina, and Roduel Rodriguez—for their tireless efforts to complete the survey; to Oscar Neidecker-Gonzales for research assistance; to Lourdes Hinayon, Nancy Romero, and Nolvia Lagos for administrative support; to Peter Hazell, Gilles Bergeron, Bruno Barbier, and other colleagues at IFPRI for advice in the conduct of the research; to Byron Miranda of the Instituto Interamericano para la Cooperación en la Agricultura (IICA), Peter Heffron of CARE and other colleagues outside of IFPRI for advice on the survey design andimplementation; to Hector Barreto and Pedro Jimenez of CIAT for providing secondary data; to IICA/Honduras for providing logistical support to the research; to numerous government agencies, municipal governments, and local teachers who helped to make arrangements for the survey in the different communities; and to Ruth Meinzen-Dick, Anna Knox, Frank Place, and Stephen Sherwood for detailed and constructive comments on the manuscript. Most of all, we are grateful to the many farmers and representatives of organizations in Honduras who generously agreed to respond to our many questions. Any errors or omissions are solely the responsibility of the authors.

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CAPRi WORKING PAPER NO. 5

COLLECTIVE ACTION IN SPACE: ASSESSING HOW COLLECTIVE ACTION VARIES ACROSS AN AFRICAN LANDSCAPE

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August 2000

CAPRi Working Papers contain preliminary material and research results, and are circulated prior to a full peer review in order to stimulate discussion and critical comment. It is expected that most Working Papers will eventually be published in some other form, and that their content may also be revised.

An earlier draft of this paper was presented at the Workshop on Property Rights, Collective Action and Technology Adoption, Aleppo, Syria, Nov 22-25, 1997. This is a revised draft for inclusion in an edited volume.

ABSTRACT

This paper develops and applies a new approach for analyzing the spatial aspects of individual adoption of a technology that produces a mixed public-private good. The technology is an animal insecticide treatment called a "pouron" that individual households buy and apply to their animals. Private benefits accrue to households whose animals are treated, while the public benefits accrue to all those who own animals within an area of effective suppression.

A model of household demand for pourons is presented. As ~~for~~ a private good, household demand for the variable input depends upon output price, input cost, and household characteristics. Input costs for pouron treatments include both the market price of the pourons and the transaction costs that the household must incur to obtain the treatments. Demand also depends upon the way that each household expects its neighbors to respond to one's own behavior. Free-riding is expected in communities with no tradition or formal organization to support collective action. Greater cooperation is expected in communities that have organizations that reward cooperative behavior and punish deviant behavior.

Data for estimation of the model were collected for all of the 5,000 households that reside within the study area of 350 square kilometers in southwest Ethiopia. Geographic reference data were collected for every household using portable Geographic Positioning System units. GIS software was used to generate spatial variables. Variables for distance from the household to the nearest treatment center and number of cattle-owning neighbors within a 1-kilometer radius of the household were created. The density of cattle-owning neighbors was

used as a measure of the potential benefits from cooperation; this variable was expected to have a positive effect on household pouron demand in communities able to support effective collective action and a negative effect in communities not able to support effective collective action. A set of community binary variables was interacted with the density variable to capture differences between communities. The results confirm the importance of the household-level variables. The results also indicate large differences in ability to cooperate between local administrative units. Everything else equal, the areas least able to cooperate were located farthest from the treatment center, were ethnically heterogenous, and had a different ethnic composition than areas around the treatment centers.

CONTENTS

COLLECTIVE ACTION IN SPACE: ASSESSING HOW COLLECTIVE ACTION VARIES ACROSS AN AFRICAN LANDSCAPE

Brent M. Swallow[*,H], Justine Wangila[H], Woudyalew Mulatu[I]
Onyango Okello,[*] and Nancy McCarthy[*,']

1. INTRODUCTION

Economists are beginning to show more interest in the spatial aspects of economic relationships. Spatial patterns of prices and land use have perhaps received most attention to date. Jayne (1994) and Omamo (1995) have analyzed spatial patterns of crop choice in Zimbabwe and Kenya. Bockstael (1996) studied spatial patterns of land use and land prices in the Patuxent Watershed in the state of Maryland. Chomitx and Gray (1995) analyzed the spatial patterns of land use conversion resulting from road construction in Belize.

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Collective action for natural resource management also has important spatial aspects. The location of individuals relative to each other and the collective good determines both the benefits and costs of collective action. Consider, for example, a collective good available at a single fixed location, for example, a water well managed by collective. Households located near to the well incur relatively low transaction costs to participate in the maintenance of the pump and low transaction costs to collect water from the well. Households located near to the well, or near to roads leading to the well, could also incur relatively high costs from the disturbance caused by neighbors walking past. Aggregate benefits and costs also depend upon the spatial distribution of individuals and resources. The more densely populated the area served by the well, the lower the monitoring costs per individual, the greater the total transaction costs associated with queuing, and the greater the incentive to free-ride on others' cooperative behavior.

The focus in this paper is on individual adoption of a technology that produces a mixed public-private good. The technology is a formulation of insecticide called that is applied to cattle as a "pouron". The mixed public-private good is control of external parasites and animal disease vectors. Household demand for pourons is hypothesized to depend upon three spatial factors: (1) distance from the household to the place where the cattle treatments are sold; (2) density of cattle owners in the neighborhood around each household; and (3) ability of the local administrative unit to foster collective action. Distance to the treatment center determines transaction costs incurred to obtain treatments. Density of cattle owners in the neighborhood affects both the opportunities for collective action and the incentives to free-ride on neighbors' use of the cattle treatments. The ability of the local administrative unit to foster collective action determines the incentives to free-ride or cooperate in provision of the public good.

Those hypotheses are tested through an analysis of individual use of cattle treatments in a study site in the Ghibe Valley of Ethiopia. The behavior of individual households regarding the use of cattle treatments is related to the characteristics of the households themselves and the characteristics of their neighbors. Neighbor variables are created using Geographic Information Systems (GIS) software and brought into a logistical regression model.

The next section provides some background on the technical and economic aspects of the problem and the particular case study. Section 3 presents a model of household demand for pouron treatments. That model provides a mathematical definition of the three spatial dimensions of demand for the mixed public-private good. Section 4 discusses the methods used to collect, process and analyze household-level census data. The econometric results are presented in Section 5. The econometric results led to a subsequent qualitative study of the ability of local communities to cooperate in the use of the pourons. Both the methods and results of that phase of the research are described in Section 6. Section 7 is a discussion and conclusion.

INDIVIDUAL AND COLLECTIVE ACTION FOR TSETSE CONTROL BY USE OF POURONS

Background

African animal trypanosomosis is an animal disease that constrains livestock productivity and agricultural development across much of sub-Saharan Africa. Trypanosomosis is caused by parasitic protozoa and transmitted by several specie of tsetse fly (*Glossina* spp.). Trypanosomosis is particularly important in Ethiopia where about 7 million cattle are at risk of contracting the disease and cattle are the main source of traction for crop cultivation.

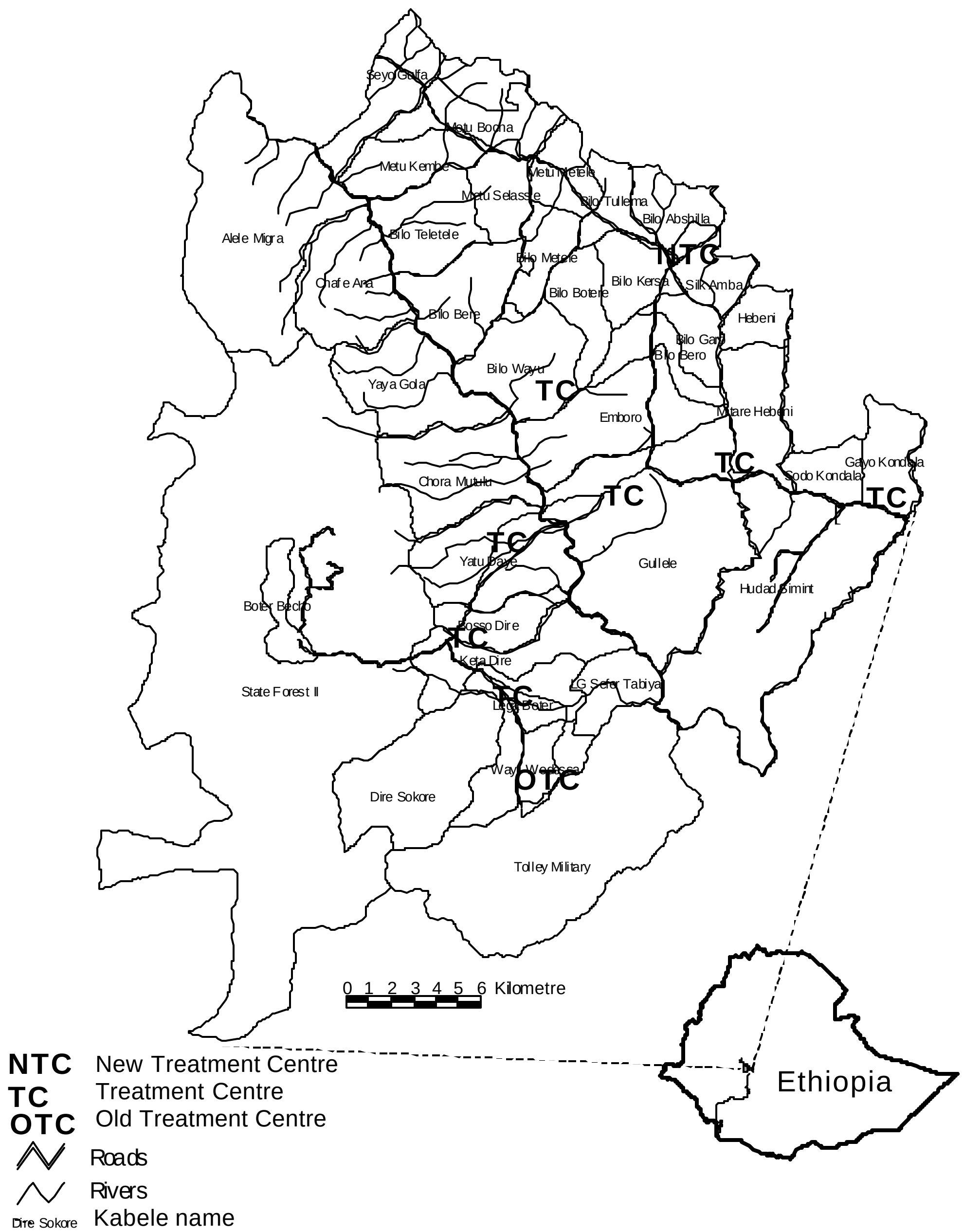
Since January 1991 the International Livestock Research Institute (ILRI) has been conducting a tsetse control trial using a cypermethrin high-*cis* pouron (ECTOPOR, Ciba-Geigy, Switzerland) in the Ghibe Valley (Gullele area) of Southwest Ethiopia (Leak et al. 1995; Swallow et al. 1995). Most cattle owners in the Ghibe Valley are sedentary agropastoralists who rely heavily on cattle for the production of traction power. Indeed, 51 percent of all cattle in the area are oxen, that is, male animals over the age of five years whose primary purpose is to provide traction power. Most cattle are grazed in village herds of less than 100 cattle. Village herds are formed each morning in the village area, and then taken to graze on fallow land and crop residues within two-four kilometers of the village. Other research conducted by the authors shows that there is relatively little overlap between the grazing territories used by communal herds. Individual households have use rights to land, with the local government unit (Kabele) having the authority to reallocate land among local residents.

In the pouron trial, a solution of insecticide is applied directly to cattle as a pouron. Tsetse flies and other external parasites that attempt to feed on the treated animals contact the insecticide and die. The pouron treatments were cost free until December 1992 when a cost recovery scheme was introduced. Thereafter individual cattle owners have been charged 3 Ethiopian Birr (about US$ 0.50) for each animal treated (Swallow et al. 1995). Any farmer who wishes to have animals treated can present their animals at one of the nine treatment centers where ILRI makes the pourons available one day each month. Figure 1 is a map of the study site.

THE PRIVATE AND LOCAL PUBLIC BENEFITS OF POURON USE

Previous studies in the Ghibe Valley show that farmers perceive three main benefits from use of the pouron: (i) less trypanosomosis in cattle; (ii) fewer problems with biting flies; and (iii) fewer problems with ticks (Swallow *et al*., 1995). Leak *et al*. (1995) have confirmed these perceptions: use of the pouron was associated with large reductions in trypanosomosis prevalence in cattle and in the relative densities of 3 species of tsetse and 2 species of biting flies. Farmers who treat their cattle with pourons obtain private benefits. Animals that receive treatments carry fewer ticks and may receive fewer bites from tsetse and other biting flies. Private treatment of animals with the pourons also generates local public benefits, namely suppression of the numbers of tsetse and other biting and nuisance flies in the local area. Given the dispersal patterns of the species of tsetse flies found in the study site, most of the benefits of tsetse suppression in one location likely accrue to people keeping cattle within a 1-kilometer radius of that location (Leak, personal communication, 1997).

Figure 1 Study site in the Ghibe Valley of Ethiopia



Pourons are thus described in economic terms as mixed public-private goods or impure public goods (Cornes and Sandler 1986). Individual farmers will purchase pouron treatments on the basis of their expectations of the marginal costs, marginal private benefits and marginal benefit from the public good. The marginal costs will be of two types: (i) cash cost of the treatment (standard cost of 3 Ethiopian Birr or $0.50 per animal treated) and (ii) transaction costs associated with procurement of the treatments. A priori, we assumed that transaction costs would be completely determined by distance from the homestead to the treatment center.

The marginal private benefit will depend upon the productivity effects of biting flies and ticks and the efficacy of the pourons in alleviating those effects. The public good benefit will depend upon the strength of the local institutions governing pouron use and the way that neighbors are expected to respond to changes in others' behavior. A priori, we assumed that these expectations would vary from one Kabele to another. Kabeles are the lowest level of government administration in rural Ethiopia and are responsible for a wide range of public services and local organization. Farmers from 23 Kabeles obtain pouron treatments at the nine treatment centers (see Figure 1). Kabeles contain an average of 200-250 households.

2. A MODEL OF HOUSEHOLD DEMAND FOR POURON TREATMENTS

This section presents a model of household demand for pourons that considers the private and local public benefits that they generate. Equation (1) defines the profits from cattle keeping for individual i as the difference between expected revenues and costs. We assume that livestock producers will choose the level of pouron use (Poi) that maximizes profits. Revenues are defined as the product of an aggregate product price (P) and the productive capacity of individual i's cattle herd (Hi). The productive capacity of a herd is a function of the number of cattle in the herd (Li), the composition of the herd, the level of pouron use by individual i (Qi), the expected level of pouron use by others who raise livestock in the area (QJ = n Qj\i) and the attributes of the herd owner. Two variables were used to measure herd composition: LOi is the proportion of oxen in the herd and LCi is the proportion of cows in the herd. Age and gender of the household head were the two attributes of the herd owner that were considered. Herd size (Li) and herd composition (LOi, LCi) are assumed to be quasi-fixed assets that are unaffected by pouron use in the short term. Thus the only costs associated with the pouron use are the costs of the pourons themselves (c) and the transaction costs associated with the pouron treatments (ti). Here it is assumed that the costs of the pourons are constant for all individuals, while transaction costs vary across individuals. A priori, we assume that the main determinant of transaction costs is distance from the homestead to the treatment center (ti(di)).

$$ð\ i = E\,[P * Hi\,(Qi, QJ; Li, LOi, LCi, Agei, Sexi)] - (c + ti(di)) * Qi \qquad (1)$$

Differentiation of equation (1) with respect to Qi produces the first order condition given by equation (2) and the implicit demand function given by equation (3). The explicit demand derived is given by equation (4). We assume that the function H is concave and continuously differentiable.

ä ð i / ä Qi = E [P (ä H/ ä Qi + (ä H/ ä Qj) * (ä Qj/ ä Qi)] - c - ti = 0 (2)

ä ð i / ä Qi = P ä H/ ä Qi + P ä H/ ä Qj E (ä Q/ ä Qi) - c - ti = 0 (3)

Qi^{D} = f (P, c, ti, ä H/ ä Qi, ä H/ ä Qj * E (ä Qj/ ä Qi); Li, LOi, LCi, Agei, Sexi) (4)

The expected signs of five of the variables follow from the standard model of variable input demand: (1) ä Qi^{D} / ä P > 0—demand is increasing in the price of the aggregate output; (2) ä Qi^{D} / ä c < 0—demand is decreasing in the cost of the pouron; (3) ä Qi^{D} / ä ti < 0—demand is decreasing in transaction costs; (4) ä Qi^{D} / (ä H/ ä Qi) >0—demand is increasing in the marginal contribution of the pouron to herd productivity; and (5) ä Qi^{D} / ä Li >0—demand is increasing in herd size. The expected signs on both of the herd structure variables, ä Qi^{D} / ä LOi and ä Qi^{D} / ä LCi, are positive since oxen and cows are the most preferred age-sex cohorts in the cattle herds. This hypothesis is supported by the earlier analysis by Swallow et al. (1995). ä Qi^{D} / ä Agei is expected to be positive since the pouron is a risk-reducing input and households whose heads are older are expected to be more risk averse. ä Qi^{D} / ä Sexi (Sexi = 1 if the household head is male and 2 if the household head is female) is also expected to be positive since female-headed households are expected to be more risk averse. This hypothesis is supported by the findings of Echessah et al. (1997) that female-headed households in the Busia area of Kenya were willing to contribute a significantly higher proportion of their income to tsetse control than male-headed households. The component of equation (4) that relates to collective action is (ä H/ ä Qj * E (ä Qj/ ä Qi). We assume that ä H/ ä QJ is always positive: the marginal benefits derived from additional units of the pouron are positive for all relevant levels of pouron use. E (ä Qj/ ä Qi) may be positive or negative. With no cooperation between neighbors, E (ä Qj / ä Qi) would be negative. That is, individual i would expect his/her neighbors to free-ride on their use of the pouron by reducing their own level of use. The more pouron used by i, the less pouron used by i's neighbors. This free-rider effect might be dampened, or even reversed, however, if there is some type of collective action to support collective action among farmers. In such a case E (ä Qj/ ä Qi) might be positive. That is, the more pouron used by i, the more pouron used by i's neighbors. We therefore re-define E(ä QJ/ ä Qi) as ë i, the index of expected cooperation held by individual i. Following the discussion in Section 2.2, we hypothesize that ë i will vary from Kabele to Kabele.

3. DATA COLLECTION, GENERATION AND ANALYSIS

GEO-REFERENCED HOUSEHOLD CENSUS

A geo-referenced census of all households in the 'market shed' of the 9 supply points for the pouron was undertaken between March and July 1996. Administration of the census questionnaire began with the villages immediately adjacent to the supply points and moved from village to village in all directions away from the distribution points until the enumerators came to villages that reported no use of the pourons during the previous year. A village was judged to be within the market shed if more than 2 households in the village reported having cattle treated with pourons during the previous year. A village was judged to be outside of the market shed if less than 2 households reported having cattle treated during the previous year.

The census questionnaire was prepared in English, translated into Amharic, pre-tested with 20 households, modified, and administered by enumerators during personal interviews with household heads. The census questionnaire was brief and took an average of 10 minutes to administer to each household. Data were collected on livestock ownership, use of pouron treatments, crop production and migration. Almost all of the questions were pre-coded closed-ended questions. Enumerators carried portable global positioning system (GPS) units and recorded the longitude and latitude co-ordinates for each household.

GENERATION OF NEIGHBOR AND NEIGHBORHOOD VARIABLES USING GIS

After translation into English, all data were entered using *Visual Dbase* (Borland, 1995) and verified in *SPSS* 6.1 (Norusis 1994). Data were then moved into *PCARC/INFO* (ESRI, 1996) GIS software, for creation of the spatial variables. The *PCARC/INFO* POINTDIST command was used to create a Point Attribute Table (PAT) file on neighbors in the 1-kilometer radius neighborhood. Microsoft FoxPro Version 3.0b (Kennamer, 1995) was used to sort the PAT data file created by the POINTDIST command and to generate attribute data on neighbors within a radius of 1 kilometer of each household. The NEAR command was used to calculate the nearest treatment center for each household. *ArcView* (ESRI 1995) was used to map the locations of households and treatment centers. The augmented data set was then brought into *SPSS* for econometric analysis.

In this analysis we relate the behavior of households to the characteristics of neighbors within a 1-kilometer radius. The 1-kilometer radius was chosen for two reasons. First, group interviews show that farmers appreciate the fact most of the benefits of tsetse suppression in a particular location will accrue within 3-4 km^2 of that location (Stephen Leak, personal communication, 1997). Second, people are able to easily monitor the tsetse control actions of households located within 1 kilometer of their homesteads. Farmers likely interact less with neighbors living more than 1 kilometer away.

A LOGISTICAL MODEL OF POURON DEMAND

Equation (4) specifies a general version of the pouron demand function. In the empirical analysis we have focused on the probability that a household treated some of their animals with pouron during the previous wet season. While there were direct measures for most of the household-level variables that would affect that probability, an instrumental variable needed to be constructed to represent collective action (or collective inaction in the case of non-cooperation). As a measure of the effects of others' pouron use on the productive capacity of the individual household (ä H / ä QJ), we use the number of cattle-owning households within a 1-kilometer radius. The higher the number of cattle-owning households in that area, the greater the potential gains from cooperation in pouron use and also the greater the incentive to free-ride on others' behavior.

A priori, we hypothesized that the degree of cooperation or non-cooperation (E(ä Qj / ä Qi)) would depend upon the Kabele in which the household is located. That is, the demand of households living in Kabeles with low cooperation would be negatively influenced by the density of cattle-owning households, while the demand of households living in Kabeles with high cooperation would be positively influenced by the density of cattle-owning households. In Ethiopia, the Kabele is the smallest unit of local administration and the smallest socio-political unit whose boundaries are fixed. While there are other social-spatial units that affect cooperation, none are observed across the study area, none are mutually exclusive, and none have fixed boundaries.

Binary variables were created to represent the 23 Kabeles in which the households were located. The population density and Kabele variables were multiplied together to create a set of 23 new variables, CGNL = CGNL1, CGNL2, ..., CGNL23, measuring the gains from cooperation or loss from non-cooperation. CGNL stands for cooperation gain or non-cooperation loss. For each household 22 of the 23 variables were equal to zero and one was equal to the number of households within the 1km radius around the household. A negative sign on a CGNL variable will indicate that households in that Kabele were generally less likely to treat their own animals when they had more cattle-owning neighbors. A negative sign indicates a group that did not overcome the incentives for free-riding. A positive sign on the CGNL variable will indicate households in that Kabele were generally more likely to treat their own animals when they had more cattle-owning neighbors. A positive sign indicates a group that was able to overcome the incentives for free-riding.

A logistical regression model was estimated to investigate factors affecting the probability that a household treated any cattle with pourons during the previous wet season. A Heckman's two-step model will also be estimated in future studies in order to test hypotheses about factors affecting the level of demand. Given space limitations here, however, we focus on the probability that a household treated any cattle.

Five versions of the logistical regression model were estimated. Version 1 included only characteristics of the household and its herd. The explanatory variables included age of household head, sex of household head, total number of cattle held, proportion of herd that was oxen, and proportion of herd that was cows. Version 2 included those household and herd characteristics and a variable measuring distance from the household to the nearest treatment center. Version 3 considered household and herd characteristics, distance to the nearest treatment center, and the 23 variables that measure the gains from cooperation or losses from non-cooperation. Version 4 was the same as Version 3, with the addition of 8 binary variables to allow for differences between the 9 treatment centers (crushes). None of those crush variables was statistically significant. Version 5 was the same as Version 3, plus 23 more variables to capture possible interactions between Kabele and distance to the treatment center.

Probi=f (household attributes—age and sex of the household head (5)

herd attributes—herd size, proportion of oxen, proportion of cows, distance to the treatment center—including the square to allow for diminishing marginal costs associated with distance;

composite variables of number of animals in 1km radius and Kabele binary variables—CGNL1, CGN2, ... CGNL23).

4. STATISTICAL RESULTS

About 5,000 households were enumerated during the census, two-thirds of which owned cattle (3,267). The average cattle-owning household held 4.7 cattle at the time of the survey, 51% of which were oxen and 17% of which were cows. Ten percent of cattle-owning households were headed by women. Ninety percent were headed by men. Seventy percent of cattle owners treated some cattle during the previous wet season (June-August 1995), 46% treated some cattle during the dry season, 44% treated some cattle during both the dry and wet season, and 1.6% treated some cattle during the dry season only.

The average cattle-owning household in the area was located 2.5 km from the nearest treatment center and had 53 cattle-owning neighbors within a 1-kilometer radius. Neighbors of the average cattle-owning household treated 59 cattle during the previous dry season and 102 cattle during the previous wet season. The average household owned 3.8% of all cattle within the 1km radius of their household. There was large variation in these spatial variables between households. One household had 143 cattle-owning neighbors within a 1-kilometer radius; others had no cattle-owning neighbors within a 1-kilometer radius. Some households resided in places where within a 1-kilometer radius, 301 cattle were treated during the previous wet season and 240 cattle were treated during the previous dry season. Other households resided in places where no other cattle were treated within a 1-kilometer radius in the previous dry season or wet season (Table 1).

Households in the market-shed of the 9 treatment centers resided in 23 Kabeles. The average Kabele had 142 cattle-owning households and 216 total households. Kabeles ranged in size from 27 to 317 households.

Several findings stand out from the results of the logistical regression model of wet-season demand presented in Table 2. First, neither the age nor sex of the household head were significant in any of the models. Second, the coefficients on the herd size and herd structure variables were significant in all versions of the model ($p < 0.001$). The relative size of the estimated coefficients indicate that large holdings of oxen are more likely to prompt farmers to treat some animals than equally large holdings of cows. Third, the results from Version 2 of the model indicate a significant non-linear relationship between distance to the crush and the probability that a household treated any animals. The finding that the probability of treatment actually increases for some distance, then decreases, might indicate that the relationship is non-linear but poorly represented by the quadratic, since the coefficient for the squared distance is non-significant. It might also indicate that proximity to the crush provides people with a stronger incentive to free-ride; this incentive might outweigh the difference in transaction costs.

Table 1 Descriptive statistics on household population included in household census (data for 3,267 cattle-owning households)

Variable name deviation	Mean	Standard	Minimum	Maximum
Use of pourons				
–proportion households in dry season	0.46			
–proportion households in wet season	0.70			
–cattle treated in dry season	1.38	1.95	0	25
–cattle treated in wet season	2.16	2.36	0	30
Household characteristics				
–Age (years)	41.50	14.60	16	111
–Sex (1=m, 2=f)	1.10	0.30	1	2
Herd characteristics				
–number cattle	4.70	4.60	1	56
–proportion oxen	0.51	0.36	0	1
–proportion cows	0.17	0.20	0	1
Distance				
–Kilometers to crush	2.50	3.10	0	19.8
Neighbor traits				
–number cattle owners in 1 km	52.67	33.23	0	143

Table 2 Results for versions 1, 2 and 3 of the model of pouron demand, estimated for 3,221 cattle-owning households in the Ghibe Valley of Ethiopia

Variable	Version 1		Version 2		Version 3	
	Coef.	P-value	Coef.	P-value	Coef.	P-value
Constant	-.8919	.0000	-.2936	.0000	-1.3841	.0000
Household traits						
–age of hh head	.0006	.8336	.0013	.6520	.0013	.6644
–sex of hh head	-.1135	.3881	.0247	.8538	-.0319	.8253
Herd traits						
–number cattle	.1889	.0000	.1820	.0000	.1858	.0000
–proportion oxen	1.8617	.0000	1.7873	.0000	1.8571	.0000
–proportion cows	.7935	.0006	.8185	.0004	1.1066	.0000
Distance						
–meters			.0003	.0000	7.6E-5	.0750
–meters squared			-.2E-8	.0000	-3.0E-9	.4829
Kab1*cattle hhs in 1km					.0188	.0002
Kab2*cattle hhs in 1km					-.0002	.9641
Kab3*cattle hhs in 1km					.0152	.0042
Kab4*cattle hhs in 1km					.0070	.0358
Kab5*cattle hhs in 1km					-.2441	.0000
Kab6*cattle hhs in 1km					-.0077	.1657
Kab7*cattle hhs in 1km					-.0050	.4738
Kab8*cattle hhs in 1km					-.0994	.0008
Kab9*cattle hhs in 1km					.0156	.0182

Table 2 Results for versions 1, 2 and 3 of the model of pouron demand, estimated for 3,221 cattle-owning households in the Ghibe Valley of Ethiopia (continued)

Variable	Version 1		Version 2		Version 3	
	Coef.	P-value	Coef.	P-value	Coef.	P-value
Kab10*cattle hhs in 1km					-.0268	.0000
Kab11*cattle hhs in 1km					-.0046	.2353
Kab12*cattle hhs in 1km					.0071	.0171
Kab13*cattle hhs in 1km					-.0170	.0000
Kab14*cattle hhs in 1km					-.0072	.0000
Kab15*cattle hhs in 1km					-.0135	.0435
Kab16*cattle hhs in 1km					.0072	.0072
Kab17*cattle hhs in 1km					.0177	.0012
Kab18*cattle hhs in 1km					.0165	.0001
Kab19*cattle hhs in 1km					.0459	.0000
Kab20*cattle hhs in 1km					.0030	.7334
Kab21*cattle hhs in 1km					.0053	.4043
Kab22*cattle hhs in 1km					-.0145	.0000
Kab23*cattle hhs in 1km					-.0130	.0000
Chi-square	367.8		410.6		804.1	
% correct predictions	75.8		75.4		77.6	

Results from Version 3 of the model indicate large differences between Kabeles in their ability to capitalize on the gains from cooperation or suffer losses due to non-cooperation. The estimated coefficients on the CGNL variables were negative for about half of the Kabeles, indicating overall free-riding behavior, and positive for the other half, indicating overall cooperative behavior. Seven of the negative coefficients are statistically significant at $p < 0.001$, three of the positive coefficients are statistically significant at $p < 0.001$. It would appear that in the remaining 13 Kabeles the incentive to free ride was roughly offset by incentive to cooperate.

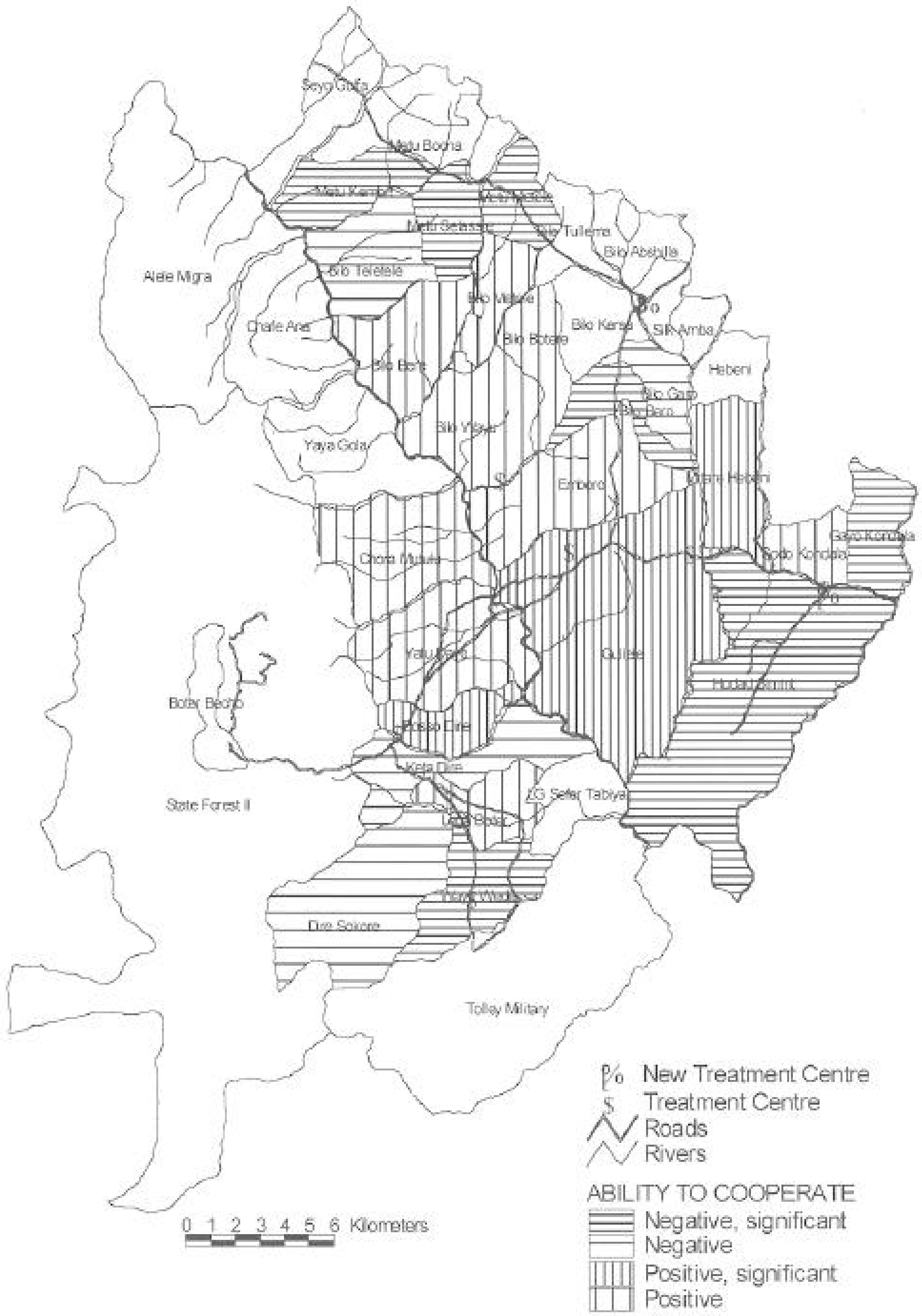
Another intriguing result from Version 3 of the model is that the distance variables were statistically insignificant, in contrast to the results from Version 2. This suggests that the distance variables were capturing the effects of the cooperation variables in Version 2, so that their significance disappeared when the cooperation variables were included in Version 3. Apparently distance had important effects on the ability to cooperate, but no other effect on household demand.

Version 4 of the model included all of the same variables as Version 3, plus an additional 8 binary variables to allow for differences between the 9 treatment centers. None of those binary variables were significant. Version 5 of the model was the same as Version 3, with 23 more variables included to capture possible interactions between Kabele and distance to the treatment center. None of those interaction variables were significant.

Figure 2 illustrates these results on a map of the Kabeles in the study area. The Kabeles indicated by vertical hatched lines have positive coefficients on the ability-to-cooperate variable. The 3 Kabeles with the narrowly-spaced vertical lines have significant positive coefficients, while the 9 Kabeles with the widely-spaced vertical lines have insignificant positive coefficients. On the other hand, Kabeles indicated by horizontal lines have negative coefficients on the ability-to-cooperate variable. The 4 Kabeles indicated with widely-spaced horizontal lines have insignificant negative coefficients, and the 7 Kabeles indicated with narrowly-spaced horizontal lines have significant negative coefficients.

The spatial distribution of the 4 types of Kabeles indicates that the ability of the Kabele to cooperate is at least partially related to distance from the treatment centers. Kabeles with low cooperative abilities tend to be on the peripheries of the overall study area, while Kabeles with high cooperative abilities tend to be in the center of the area. Three clusters of Kabeles suggest that there are other important factors at play. In the south-west of the study area, there are 4 neighboring Kabeles with the different levels of cooperative ability, despite the fact that all are located near to treatment centers. There are similar clusters of Kabeles in the south-east and northern parts of the study area.

Figure 2 Index of cooperation for 23 Kabeles in the ectopor area, Ghibe Valley, Ethiopia


Seyo Gofa
Matu Bocha
Alele Migra
Bilo Tulema
Bilo Abshilla
Bilo Telelele
Chafe Ana
Bilo Kersa
Silk Amba
Bilo Botare
Hebeni
Yaya Gola
Embero
Chora Mutule
Gayo Kondala
Sodo Kondala
Gullele
Boter Becho
State Forest II
Keta Dire
Dire Sokore
Tolley Military
New Treatment Centre
Treatment Centre
Roads
Rivers
ABILITY TO COOPERATE
Negative, significant
Negative
Positive, significant
Positive
0 1 2 3 4 5 6 Kilometers

5. GROUP INTERVIEWS: WHAT CAUSED DIFFERENCES IN COOPERATION?

The results from Version 3 of the model indicate significant differences between Kabeles in their abilities to foster cooperation in pouron use among neighbors. These results raise additional questions. First, do the results capture real differences in cooperation or some other phenomena that is only statistically related? Second, are Kabeles important in their own right, as assumed a priori, or are Kabeles spatially correlated with some more important social groupings? Third, why is it more difficult to undertake collective action in Kabeles close to the treatment centers than in Kabeles further away from the treatment centers?

Follow-up research was conducted to answer those questions. Results from the econometric analysis were used to select three pairs of Kabeles. Each pair included one Kabele with a high ability to cooperate and another nearby Kabele with a low ability to cooperate. In the southwest part of the study area, Wayu Wedessa was selected as an area of low cooperation and Bosso Dire was selected as an area of high cooperation. In the southeast part of the study area, Mitare Hebeni was selected as an area of low cooperation and Bilo Mero as an area of high cooperation. And in the northern part of the study area, Metu Selassie was selected as an area of low cooperation and Bilo Metele as an area of high cooperation. Interviews were held in each of the 6 Kabeles during a 3-day period in February 1998. Between 5 and 30 livestock owners participated in each group interview. About 10-12 open-ended questions were asked during interviews lasting 1 to 2 hours. Participation in the group interviews was the first indication that the statistical results were accurate. No more than 10 livestock owners attended the group interviews in the low cooperation villages. Twenty to thirty livestock owners attended the group interviews in the high cooperation villages.

The results provided answers to the three questions posed above. The econometric results were indeed consistent with large differences in actual cooperation between the Kabeles. All three Kabeles that were identified through the econometric analysis as having low ability to cooperate did indeed report low levels of pouron use and little or no active collective action to support pouron use. Alternatively, the three Kabeles that were identified as having high ability to cooperate indeed reported much higher levels of pouron use and very active collective action at the level of the Kabele.

Examples of active and deliberate cooperation were found in the Kabeles identified through the statistical analysis as having high ability to cooperate. For example, the livestock owners and Kabele officials that we interviewed in Bilo Metele reported several forms of active cooperation, most of which was led by the Kabele officials: 1) People in the Kabele have formed groups for disseminating information about upcoming meetings and important events. The head of each group is a contact point for receiving information and he is responsible for disseminating the information to other group members. Information about the dates when pouron treatments are available is disseminated through these groups. 2) People help each other by taking each other's animals to the treatment center. They do this despite the difficulties of handling others' animals in strange places. 3) The Chairman of the Kabele has met with nearby Kabeles to organize joint work to clear the road along which they walk their animals to the crush where treatments are available. 4) A village of recent immigrants who live farther away from the crush are allowed to graze their animals around the village en route to getting treatments.

In contrast, in Wayu Wedessa, farmers interviewed during the group interview were ready to admit that they had deliberately discouraged their neighbors from receiving pouron treatments. Their logic was this: if they told their neighbor that pouron treatments will be available on a certain day, that neighbor will ask them to take their animals when they go. The strange animals may be difficult to handle and cause crop damage along the way.

An answer to the second question is supported by both the econometric analysis and the group interviews. In Version 4 of the model none of the coefficients on the treatment center binary variables was significant, implying that cattle owners do not group around the treatment centers. The groups of farmers interviewed in the three Kabeles with high levels of cooperation mentioned examples of collective action at the Kabele level, but did not mention examples of collective action for pouron use around any other social group. This suggests that the Kabele is a locus of collective action for tsetse control in some of the areas. No other social group was identified as playing that role.

The group interviews also provided a possible answer to the third question about the reasons why it appears to be more difficult to sustain collective action in Kabeles farther from the treatment center? The types of collective action that the farmer groups mentioned involve transaction costs. Gathering and disseminating information about the dates when pouron treatments will be available is costly. Taking neighbors' animals to and from the treatment centers is costly. Maintaining a clear walking path through intensively-used farmland is also costly. All of these transaction costs are positively related to distance to the treatment centers. The greater the distance, the higher the transaction costs associated with cooperation, and thus the less likely was cooperation.

Transaction costs are also positively related to ethnic heterogeneity. We propose two hypotheses that are consistent with this result. First, the greater the ethnic heterogeneity within a Kabele, the greater the transaction costs associated with collective action. This is consistent with both theory and other case study evidence (see Baland and Platteau, 1994). Second, the greater the ethnic difference between the Kabele that hosts a treatment center and another outlying Kabele, the greater the transaction costs associated with the collective action in the outlying Kabele. Two of the non-cooperative Kabeles were populated by mixtures of Oromo-speaking and Amhara-speaking people, while the third was mostly populated by Oromo speakers. The pattern of settlement in the study area is such that all of the crushes are located in areas where Amharic-speaking persons predominate. Because they don't interact as freely with Amhara speakers, the Oromo speakers had to bear more costs in order to obtain information about the treatment dates. In addition, Oromo speakers do not feel welcome to walk their animals through the Amhara areas en route to the crushes or to wait around the crushes to have their animals treated. Crop damage cases would be more costly and difficult to resolve.

6. DISCUSSION AND CONCLUSIONS

THE CASE STUDY

Several of the results from the case study warrant further discussion. Consider first the result that the gender of the household head has no effect on the probability that a household will give pouron treatments to its animals. This result is consistent with an earlier analysis of pouron demand in the Ghibe Valley that found no household characteristics to have significant effects on pouron demand (Swallow et al. 1995). It appears inconsistent, however, with the findings of Echessah et al. (1997) that female-headed households in the Busia District of Kenya were willing to contribute significantly more money to tsetse control than male-headed households. The differences may be due in part to the difference in disease risk. Both people and livestock are at risk of contracting trypanosomosis in Busia, while in Ghibe only livestock are at risk. In both sites men have primary responsible for animal health, while women have primary responsible for family health.

The results from Version 3 of the model indicate significant differences between Kabeles in their abilities to foster cooperation in pouron use among neighbors. The group interviews conducted in the three pairs of Kabeles confirmed these findings and provided three important insights. First, Kabeles are an important locus of cooperation even though Kabeles were not formally involved in the control program. Second, cooperation is costly. It is costly to acquire and exchange information and both costly and risky to move animals to the treatment centers. Third, anything that increases the costs or risks of cooperation will reduce the likelihood of successful cooperation. Differences in ethnicity and distance to the treatment center increase those costs.

The pilot tsetse control trial was changed in two ways because of the insights obtained from this study. First, two new treatment centers were opened in low cooperation areas that are mostly populated by Oromo speaking people. This should make the treatments more easily accessible to Oromo-speaking people in the area and increase cooperation. Second, the dates when pouron treatments will be given are now announced at least a month in advance. This should make information more easily and cheaply available. These lessons will extend to other locations where this approach to pouron delivery and utilization is attempted.

IMPLICATIONS FOR ANALYSIS OF THE ECONOMICS OF SPACE

Several things about this study distinguish it from most other studies of economic behavior and economic activity in developing countries. First, the large number of observations (5,000 households, two thirds of which owned cattle) allowed more accurate estimation of parameters than is usual. The costs per household of data collection and data processing were very low because there were no costs associated with sampling (e.g. compilation of an accurate sampling frame, location of selected households) and because the questionnaire was very focused.

Second, the large number of observations allowed the accurate estimation of the parameters and thus more complete testing of hypotheses. Version 3 of the model included 31 variables, over half of which were statistically significant at $p < 0.001$. Two additional versions of the model, not shown here, were run with several more variables.

Third, the geo-referenced census yielded information about all of the neighbors of every household. Manipulation of the census data with the GIS tools allowed the creation of the neighbor variables and the tests of hypotheses about ability to cooperate. This approach could be extended to the many other types of economic behavior and economic outcomes that are related to space. In this case, this approach was possible because of close contact and collaboration between economists and geographers and the availability of computer software and hardware for GIS and econometric analysis.

Fourth, the geo-referencing of the census data allowed us to create several new spatial data layers that can be used for other purposes. For example, we now know the location of all households in our study area, the year that they established their homestead in its present location, and from where they originated. Those data are being used to estimate the temporal and spatial patterns of in-migration into the study area and the effects of tsetse and trypanosomosis on those patterns.

REFERENCES

Baland, J.M. and J.P. Platteau. 1994. *Halting degradation of natural resources: Is there a role for rural communities?* FAO: Rome.

Bockstael, N. 1996. Modeling economics and ecology: The importance of a spatial perspective. *American Journal of Agricultural Economics* 78: 1168–1180.

Borland International. 1995. *Visual Dbase*. Scotts Valley, CA.

Bromley, D.W. and J.P. Chavas. 1989. On risk, transactions and economic development in the semi-arid tropics. *Economic Development and Cultural Change* 37: 719–738.

Chomitz, K.M. and D.A. Gray. 1996. Roads, land use and deforestation: A spatial model applied to Belize. *The World Bank Economic Review* 19(3): 487–512.

Cornes, R. and T. Sandler. 1986. *The theory of externalities, public goods and club goods.* Cambridge: Cambridge University Press.

Echessah, P.N., B.M. Swallow, D.W. Kamara, and J.J. Curry. 1997. Willingness to contribute labor and money to tsetse control: Application of contingent valuation in Busia District, Kenya. *World Development* 25(2): 239–253.

Environmental Systems Research Institute (ESRI). 1995. *PC Arc/Info version 3.5*. Redlands, Central Asia.

________. 1996. *PC ArcView version 2.16*. Redlands, CA.

Kemmamer, W. 1995. *Microsoft FoxPro version 3.0b.* Microsoft Corporation.

Jayne, T. 1994. Do high food marketing costs constrain cash crop production? Evidence from Zimbabwe. *Economic Development and Cultural Change* 42: 387–402.

Leak, S.G.A., W. Mulatu, G.J. Rowlands, and G.D.M. D'Ieteran. 1995. A trial of a 'cypermethrin pouron' insecticide to control *Glossina pallidipes*, *G. fuscipes fuscipes* and *G. morsititans submorsitans* (*diptera: glossinaidae*) in southwest Ethiopia. *Bulletin of Entomological Research* 85: 241–251.

Norusis, M.J. 1994. *SPSS advanced statistics 6.1*. Chicago: SPSS.

Omamo, S.W. 1995. Smallholder agriculture under market reform: The case of Southern Siaya District, Kenya. Ph.D. diss., Stanford University, Stanford, CA.

Swallow, B.M., W. Mulatu, and S.G.A. Leak. 1995. Potential demand for a mixed public-private animal health input: Evaluation of a pouron insecticide for controlling tsetse-transmitted trypanosomosis in Ethiopia. *Preventive Veterinary Medicine* 24: 265–275.

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CAPRi WORKING PAPER NO. 7

COLLECTIVE ACTION IN ANT CONTROL

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CGIAR System-wide Program on Property Rights and Collective Action

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Washington, D.C. 20006 U.S.A.

October 2000

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ABSTRACT

Leaf-cutting ants (*Atta. cephalotes*) represents a serious problem to farmers in many parts of Latin America and accounts of ants eating up a whole cassava plot or destroying one or more fruit trees overnight are not uncommon. Ants do not respect farm boundaries. Therefore, farmers who control anthills on their own fields might still face damage on their crops caused by ants coming from neighboring fields where no control measures are taken. In that sense, crop damage caused by leaf-cutting ants constitutes a transboundary natural resource management problem which, in addition to technical interventions, requires organizational interventions to ensure a coordinated effort among farmers to be solved. This paper reports on a research effort initiated by CIAT and implemented jointly between CIAT and farmers in La Laguna—a small community in the Andean Hillsides of Southwestern Colombia. The objective of the research effort was two-fold: i) to identify low cost technical options for ant control, and ii) to analyze and visualize the transboundary nature of the ant control problem and thus identify organizational options to enable collective or coordinated ant control.

CONTENTS

COLLECTIVE ACTION IN ANT CONTROL

Helle Munk Ravnborg, Ana Milena de la Cruz, María Del Pilar Guerrero, and Olaf Westermann[1]

1. INTRODUCTION

Leaf-cutting ants represent a serious problem to farmers in many parts of Latin America. In *La Laguna*, a community in the Andean hillsides of Southwestern Colombia, small-scale farmers ranked the damage caused by leaf-cutting ants (*Atta. cephalotes*) as one of their most serious agricultural problems.[2] Accounts both from *La Laguna* and elsewhere in Latin America (Cherrett 1986) of leaf-cutting ants eating up a whole cassava plot or destroying one or more fruit trees overnight are not uncommon. In

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[1] Helle Munk Ravnborg is a research fellow with Centre for Development Research, Copenhagen. From 1994-98, she was employed as a rural sociologist with Centro Internacional de Agricultura Tropical (CIAT). Ana Milena de la Cruz is an Entomologist who worked with CIAT up to 1997. María del Pilar Guerrero is a sociologist, currently working as a consultant to CIAT, and Olaf Westermann is a rural sociologist with CIAT's hillsides project. The authors feel indebted to Marleny Aranda Morales who acted as our local field assistant and played a tremendously important role in helping and stimulating farmers in their efforts to undertake collective ant control. Also we wish to thank farmers of in *Los Zanjones* for wishing to work with us and making our many Saturdays spent at *Los Zanjones* truly pleasant memories. Ruth Meinzen-Dick, Anna Knox and Brent Swallow provided valuable comments on an earlier draft of this paper for which we are very grateful. Last but not least, we wish to thank IDRC and DANIDA for financing this research.

[2] In a group diagnosis of agricultural and natural resource management problems, the problem of ant control ranked second to the cassava pest, (Cyclocephala sp.) among the problems identified, while in a questionnaire survey concerning crop pest and disease problems in the area, the ant control problems came out as the most frequently mentioned problem.

general, *La Laguna* farmers estimate that they lose between 20 and 50 percent of their cassava due to attacks from leaf-cutting ants. The most common control practice is the use of the chemical chlorpyrifos (an organophosphorous), known in the area under the commercial name *lorsban*. *Lorsban* is recommended to be pumped into the ant nest. However, due to cash constraints for purchasing both the pump and sufficient quantities of *lorsban*, the most common practice is to place *lorsban* around the entrances and exits of the anthill directly from the bag. Farmers complain about the ineffectiveness of this method as well as the human and environmental health problems with which it is associated.

In more than one way, crop damage caused by leaf-cutting ants is a problem related to collective action. From the perspective of the ant colony, collective action among the ants—the highly developed division of labor and the occurrence of altruistic behavior in an effort to protect the colony as a whole—is the key to explain the tremendous ecological impact that ants have. As indications of their ecological impact, ants are claimed to move more soil than earthworms, to be the principal catalyzers of energy within ecosystems, and their total weight is estimated to four times that of all vertebrates combined (Lopéz 1996). From a farmer perspective, it is the *lack* of collective action which is key to understanding the difficulties involved in controlling the leaf-cutting. Ants do not respect farm boundaries. Therefore, farmers who control the anthills in their own fields might still face damage on their crops caused by ants coming from neighboring fields where no control measures are taken. In that sense, crop damage caused by leaf-cutting ants constitutes a transboundary natural resource management problem.

Like the ant control problem, many other agricultural and more broadly natural resource management problems cannot be properly understood and solved at the plot or farm level but need to be addressed at the landscape level.

The transboundary nature of many agricultural and natural resource management problems has both technical implications in terms of experimental design and resource monitoring approaches (Ravnborg 1997), and organizational implications in terms of the need for coordination among farmers of the timing and kind of management practices employed. It means that the search for alternative solutions or management practices cannot be seen as a purely technical endeavor, taking into consideration only the technical effectiveness and the economic and financial aspects of potential solutions. Organizational aspects, that is mechanisms that stimulate and facilitate coordinated or collective management efforts at various levels, have to be included as an integral part of the alternative solutions. This paper illustrates the importance of organization in the case of ant control.

The present chapter is organized into eight sections. The following section (Section 2) gives an account of site selection and methods used. An important element in stimulating coordinated or collective resource management is to demonstrate and, if possible, visualize its need and advantages (Uphoff 1992). Section 3 describes an attempt to visualize the need for collective ant control in the case of *La Laguna*. Section 4 continues by briefly summarizing the ant control practices employed in the area prior to the search for alternative ant control methods. In response to farmers identification of ant control as one of the most important and widespread problems, the CIAT research team committed itself to assisting farmers in searching for alternative solutions, technical as well as organizational. Section 5 describes an experiment set up to test some of the potential technical solutions identified through this joint search, while Section 6 summarizes the results. One of the potential solutions tested in this experiment was evaluated favorably by farmers. Hence, Section 7 turns to describe some of the organizational problems—and challenges—encountered when seeking to implement this solution at a landscape level. Finally, Section 8 offers some tentative conclusions from this work in progress.

2. METHODS

In the beginning of 1996, CIAT's Hillsides project began undertaking 'participatory landscape-level experimentation' on what could be considered a pilot level. The basic idea was to explore the methodological implications, both for bio-physical and social and institutional research, of dealing with natural resource management problems at a landscape level rather than, as conventionally done, solely at a plot level. CIAT has a long history of undertaking both researcher-led and farmer-led on-farm experimentation, particulturaly in the municipality of Caldono in the Department of Cauca, situated in the Andean foothills in southwestern Colombia at altitudes between 1000 and 2200 meters. The area is inhabited by a multi-ethnic population, including so-called *mestizo* small-scale farmers, indigenous (both Paez and Guambiano) farmers, and so-called *white* or *caleño* settlers who bought land during the past decades which they are cultivating, often by contracting caretakers. Thus, without making claims of being representative in a strictly statistical sense, the area is characteristic of much of the medium altitude and culturally diverse hillsides of Latin America where small-scale farming dominates. It was therefore natural to start the participatory landscape-level experimentation in this area. More specifically, a contiguous area big enough to include different types of land use and users and small enough to make it possible for landscape users to meet face-to-face was selected. As many natural resource management problems relate to movements of water and soil within a landscape (though not all—including the ant control problem treated in this paper), site identification was done on a watershed basis, identifying all watersheds in the area of a size between 25 and 150 hectares. Previous research done in the area, including a census questionnaire survey undertaken in 1993 and a poverty profile undertaken in 1994 (Ravnborg and Guerrero 1996) allowed us to select watersheds with great diversity in terms of land use and land users. *Los Zanjones*, located in La Laguna, was one of these watersheds.

Los Zanjones comprises 44 hectares, subdivided among 14 individual owners, giving an average plot size of 3.1 hectares. In addition to owner cultivation, various other forms of access to land are common in the area, such as renting in land, sharecropping or employment as caretakers. Including these forms of tenure in addition to owner cultivation, *Los Zanjones* has a total of 17 land users.

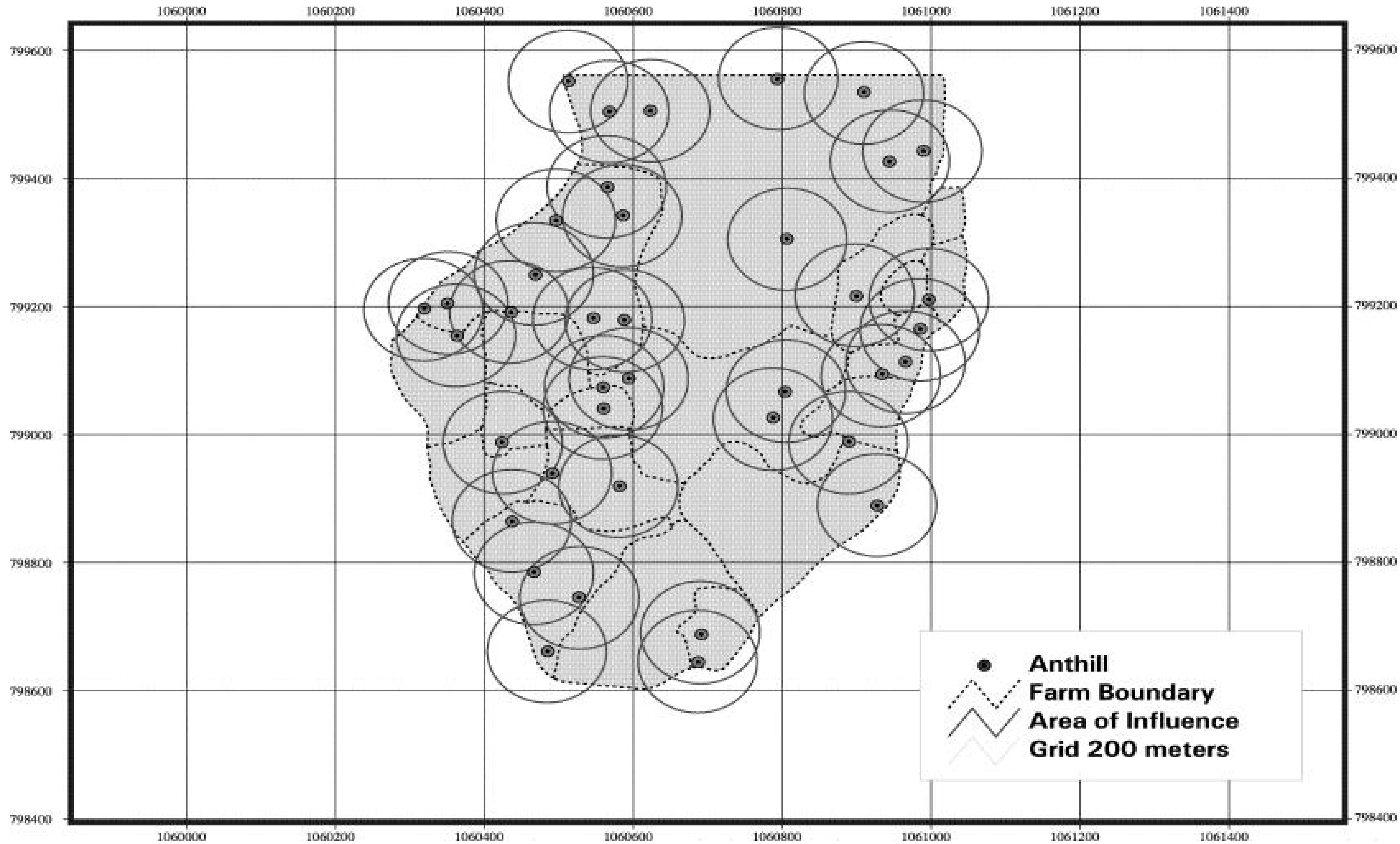
Having selected the micro-watershed, CIAT invited all land users for a series of meetings in order to explore their interest in working collectively to analyze and attempt to solve agricultural and natural resource management problems that farmers cannot solve on an individual basis. Apart from their role as organizers, CIAT researchers acted as facilitators during these meetings and various activities were undertaken, including problem identification, ranking and analysis. The meetings also served as fora within which experiments were planned and monitored, as in the present case of testing potential ant control practices. In parallel to the meetings, open-ended semi-structured interviews were undertaken on an individual basis with land users selected through contrast sampling (Ravnborg and Guerrero 1999) to examine in more detail the diversity of perceptions of natural resource management problems, interests and conflicts. A structured questionnaire survey was undertaken to provide more detailed information concerning pest and disease problems and current management practices in the area (de la Cruz and Cardona 1996). In addition to ant control, other problems such as decreasing soil quality and protection of riverbeds and springs were identified and worked on as priority problems. Throughout the period of experimentation, regular meetings were held and occasionally conversational interviews were undertaken to obtain more detailed understanding of farmers' perceptions of progress and problems.

As already mentioned, the research, of which collective ant control experimentation is part, was initiated on a pilot basis in order to explore the bio-physical, social, and institutional implications of managing natural resources on a landscape level rather than a plot level. Moreover, studies were undertaken very recently and are meant to form the basis for the design of a more comprehensive research program. Rather than final conclusions, the results reported in this paper are of an indicative nature.

3. ANT CONTROL—A TRANSBOUNDARY NATURAL RESOURCE MANAGEMENT PROBLEM

Leaf-cutting ants do not respect farm boundaries. Hence, in areas where small farms predominate, crop damage caused by leaf-cutting ants tends to be a transboundary resource management problem, which calls for coordinated or collective action to solve. Following farmers' identification of ant control as a major problem, one of the objectives of the CIAT research team working on participatory landscape-level experimentation was to find ways to visualize and to some extent quantify the transboundary nature of the ant control problem, and thus raise awareness of the need for a coordinated effort. Such an attempt was made for *Los Zanjones*. Subdivided into two groups walking through the watershed, equipped with a very detailed map (an ortho-photograph) of the area, land users conducted an inventory of major anthills. Thirty-nine major anthills or nests were identified and located in the map. Figure 1 shows the extensions of the 19 plots, overlaid by the location of the 39 major nests. On the basis of farmers' experience from following the ant tracks from the anthills in the area, the average radius of action of the leaf-cutting ants, that is the distance from the nest that the ants move to forage, was estimated at 80

Figure 1: Location of anthills, their radius of action and farm boundaries, Los Zanjones, La Laguna, Colombia



1060000
1060200
1060400
1060600
1060800
1061000
1061200
1061400
799600
799400
799200
799000
798800
798600
798400
Anthill
Farm Boundary
Area of Influence
Grid 200 meters

meters[3]. A circle with a radius corresponding to 80 meters has therefore been drawn around each nest in Figure 1 to indicate their respective area of influence. Thus, calculating from the map, each plot is potentially affected by an average of 5.5 anthills (ranging from 1 to 13) of which 3.4 anthills (ranging from 0 to 9) are located on plots belonging to other farmers—on average belonging to 2.5 other farmers (ranging from 0 to 6). In addition to the damage caused by ants that have their nest within the farm boundaries, this means that farmers can expect crop damage to be caused by ants coming from more than three nests located outside their own farm, belonging to two to three other farmers. Controlling the ants on one's own plot thus provides limited security against crop damage caused by leaf-cutting ants unless there is guarantee that the neighbors also control the ants on their plots.

4. CURRENT ANT CONTROL PRACTICE

The current ant control method employed in the area is the use of a powdered insecticide with the commercial name *lorsban*, in which chlorpyrifos is the active ingredient. In *Los Zanjones*, 88 percent of the households use *lorsban* for ant control. *Lorsban* is recommended to be pumped into the ant nest to be effective, but the most common method of application, used by 41 percent of the farmers, is to pour *lorsban* directly from the bag around

[3] It should be noted that the 80-meter action radius is a conservative estimate since leaf-cutting ants are known to cut leaves at distances up to 200 meters from the nest (Cherrett 1986).

the entrance and exit holes of the anthill (see Table 1). As soon as the ants detect the poison, they leave the old entrances and start opening new ones. The reasons stated by farmers for this sub-optimal use of *lorsban* are the lack of a pump for pumping *lorsban* into the nest, and the fact that pumping *lorsban* into the ant nest requires the use of larger quantities of *lorsban* (and is therefore more costly) compared to just pouring the powder around the holes.

Table 1: Ant control method used, *Los Zanjones, La Laguna*, Colombia

Ant control method	Percent [a] farmers using
Pour *lorsban* around the entrance/exit hole directly from the bag	41
Pump *lorsban* into the nest, using a pump	18
Apply *lorsban* directly from the bag around the entrance/exit holes, using a spoon	12
Make a hole into which *lorsban* is poured	12
Sometimes using a pump, sometimes pouring *lorsban* directly from the bag	6
Do not control ants	12
N	17 [b]

Notes: [a] The percentages do not add up to 100 due to errors of rounding.
[b] The number of farmers does not correspond to the number of land owners due to the existence of tenure arrangements others than owner cultivation, such as sharecropping and caretaker cultivation.

Table 2 shows the amounts of *lorsban* used during the period May 1996 to May 1997, as recalled by farmers in May 1997. The most frequently used quantity was between 1 and 3 kilos, used by 41 percent of the farmers. For comparison, to control an anthill by pumping *lorsban* into it requires on average three applications of 0.5 kilos, that is 1.5 kilos of *lorsban*. Figures reflect the total amount of *lorsban* used per farm, which may be to control one or more anthills, or to spray crops.

Table 2: Amount[a] of *Lorsban*[b] used in *Los Zanjones* from May 1996 to May 1997, *La Laguna*, Colombia

	0 kilos	1-3 kilos	4-6 kilos	12-15 kilos	30 kilos
Percent farmers using	12	41	24	18	6

Notes: (N=17 farmers)

[a] 13 farmers (76 percent) indicated use of *lorsban* only for ant control while 2 farmers (12 percent) used *lorsban* both for ant control and to spray crops. This partly explains the large quantities used by some farmers.

[b] 1 kilo of *lorsban* costs US$2 (for comparison, an agricultural laborer is paid US$4.5 per day).

Less than 10 percent of farmers in *Los Zanjones* use any form of protection (protective gloves or masks) when applying *lorsban*. This is unfortunate since chlorpyrifos, classified by WHO as toxicity class II, is a chemical that easily penetrates the skin.

Rather than being attributable to the chemical as such, the failure to control ants in *Los Zanjones* with the use of *lorsban* is assumed to be due to a combination of two other factors, namely the sub-optimal method of application and the fact that ant control is not coordinated among farmers. Moreover, farmers complained about the cost of *lorsban* and expressed their general environmental concerns related the use of insecticides. These concerns therefore motivated the search for alternative ant control methods.

5. ALTERNATIVE ANT CONTROL METHODS—THE EXPERIMENT

Four alternative control methods and a control (no treatment) were selected for farmer experimentation in *La Laguna* for control of existing anthills. These are:

1. agricultural lime, pumped into the anthill;
2. lime mixed with *lorsban*, pumped into the anthill;
3. gasoline, poured into the anthill and set fire in order to produce an explosion; and
4. washing powder, poured into and around the entrances/exists of the anthill.

Agricultural lime does not work directly to kill the ants. Rather, it has an indirect effect by increasing the pH of the interior of the anthill and thereby creating conditions under which the fungus cultivated by and upon which the ants feed[4] cannot survive. Thus, lime causes the gradual starvation of the ants by inhibiting their fungus cultivation. For ease of pumping and maximum effectiveness, a fine-powdered lime with 100 percent calcium content should be used. This control method was proposed to farmers by CIAT researchers, following advice from national extension workers in other parts of Colombia.

In response to initial experiences with the application of lime, farmers proposed to mix lime with *lorsban* for combined application in a proportion of lime to *lorsban* of 3:1 and to gradually decrease to zero the amount of *lorsban* added to the lime. Since *lorsban* works by directly killing the ants, farmers in this way obtain immediate ant control while waiting for the

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[4] Leaf-cutting ants do not directly feed on the leaves they cut, but on a fungus cultivated in the nest on the basis of the leaves.

effect of lime to build up. In the experiment, the average ratio of lime to *lorsban* was 6.33:1, calculated over all the applications.

Gasoline works by exploding and thus physically eradicating the anthill. This method was proposed especially by young, male farmers.

A fourth method proposed by female farmers was the use of washing powder, poured into and around the anthill. Presumably, alkaline washing powder has an effect similar to that of lime, namely to increase the pH of the anthill, thus inhibiting the growth of the fungus on which the leaf-cutting ants live.

Farmers were asked to volunteer for participating in the experiment, each with one anthill. Fifteen anthills[5] were included in the experiment, and by way of a lottery, a treatment assigned to each anthill, resulting in three replications per treatment. After testing several methods of evaluating anthill activity,[6] a relatively simple method was chosen: all holes (entrances and exits to the nest) were closed following the treatment. After a period, say of two

[5] Due to the inclusion of controls (no treatment) two farmers insisted of participating with two anthills in the experiment. Thus, a total of 13 farmers participated in the experiment.

[6] In addition to the method of counting holes, two other methods were tried out. The first method, proposed by Fowler et al. (1993), consists of cutting drinking straws of different colors into pieces of 2.5-3.0 mm and bathing or impregnating these pieces in orange juice or mashed banana. These were placed on plates around the entrances and exits of the anthill, and the number taken into the anthill was used as an indicator of activity. However, for the ants to leave any little pieces of impregnated straw, the number of pieces placed around the nest had to exceed 1,000, something which made this method a very tedious, time-consuming, and thus impractical for farmer evaluation. The second method was excavating the nest and counting the number of healthy and destroyed 'garden cells', that is cells or chambers containing the fungus. This method was employed occasionally, but as a regular evaluation method it cannot be recommended since the ant nests can be very deep—up to five meters.

weeks, the number of holes which have been (re)opened were counted. Application and/or monitoring visits to the anthill, that is counting of (re)opened holes, was recommended to be undertaken every fortnight but in practice, the interval between individual applications/monitoring varied from a week to a month. The periods of application of the various techniques were uniform (with the exception of the interval between the applications around Christmas), except of course for the cases where the anthill had been effectively controlled before the last application/monitoring date. The last application/monitoring date was the same for all treatments.

In addition, a fifth control method was proposed by CIAT researchers to prevent young queens from establishing new anthills. The young queens usually leave the anthill in the first days of the rainy season. In *Los Zanjones*, it is some time in late October/early November. After fecundation, the queens seek to dig themselves into the ground in order to establish a new nest. The period from when the queens leave the old nest until they establish new ones only lasts a couple of days. As a control measure, a competition was announced in *Los Zanjones* among the children, awarding of prizes just before Christmas to those who collected the most young queens.

6. RESULTS FROM THE EXPERIMENT

Table 3 shows the results of the experiment using the four treatments mentioned above, measured as the initial number of entrance and exit holes to the ant nest and the number of holes (re)opened after each application or monitoring visit over the five-months period covered by the experiment. It should be noted that the anthill activity varies over the season as well as with the age of the anthill. Thus, even without any treatment, the number of holes can be expected to change. The table shows that lime mixed with *lorsban* and gasoline were the two most effective treatments, reducing the number of holes by 95-100 percent.

Table 3: Results from ant control treatment, La Laguna, Colombia

Treatment	Anthill number	Number of holes at first application/monitoring visit	Number of holes at last application/ monitoring visit	Total number of applications	Percent reduction in number of holes
Washing powder	1	44	7	7	84
Washing powder	2	135	20	9	85
Washing powder	3	25	43	9	(-72)
Lime	4	109	1	10	99
Lime	5	257	18	9	93
Lime	6	22	26	9	(-18)
Lime+*lorsban*	7	70	3	7	96
Lime+*lorsban*	8	25	0	3	100
Lime+*lorsban*	9	13	0	4	100
Gasoline	10	8	0	2	100
Gasoline	11	35	0	2	100
Gasoline	12	102	0	3	100
Control	13	30	6	N.A.	80
Control	14	8	6	N.A.	25
Control	15	17	9	N.A.	47

N.A. Not applicable

Table 4 summarizes the costs of the treatments and shows that while least effective, the most costly treatment was the use of washing powder with an average cost per anthill of US$11.76. On the other hand, the use of lime mixed with *lorsban* was the cheapest, with a total average cost per anthill of between US$5.36 and US$5.60, depending on the type of lime used.[7] This is the same cost as calculated for the use of *lorsban* if pumped into the anthill (US$5.56). For cash constrained farmers, however, the composition of the cost is important. While both the use of washing powder and gasoline have high input (cash) costs (US$6.86 and US$8.05, respectively), lime mixed with *lorsban*, and particularly lime (*cal viva*) alone, have relatively low input (cash) costs (ranging from US$0.56 for *cal viva* alone to US$1.15 for *supercal* mixed with *lorsban*). Lime alone has higher labor costs because of the need for more applications. The input cost calculated for the use of *lorsban* pumped into the anthill of US$2.89 is somewhat above the input costs for lime and lime mixed with *lorsban*.

Table 4: Average total costs per anthill of different ant control treatments (US$—1998 prices)

Treatment	Input costs[a]	Labor costs[b]	Total costs
Washing powder	6.86	4.90	11.76
Lime (*cal viva*)	0.56	8.89	9.44
Lime (*supercal*)	1.11	8.89	10.00
Lime (*cal viva)* + lorsban	0.97	4.44	5.36
Lime (*supercal*) + *lorsban*	1.15	4.49	5.60
Gasoline	8.05	2.06	10.11
Lorsban pumped into nest *(calculated; treatment not included in experiment)*	2.89	2.67	5.56
Queen-catching competition	1.20–2.41	N.A.	1.20–2.41

Note: [a] calculated on the basis of retail prices at the local markets.

[7] Two types of fine-powdered lime with a 100 percent calcium content are available in the area: one called supercal which is available in 10 kilo bags at a cost of US$2.22 (or US$0.22 per kilo) and another called cal viva which is available in 50 kilo bags at a cost of US$5.55 (or US$0.11 per kilo). Although more expensive per kilo, ease of transport, local availability, less risk of storage losses and a smaller cost per bag make farmers prefer supercal to cal viva.

[b] calculated on the basis of the local payment for an agricultural day-laborer, corresponding to US$0.6 per hour.

With respect to the competition collecting young queens during the days when they leave the old nest in order to establish new ones, a total of 4,616 queens were collected between the twelve participants in the competition. The number of queens collected per person ranged from 75 to 1,897. Even if not collected, far from all of these queens would have managed to establish new nests: on average, only 0.5-1 percent of all young queens manage to establish new nests. This means that by way of the competition, between 23 and 46 new ant nests were avoided. The total cost related to this method, that is the prizes given to the winners as well as consolation prizes, was US$55.38, corresponding to between US$1.20 and 2.41 per avoided anthill, depending on the exact number of new nests avoided. The following year (1998), very few queens left the anthills, probably due to a combination of the fact that a considerable number of the anthills had been controlled and that 1998 was a very wet year caused by the climatic phenomenon called *el niño*, and the queen catching competition was therefore not . However, inspired by CIAT's work on collective ant control, mid-1999 an association of extension workers employed by a range of governmental and non-governmental organizations in Río Cabuyal—a 7,000 hectare watershed of which *Los Zanjones* forms part—decided to form a sub-committee to deal specifically with ant control. As their first joint initiative, they decided to launch the queen catching competition among children in 10 villages in Río Cabuyal. Twenty-three villages signed up for the competition in 1999, which resulted in the capture of more than 100,000 queens by October 15, 1999.

In an open-ended evaluation, farmers included both cost and effectiveness in terms of controlling ant activity in their assessments of the different methods. The use of washing powder was discarded both due to its low effectiveness and its high costs. In addition, farmers included a third, environmental, aspect into their assessment. The use of lime and particularly lime mixed with *lorsban* were evaluated positively because, apart from cost-effectively controlling ants, they were perceived to improve the soil which in the area is rather acid (pH around 5). An example was mentioned of a large anthill, which had been completely bare of vegetation for many years. After being treated with lime, which managed to put an end to the ant activity, vegetation emerged on what had been the anthill. This effect was attributed to the lime. The use of gasoline, on the other hand, though effective and liked, particularly by the young, male farmers due to the excitement involved in its application, was discarded as a feasible control method by the same young, male farmers. The reason given was the high cost of restoring the soil afterwards in terms of nutrients, soil life, and structure where the explosion had occurred. Also, compared to the current practice of applying *lorsban* alone, the use of lime mixed with *lorsban* was preferred, primarily on environmental grounds, since it used fewer insecticides.

The use of lime mixed with gradually decreasing amounts of *lorsban* was consequently the treatment evaluated most favorably by farmers, and considerations began on how to initiate ant control on a collective rather than an individual basis.

7. TOWARDS COLLECTIVE ANT CONTROL

Testing alternative technical methods of ant control constitutes only part of the solution to the ant control problem and the participatory landscape-level experiment initiated in *Los Zanjones*. An equally important part of the solution lies in the identification of mechanisms to facilitate the adoption of promising ant control methods in a coordinated fashion. It is important to stress that undertaking ant control in a coordinated fashion does not imply that the actual treatment, i.e. the pumping of lime and *lorsban* into the ant nest, should be done collectively. Rather, collective action is necessary to ensure that all anthills are treated simultaneously. Not surprisingly, this part of the ant control problem has in many respects proved to be the most difficult to solve, and still has to be completed. Though not all equally successful, this section describes some of measures taken and experiences gained in the joint efforts between farmers and researchers to stimulate collectively coordinated ant control.

In a meeting held on the technical evaluation of the various ant control methods, farmers decided to use part of a fund established by CIAT (using an IDRC grant intended to facilitate collective management of watershed resources) for purchasing a pump to be shared between the 17 farmers in the area for application of lime mixed with lorsban. The decision was made that the pump should rotate between farmers, who each could use it for one day every two weeks. This decision was implemented and the pump has been rotating, at least to some extent. Two problems have, however, been encountered. First, there has been a problem of maintenance. Some farmers did not get the right type of very fine powdered lime, but were persuaded by agricultural supplies dealers to buy a more coarse type, which apparently damaged the pump and thus discouraged farmers from continuing lime-lorsban ant control. This problem has now been resolved. The pump has been repaired, and in mid-1998, a survey was conducted at adjacent local markets to establish the commercial names of the feasible kinds of fine-powdered lime (and the ones to be avoided), as a guide to farmers when they make their purchases. Thus, there have been no further incidences of pump breakdowns.

The second problem, which still has only been partly resolved, relates to the difficulties of transporting the pump from one place to another in the rather hilly watershed. The system initially proposed by farmers was that the pump should always be returned to the same person, the pump caretaker. The advantages of this system are that the pump caretaker assumes responsibility for the pump and everyone knows where to find the pump. The drawback, however, is that it is always the same group of farmers, namely those living at some distance from the pump caretaker, who have difficulty getting access because they have to walk uphill or downhill to get the pump. In response to the problem of transporting the pump, farmers decided to purchase a second pump with the fund, and this has somewhat eased the problem of transportation. Moreover, the system of having the pump returned to the pump caretaker after every use has gradually been relaxed and evolved into more of a rotational system. However, this has created an information problem, making it difficult for farmers to locate the pump. A local field worker employed by CIAT has, to a large extent, stepped in to help farmers locate the pump. Finally, a number of the more resourceful farmers have decided to purchase their own pump, which has increased the availability of pumps in the area to all farmers. The cost of the type of mechanical pump used in the area is approximately US$55.

The second decision taken by farmers relates to the organization of work. Pumping lime into an anthill is hard work and lime can get damp if stored for a longer period during the rainy season. However, it is only commercially available in bags of minimum 10 kilos, while each application only consumes around half a kilo. For these reasons, farmers suggested subdividing themselves into working groups of two to four neighboring households, who would collaborate in undertaking applications as well as purchasing of lime collectively. Six groups were established, each of which decided upon different arrangements for sharing input purchase and work. However, only one group, consisting of two Guambiano farmers (a man and a woman) and one female mestizo farmer, has succeeded in dividing the purchase of inputs between them and jointly treating the anthills on a fortnightly basis. The remaining groups managed in varying degrees to buy inputs and work together, but due to problems of cooperation, lack of time, and unwillingness of some to undertake ant control, many farmers ended up doing the ant control on an individual basis. Thus, some farmers still complain that undertaking the applications *alone* is hard work.[8]

Encouraged by CIAT researchers, farmers made a third decision that each should fill out a form after each application or monitoring visit to an anthill, indicating the number of (re)opened holes and, if relevant, the type of application undertaken. Moreover, all anthills in *Los Zanjones*, whether receiving treatment or not, should be located in a map—the same map as the one used for the anthill inventory of which each farmer got a copy—and monitored. These two measures combined would enable a more global monitoring of the successfulness of ant control for the whole micro-watershed. The local field worker employed by CIAT has provided initial assistance to farmers in locating the anthills in the map and in filling in the monitoring sheet for each anthill. Combined, these maps depict approximately 90 anthills in *Los Zanjones*, including smaller anthills. However, farmers have complained that they found the monitoring sheet difficult to complete, partly because it involved the use of codes to identify the anthills; partly because by including all anthills and not just the major ones, the number of anthills to monitor became cumbersome to manage; and partly because they did not feel comfortable in writing and were afraid of making mistakes. The monitoring sheet has been revised so as to avoid the use of codes, but ways to overcome farmers' uneasiness with respect to writing and the great number of anthills to be monitored still have to be found. Since monitoring change is so central to the understanding of many transboundary natural resource management problems, including the problem of ant control, the development of monitoring systems which can be managed and analyzed by farmers themselves remains an important challenge to participatory landscape-level research.

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[8] Each application implies an average of half an hour just for pumping in addition to which has to be added time for carrying the pump and the lime to the ant nest.

Fourth, and from the point of view of collective action most important, farmers who had participated in the experiment and/or the meetings concerning ant control, decided to encourage farmers who hitherto had not participated to undertake ant control. This decision was made in view of the perceived importance that all anthills should be controlled simultaneously to obtain effective protection against crop damage caused by leaf-cutting ants. Initially, enthusiastic farmers tried to convince their neighbors to undertake ant control, but with little luck. This was in 1997 before the mapping exercise of the major anthills and their radius of influence (Figure 1) had been completed. Thus, farmers did not feel that they had come any closer to a solution of the ant control problem. Among the reasons encountered were that some farmers did not feel economically affected by the ants because their land was lying fallow or was planted with a crop, like beans, which is not attacked by the ants, or that the farmer was sharecropping or taking care of somebody's farm and unless the owner gave his acceptance and/or paid for the inputs, the sharecropper or caretaker could not undertake any ant control. On the other hand, there were examples of farmers who had their crop damaged by ants coming from neighboring fields and subsequently trespassed into the neighboring field to undertake ant control themselves.

In 1998, farmers decided to try another way of encouraging ant control to be undertaken more globally throughout *Los Zanjones*. They launched a competition. Over a period of three months (the time it takes on average to effectively control an anthill using lime mixed with *lorsban*), the control of anthills in the area would be recorded and a winner, that is the person who had controlled the most anthills on his or her own as well as on fields belonging to neighbors, would be found. The reward would be a *minga*, that is a labor party at the winner's land, in which the workers would be farmers who had entered themselves in the competition and the lunch would be paid by the fund established by CIAT. To identify a winner, farmers developed a scoring system and the farmer with the highest score would be the winner. Scores were allocated on the following basis:

For every anthill controlled on own farm	5 points
For every anthill controlled on neighbor's farm (with the permission of the neighbor)	10 points
For every anthill a farmer could convince a neighbor to control (based on consent between the 'convincer' and the 'convinced' that this was what happened)	20 points
For every anthill controlled in groups, every member of the group receives	20 points

Only about half (9) of the farmers participated in the competition. However, through the competition, an additional four farmers were convinced to undertake ant control and all participants in the competition got permission from their neighbors to control anthills on their land. Despite favoring ant control in groups, the scoring system did not manage to encourage farmers to do so. Only three of the participants undertook ant control in groups. Participants in the competition collected between 5 and 180 points and the winner had managed to control 14 anthills on her own farm, seven at a neighbor's farm and, in addition, she had managed to convince one of her neighbors to control some anthills on his farm. The fact that all competitors participated in the *minga* at the winner's farm provides an indication of their commitment and their recognition of the efforts of the winner. In total, 56 anthills or approximately two thirds of the estimated total number of anthills in the area were controlled through the competition.

Thus, the competition as such and the fact that farmers had developed a stronger sense of the transboundary nature of the ant control problem which helped to strengthen their arguments to convince neighbors to take up ant control, turned out to be an effective means of stimulating a coordinated ant control effort. As a somewhat ironic indication of success of the coordinated ant control efforts as part of their collaboration with CIAT, farmers in *Los Zanjones* today do not wish to continue their work in ant control because they no longer perceive it as a major problem (although they do recognize the importance of controlling remaining anthills). Instead, they wish to embark upon other problems such as land use around riverbanks and springs, and erosion control which also require coordinated efforts.

8. CONCLUSION

Technical designs are rarely sufficient to solve transboundary natural resource management problems. The case of crop damage caused by leaf-cutting ants described in this paper illustrates that, although technically feasible ant control methods were developed, it was not until a mechanism was identified which managed to encourage a significant proportion of the farmers of *Los Zanjones* to simultaneously control their ant nests that progress was made in effectively limiting the ant activity. Thus, the case of participatory experimentation to solve the ant control problem reported in this paper has been successful in the sense of having significantly limited the crop damage caused by leaf-cutting ants in *Los Zanjones* as well as in demonstrating the transboundary nature of the ant control problem and the importance of collective action.

Yet coordination is cumbersome, particularly in groups that are so heterogeneous in terms of livelihood strategies (day-laboring farmers, small-scale farmers, sharecroppers and caretakers and absentee landlords), ethnicity, and resource endowments as are the land users of *Los Zanjones*. Heterogeneity can contribute to lack of trust and mutual understanding within the group and lack of experience working together. The multi-faceted relationships between neighbors can also create fears that encouraging someone to undertake practices such as ant control might be taken as a reproach and thus endanger future relationships and perhaps block for future favors—all of which hamper communication. Unfortunately, heterogeneity is the rule rather than the exception. The solution to many natural resource management problems depends upon the coordinated efforts of diverse, rather than homogeneous, land users and their ability to negotiate conflicts between short-term *versus* long-term interests, as well as between individual *versus* collective interests.

In the case of *Los Zanjones*, CIAT has been instrumental in overcoming many of the organizational difficulties involved in coordinated ant control, such as organizing meetings, facilitating the rotation of the pump, undertaking a market survey to establish the types of lime compatible with pumping, and pushing and partly conducting the monitoring of ant control. The participatory experimentation initiated and supported by CIAT to encourage collective ant control shows that with third party organizational support, it is possible even in heterogeneous groups to achieve coordination among individual farmers and thus achieve results—in this case, effective ant control—which critically depends upon such coordination. Inspired not only by the technical results with respect to the use of lime mixed with *lorsban*, but also by the organizational lessons in terms of the importance of coordinating the ant control of the individual farmers, an association of extension workers employed by a range of governmental and non-governmental organizations have decided to undertake a joint effort in ant control in the 7,000 Río Cabuyal watershed of which *Los Zanjones* is part. Still, more effective means to support coordination and stimulate farmers themselves to eventually assume the responsibility of organizing their collective efforts, not only in ant control but more widely in natural resource management, would need to be explored. This constitutes a major task for future research into the importance of collective action in agricultural development and natural resource management.

REFERENCES

Cherrett, J.M. 1986. The economic importance and control of leaf-cutting ants. In *Economic impact and control of social insects*, ed. S.B.Vinson. New York: Praeger.

de la Cruz, A.M. and M.C. Cardona. 1996. Caracterización fitosanitaria de la microcuenca de La Laguna, Municipio de Caldono, Cauca. Cali: Centro Internacional de Agricultura Tropical. Mimeo.

Fowler, H.G. 1993. A simple method for determining location of foraging ant nests using leaf-cutting ants as a model. *Journal of Applied Entomology* 116(4): 420–422.

Lopéz, A. 1996. La sociobiología: una disciplina. *Innovación y Ciencia* 5(3): 48–55.

Ravnborg, H.M. 1997. Beyond the farm and within the community: Issues of collective action in participatory natural resource management research. In *New frontiers in participatory research and gender analysis*. Proceedings of the international seminar on participatory research and gender analysis for technology development, September 9-14, 1996. Cali: Centro Internacional de Agricultura Tropical.

Ravnborg, H.M. and M. del Pilar Guerrero. 1996. Poverty profiles for designing and evaluating rural research and development activities—A methodology. In *CIAT Hillsides Program Annual Report 1994-1995,* 165–202. Cali: Centro Internacional de Agricultura Tropical.

________. Collective action in watershed management—Experiences from the Andean hillsides. *Agriculture and Human Values* 16(3): 257–266 (forthcoming).

Uphoff, N. 1992. Learning from Gal Oya. Possibilities for participatory development and post-Newtonian social science. Ithaca: Cornell University Press.

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CAPRi WORKING PAPER NO. 10

COLLECTIVE ACTION AND THE INTENSIFICATION OF CATTLE-FEEDING TECHNIQUES: A VILLAGE CASE STUDY IN KENYA'S COAST PROVINCE

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November 2000

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ABSTRACT

The adoption of intensified cattle-feeding techniques by smallholders in Sub-Saharan Africa has been slower than anticipated. This study seeks to better define and understand the role of local collective action in conditioning the strategies that smallholders choose to intensify their cattle-feeding techniques. Collective action was analyzed as a determinant of the transaction costs of accessing feed for these techniques. An in-depth case-study method was used in a single peri-urban village that was at a low-but-increasing level of intensification of land use. The research found that cattle-keepers were intensifying their cattle-feeding techniques, but in a much more marginal, step-wise fashion than anticipated. The process of intensification involved changes in transaction costs, which were born differently by smallholders depending on their sources of wealth and personal networks. Whereas pervious studies have found wealth to be a key factor conditioning the adoptability of new techniques, this study shows that personal networks can be used in some cases as a substitute for wealth.

CONTENTS

COLLECTIVE ACTION AND THE INTENSIFICATION OF CATTLE-FEEDING TECHNIQUES: A VILLAGE CASE STUDY IN KENYA'S COAST PROVINCE

Kimberly A. Swallow*

1. INTRODUCTION

Throughout Sub-Saharan Africa, intensification of dairy production has been seen by policy makers as a possible solution to three problem areas: (1) dairy market supply deficits, especially in urban areas; (2) increasing land scarcity; and (3) the need for income earning opportunities for smallholders. It was anticipated that these opportunities and problems as viewed by smallholders would lead them to seek more intensive cattle-feeding techniques. To aid this process, technical assistance programs were designed to add an intensive cattle-feeding technique to the options available to smallholder cattle-keepers. The technique most widely recommended across sub-Saharan Africa was stall-feeding based on specialized feeds grown on-farm, such as Napier grass (*Pennisetum purpureum*) and *Leucaena l*., and purchased agro-industrial by-products. Smallholders have chosen stall-feeding in the highlands of Kenya and Tanzania, but a slower-than-anticipated pace of intensification has been the norm throughout the remainder of the region (Gass and Sumberg 1993; McIntire et al. 1992).

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* The author thanks the editors for helpful comments on an earlier draft. The research reported here was assisted by a grant from the Joint Committee on African Studies of the Social Science Research Council and the American Council of Learned Societies with funds provided by the Rockefeller Foundation. The support given by the Centre Director and staff of the Kenya Agricultural Research Institute's Regional Research Centre, Mtwapa, is acknowledged with thanks.

The purpose of the research reported here was to provide input into the process of reevaluating this technical support. This was done by providing a detailed view, from users' perspectives, of the issues involved in intensifying cattle-feeding techniques. It was hoped that such insight would provide policy makers, development workers, and extensionists with a more realistic understanding of the process of technique change, which would both engender respect for the time required and, if necessary, inspire the creation of a broader range of options.

It was suggested in the theoretical literature that the process of technical change involves local socioeconomic institutions such as rights of ownership of inputs and conventions about the means of accessing inputs (Platteau 1995). Empirical literature has shown these variables to be particularly important in the case of changing cattle-feeding techniques in sub-Saharan Africa. In this region, the recent history was for feed used in cattle-feeding techniques—for example, natural vegetation used in the herder-grazing technique—to be obtained from land that was not individualized (McIntire et al. 1992). Thus, this study focused on village-level socioeconomic institutions and collective action to establish, maintain, or change those institutions.

This village-level focus on understanding a process of change methodologically favored a detailed case study approach. The selected village was located within the milkshed of Kenya's second largest city, Mombasa. This area was chosen for several reasons. First, there were both demand-pull and cost-push factors to encourage commercial dairying in this area. Second, this area, like much of Sub-Saharan Africa, was at the early stages of intensification of land use which provided an opportunity to study this process. Third, a dairy intensification extension program had been implemented in the area for 12 years prior to the study. Although the case-study villagers knew about the technical package of the program, most had chosen not to adopt it. The case study was undertaken between 1991 and 1995. Data were collected using both qualitative and quantitative methods. Primary data were collected from all 132 extended-family homesteads in the village. A detailed two-year study was done to document, on a weekly basis, the transactions over cattle feed of eight operators of cattle enterprises that were differentiated by commercial orientation and level of intensification of cattle-feeding techniques. The three commercial-dairy enterprise operators who used stall-feeding year-round were studied in the most depth. Information on collective action to reduce the information gathering, contracting, and monitoring and enforcement costs of these transactions was assessed through qualitative methods and secondary sources.

This chapter opens with a description of the case-study situation, including descriptions of the case-study village as a social unit as well as the cattle enterprises and cattle-feeding techniques used in the village. This background is followed by a short review of the relevant theoretical literature and a description of the conceptual framework that was used to guide the research. The research methods are then explained. Research findings are reported in three sections. In the first section, the eight case-study homesteads' heads are described in general while focusing on the personal wealth and networks of the three heads who are operators of commercial-dairy enterprises. The focus of the second section is the eight homestead heads' use of others' feed sources and the transactions used to access them. The third section contains a discussion of the factors that shaped the village's capacity for collective action to support transactions over cattle feeds, especially during times of change. Finally, conclusions are discussed.

CASE-STUDY BACKGROUND

The case-study village was located in the milkshed of Kenya's second largest city and the capital city of Kenya's Coast Province, Mombasa. Intensification of dairy production in Mombasa's milkshed had been technically supported for some time, but it had not occurred at the predicted rate. Intensification of dairy production was expected in this area due to high market demand for milk in Mombasa, a relatively high population density, and declining income-earning potential from the traditional cash crop of copra. In 1992, the annual shortfall of milk production in Coast Province was 113 million liters (Mullins 1992). A technical package of improved breeds of dairy herds and stall-feeding was extended in Coast Province between 1980 and 1995 by the National Dairy Development Project. Complete confinement and use of the stall-feeding technique was recommended. Feed recommendations were based on forages planted on homestead plots—mostly Napier grass (*Pennisetum purpureum*)—or purchased agro-industrial by-products such as copra cake (Maarse et al. 1990). A major obstacle for potential adopters was the high cost of production due to a variety of factors including: (1) lack of formal credit; (2) increasing scarcity of land; (3) variable availability of feeds; (4) high labor requirements; (5) lack of adequate veterinary services; and (6) lack of marketing infrastructure such as a milk collection service. While as many as 350 coastal dairy operators once fully implemented the National Dairy Development Project package, field visits in 1994 revealed that very few still adhered to the prescribed package (Mullins et al. 1994).

The case-study village was connected to Mombasa by five kilometers of dirt road followed by 45 kilometers of paved road with good public transportation. Livelihood in the village was primarily based on subsistence production and remittances from income earned in Mombasa. Income from on-farm production was very low and unreliable. Bi-modal rains averaging 1,100 millimeters annually supported an intercrop of maize, cowpea, and cassava with coconut palms planted throughout the area (Jaetzold and Schmidt 1983). There was little-to-no use of chemical or organic fertilizers, or improved seed stock. In general, the farming system was a low-input, low-output system.

The village's human population density of 591.7 persons per sq km (Swallow 1996) and the low productivity of its soils meant that it was at a threshold of increasing population density and land scarcity. During the cropping season of 1992, only 44 (17.5 percent) of the 252 plots used by case-study villagers contained some fallow (Swallow 1996). While this degree of land scarcity meant that farmers could no longer rely exclusively on fallowing to renew soil fertility, they still did not use manure or other fertilizers. Consequently, the land area of the village was not sufficient to produce enough to feed the villagers year round, and basic food items were purchased during the long-dry season (Waaijenberg 1994).

Village as a Social Unit and its Institutions

The village was established in the 1800s, and at the time of the study consisted of 132 extended-family homesteads. Ethnically, the village's members were almost exclusively Giriama. There was little in- or out-migration, although many homestead heads and young people were nonresidents working in Mombasa, who remitted income to their village homesteads. The religious composition of the village's homesteads was 58.3 percent followers of the customary religion, 25.8 percent Christians, and 15.9 percent Muslims (Swallow 1996).

The segmentary nature of Giriama society meant that the village was organizationally decentralized. Customary institutions were based on councils of elders, secret societies, and diffuse monitoring and enforcement. Councils of elders were *ad hoc* groups of homestead heads that mainly focused on the adjudication of disputes over tardy bride payment, theft, and especially, the ownership and inheritance of land and coconut palms (Spear 1978). Overlapping personal networks among villagers were based on several principles: (1) agnation (relationships traced through the father's bloodline); (2) matriliny (relationships traced through the mother's bloodline); (3) affinality (relationships based on marriage); (4) neighborhood; (5) friendship; (6) religious affiliation; and (7) other personal relationships.

There was to some extent a duality of local and national control of land in the village. Officially, land was managed under a system of individualized ownership and use. Indeed, all of the village's $3.5km^2$ was held under individual title. Villagers had registered their titles in the early 1970s during a compulsory governmental land registration program. There were no spatial niches such as a forest, pasture area, or roadsides lacking individual claims other than the roadways themselves, footpaths, and water holes. However, coexisting in the same spatial niche with this *de jure* individualized system administered by the national government was a multiple-use system that had customary roots and was decentrally managed by villagers through an evolving set of rules and conventions.

Historically, the latter set of institutions stipulated that cattle-keepers could graze their cattle on any piece of land in the village that was either in fallow or had been harvested, with no need to seek permission. Use rights were acquired by virtue of group membership. At the time of the case study, the vast majority of cattle-keepers in the village depended on forages accessed from land that was registered to another homestead. Few cattle-keepers held title deeds to enough land to herd their cattle year round. In addition, the needs of optimal sequencing of land use for cultivation and grazing, and the needs of optimal use of diverse agro-ecological niches for cattle feed meant that even those cattle-keepers with a favorable ratio of land to cattle could benefit from using other villagers' land periodically.

Recently, however, the institutions that supported secondary access to others' land were being viewed by some villagers in a new light. One cattle-keeping homestead head built the first two fences in the village to protect the forages that he planted for his commercial-dairy operation. Some noncattle keeping homestead heads had started grumbling about upholding the stipulations of good neighborliness when their cattle-keeping neighbors appeared to be doing better than they were. Several such homestead heads refused to allow use of their land by their cattle-keeping neighbors.

Cattle Production

Of the village's 132 homesteads, 37 (28.0 percent) kept cattle. The average herd size was 10.5 (s. d. 9.5) animals; the range was one to 35 animals. The cattle enterprise types in the village were the traditional subsistence-oriented multiple-output enterprise that was operated by 35 homesteads, and the new commercial-dairy enterprise that was operated by three[1] homesteads. The cattle kept by operators of multiple-output enterprises were mainly zebu (B*os indicus*) cattle, but a few operators kept first generation zebu-dairy (B*os taurus*) crosses. Commercial-dairy enterprise operators, in contrast, kept cattle that were at least second-generation crosses. The herds of these enterprises were small, containing only two to three animals.

The ends sought by the operators of these two enterprise types were very different. A variety of ends were sought by multiple-output enterprise operators: (1) milk for home consumption; (2) plowing; (3) milk sales; (4) savings and investment; and (5) social benefits (i.e., funeral sacrifices, bride wealth payment, and status). In fact, of the 35 multiple-output enterprises, only 6 (17.1 percent) sometimes sold milk. Operators of commercial-dairy enterprises sought profit. Of the three operators of commercial-dairy enterprises, two sold milk locally and one sold milk to a small café in Mombasa. The latter transported the milk by bicycle and public bus. There were no milk collection, refrigeration, or transportation services offered in the village.

Each cattle-keeper in the village used one or more of three types of cattle-feeding techniques: herder-grazing, tethered-grazing, and supplemental stall-feeding. For the most part, cattle-keepers maintained the same combination of cattle-feeding techniques throughout the year. They responded to seasonal variations in feed supply mainly by

[1] Although there were only 37 cattle-keeping homesteads in the village, there were 38 cattle enterprises because one homestead operated two separate cattle enterprises—one each of the two cattle-enterprise types under operation in the village.

changing the way that the techniques were used. The area usually used for cattle grazing—whether herder- or tethered-grazing—was typically less than a 30-minute walk from the homestead and within the borders of the case-study village.

Herder-grazing was used by the vast majority of the 37 cattle-keeping homesteads in the village, and it was the only cattle-feeding technique used by 19 (51.4 percent) of those homesteads. While herder-grazed, the cattle were never left unsupervised. They were guided through irregularly shaped fallow fields scattered amongst cropped fields during the cropping season, and both fallowed and harvested fields during the noncropping season. Tethered-grazing was used by 18 (48.6 percent) of the 37 cattle-keeping homesteads in the village. It was done on the same types of fields as herder-grazing; the difference being that with tethered-grazing the cattle were tethered and left unsupervised while grazing.

Stall-feeding was used as a supplement to grazing by four homesteads in the village. No cattle enterprise depended solely on stall-feeding. Three of the four homesteads that used the technique were the three operators of commercial-dairy enterprises in the village, and one was an operator of a multiple-output enterprise. Cattle were stall-fed during the morning and/or evening milking sessions. A great variety of feeds were stall-fed: (1) species of natural vegetation; (2) crop and tree by-products and residues (such as maize bran);[2] (3) specialized planted cattle feeds (such as Napier grass (*Pennisetum p*.) and *Leucaena l*.); and (4) specialized purchased cattle feeds (such as

[2] The maize bran that was used in the case-study village was a by-product of maize being pounded into flour that was used to produce *ugali*, the main staple for human consumption.

copra cake). Cattle-keepers used larger quantities of the relatively cheap bulk feeds such as natural vegetation, or if possible Napier grass, and smaller quantities of the more expensive, higher quality feeds such as maize bran, or if possible *Leucaena l.* or copra cake.

The majority of cattle-enterprise operators did not think that land scarcity was yet so acute as to necessitate the cultivation of specialized cattle feeds. Only two homestead heads—both operators of commercial-dairy enterprises—engaged in the practice. Cattle-enterprise operators chose other methods of responding to increasing land scarcity: (1) reducing the size of their herds; (2) altering their use of the herder-grazing cattle-feeding technique; and/or (3) increasing their use of the more land-use intensive cattle-feeding techniques of tethered-grazing and supplemental stall-feeding.

2. CONCEPTUAL FRAMEWORK

The objective of the research was to identify the factors that affected the transaction costs of accessing feed for different cattle enterprises and cattle-feeding techniques in the situation of techno-institutional change described above. The focus of the analysis was on the difference between the transaction costs that were theoretically possible and those that were actually internalized by the transaction partners. Collective action in the form of the establishment and maintenance of institutions used in transactions was investigated as one of the factors that could contribute to this difference. Given that the case-study village was decentrally organized, the broadest possible notions of collective action were used. One of the tested hypotheses was that variations in transaction costs and individuals' abilities to bear those costs condition individuals' choices to adopt new cattle-feeding techniques. The factors investigated as determining individuals' abilities to bear transaction costs were personal wealth and personal networks within the village.

Transaction Costs

According to Bromley (1989), transaction costs result from the information seeking, contracting, and monitoring and enforcement activities associated with transactions. Information is needed about the benefits-cost streams to be transacted over; their ownership; and others' preferences, willingness to exchange, and trustworthiness. Contracting involves negotiating, agreeing on, and formalizing an agreement of expectation.

The incidence of costs that are actually internalized by the transaction partners may be determined by a third party, such as a sub-group of the village, the village as a whole, or the national government. This is accomplished by establishing expectations, or institutions such as conventions or entitlements (rights), about specific aspects of a transaction such as the rights of ownership of the items being transacted over and the structure of the transaction. Aspects of the structure of the transaction over which expectations can be established include the incentives for cooperation, the extent of personalization of the transaction, and the *quid pro quo* or non-*quid pro quo* nature of the transaction.

Since establishment of such expectations bears a collective cost, different types of transactions have varying degrees of support depending on the expected collective benefit. Bromley (1989) calls transactions over commodities that receive the most collective support "commodity transactions." If a transaction does not have collective support, transaction partners can negotiate on a one-to-one bases through "bargaining transactions," or they can attempt to change the level of collective support through "institutional transactions" (Bromley 1989).

Commodity Transactions

The focus in this study on collective support for transactions means that the primary unit of analysis is a set of institutions that transaction partners can use to reduce the transaction costs of their commodity transactions. This set of institutions will be called a "transaction sector" in this conceptual framework. The transaction sectors that will be used in the conceptual framework are, in the first instance, derived from Ostrom's (1986) commonly-accepted model of three commodity and transaction-sector pairs: (1) private goods and the private sector; (2) common-pool goods and the collective-action sector; and (3) public goods and the public sector. The overriding principle for assigning commodities to sectors is the collective cost of defining private rights to the commodity, which is determined by the degree of rivalry of consumption and the cost of excluding consumption of the benefit streams that emanate from the commodity. Rivalry, also known as subtractability, is when one individual's consumption of a benefit stream subtracts from the welfare that another individual receives from consumption of that same or another benefit stream. The costs of defining property rights are low if rivalry is low. When rivalry is very low or nonexistent, there may actually not be a need to define property rights at all. If the costs of excluding consumption are low, then the costs of protecting private rights to the commodity are low. However, rivalry and excludability are separate characteristics such that one does not determine the other.

Since private goods tend to have high rivalry of consumption and low costs of exclusion, the collective costs of defining and protecting private rights of ownership are relatively low, such that property rights are best held by an individual and transactions are sufficiently supported by the private sector. In this sector, incentives for cooperation are based on utility, and transactions are impersonal and *quid pro quo* in nature. The collective costs of defining private rights to common-pool goods characterized by high rivalry of consumption and high costs of exclusion are prohibitive, so that the appropriate sector for supporting transactions over these goods is the collective-action sector. In this sector, the collective defines itself as the holder of property rights, normative-voluntary incentives support cooperation in transactions, and transactions are not *quid pro quo*. Finally, in the case of public goods characterized by low rivalry of consumption and high costs of exclusion, the public sector, where individuals' incentives for cooperation are based on the credible threat of enforcement by the state, is the most appropriate sector.

This commonly-accepted model of commodities and sectors was adapted to the objectives of the research project and the specifics of the case-study situation as they were understood during the initial phases of the research. Since none of the feeds used by the case-study homesteads resembled public goods, the public sector was removed from the model. In addition, the focus of the research was on a process of intensification of cattle-feeding techniques that was hypothesized to necessitate a change from the use of feeds that were common-pool resources to feeds that were private resources. This meant that the continuum between the private and the collective-action sectors needed to be fleshed out.

Whereas cooperation during transactions in the private sector rely on the utility motive, reciprocal transactions, as noted by Oakerson (1986) and Polyani (1944), are motivated by normative-voluntary incentives, and the terms of transactions are based on a personal relationship between the transacting parties. Commodities transacted over using this set of institutions lie closer to the pure private than the pure common-pool good and can be said to occupy a "reciprocal-transaction sector." Another transaction that has been embraced in the theoretical literature as a type of collective-action sector transaction is one in which a resource is owned by a collective and normative-voluntary incentives are sufficient to insure cooperation. In this case, members receive rights of use by virtue of their position in the collective such that transactions are impersonal. Commodities transacted over using this set of institutions lie closer to the pure common-pool than the pure private good. The sector in which this type of commodity is transacted over is called the "community-transaction sector" in the conceptual framework to be used here. Thus, the model of commodity transactions that is appropriate for the research consists of three transaction sectors: private, reciprocal, and community.

In the case-study village, the individual holder of rights to cattle feed transacted in the private- and reciprocal-transaction sectors was the head of the extended-family homestead. The holder of rights to commodities transacted over in the community-transaction sector was the village as a whole. Private sector transactions were operationalized as those for which *quid pro quo* payment was necessary to access feed.

Reciprocal-transaction sector transactions were operationalized as those for which permission was needed but no immediate *quid pro quo* payment was expected. Community-transaction sector transactions were operationalized as those for which no permission was needed to access feed.

Bargaining Transactions

There are inherently some situations in which a collective will deem the costs of supporting a transaction in the ways just described to be unwarranted. Indeed, in Sen's (1984) view, when a collective does define rights to commodities, that definition is necessarily ambiguous to some extent. This is due to the increasing cost of specificity of rights, and thus the need to apply rights to a large number of circumstances. The result of this ambiguity is that rights themselves can be represented by 'fuzzy sets' which individuals are continually making efforts to bring into focus through one-to-one negotiations. The negotiations that take place in both situations are called "bargaining transactions" by Bromley (1989).

In the conceptual framework used to guide the research presented here, "fuzzy" area of transactions over commodities is called the "gray area." The characteristics of the transaction sectors and the gray areas are summarized in Table 1. It is hypothesized that in situations of change, the gray areas temporarily increase as transaction partners' search for a scheme of cooperation leads them to attempt to stretch the application of existing institutions to new situations (Mearns 1995). Operationally, it will be determined that a commodity was transacted over in a gray area between two transaction sectors when there were important instances in which it was transacted over in both sectors.

Table 1—Sectors for commodity transactions

	Private-Transaction Sector	Gray Area	Reciprocal-Transaction Sector	Gray Area	Community-Transaction Sector
Rivalry of Consumption	High	Intermediate	Moderate	Intermediate	Low
Costs of Exclusion	Low	Intermediate	Moderate	Intermediate	High
Holder of Rights of Ownership of Commodities	Individual (Collective Member)	Individual (Collective Member)	Individual (Collective Member)	Contested	Collective
Structure of Transaction					
Incentives for Cooperation	Utility	Contested	Normative-Voluntary	Normative-Voluntary	Normative-Voluntary
Personal/ Impersonal	Impersonal	Contested	Personal	Contested	Impersonal
Means of Access	Pay	Contested	Ask-But-Don't-Pay	Contested	Don't-Ask

Institutional Transactions

The choice to engage in a bargaining transaction is one response to a situation in which transactions over a commodity do not have collective support. An alternative response is to engage in an institutional transaction (Bromley 1989). During bargaining transactions, transaction partners bargain on a one-to-one basis within an existing institutional structure that defines transaction sectors for commodity transactions. In the case of institutional transactions, on the other hand, individuals engage in transactions to change that institutional structure. This could mean a change in the collective definition of ownership of the resource, for example.

In this conceptual framework, the ability of collective members to engage in institutional transactions depends on their capacity for collective action and the cost of institutional transactions. The same types of transaction costs that apply to commodity and bargaining transactions apply to institutional transactions: information-gathering, contracting, and monitoring and enforcement costs. The transaction costs of institutional transactions are determined by several factors: (1) collective members' incentives to organize; (2) the costs of organizing the collective; and (3) the difficulty of solving the transaction problems in question on a collective basis. Collective members will have stronger incentives to organize if they are unable to bear the costs of bargaining transactions and they perceive that collective action can effectively reduce the costs of commodity transactions. The ability to reduce the costs of the costs of organizing a collective has been attributed to a variety of factors: (1) homogeneity of values and beliefs (Baland and Platteau 1996); (2) homogeneity of access to the resource (wealth) (Baland and Platteau 1996); (3) multiplexity of member relationships (Mearns 1995, Singleton and Taylor 1992); (4) appropriate nesting with outside organizations (both vertically and horizontally) (Ostrom 1990); and (5) a general state of stability of expectations (Mearns 1995, Mitchell 1973).

3. METHODS

Fieldwork was conducted in three phases from November 1991 to February 1995. Knowledge gained from each phase was incorporated into the design of the following phases. The overview phase consisted of a rapid appraisal, direct observation, a case study of one homestead in the case-study village, key-informant interviewing, and an indigenous knowledge study of the farming system that focused on livestock feeds. The purpose of the village case study phase was to identify the characteristics of the village as a collective that conditioned the transaction costs of institutional transactions. During this phase, a village census, semi-structured key-informant interviews, and single-visit questionnaire interviews were conducted. The latter were conducted with all 132 homesteads in the village, and covered the socio-economic characteristics of the homesteads and, for the village's 37 cattle-keepers, details about cattle enterprises and cattle-feeding techniques.

The final homestead case study phase focused on production behavior and commodity and bargaining transactions. Data collection methods consisted of longitudinal monitoring using questionnaires, direct observation, and semi-structured interviews. The latter were conducted weekly over 105 weeks between 1992 and 1994, with eight of the nine cattle-keeping homesteads in the village that reported use of a cattle-feeding technique that was something akin to stall-feeding. More information about those eight homesteads is provided below. Longitudinal monitoring was used to collect data on a variety of variables: (1) the cattle-feeding technique used; (2) feed utilization; (3) the source of feed item; (4) the means by which feeds were accessed; and (5) the relationship between transaction partners. A herd-following exercise was done with two of the eight participating homesteads. These two homesteads were those who grazed their herds farthest from the homestead. Herd following was done to provide a spatial understanding of herding routes as well as a check on the numbers of transaction partners reported.

CASE-STUDY HOMESTEADS

The case-study homesteads were eight of the nine[3] homesteads in the case-study village that reported using something akin to the stall-feeding technique at some point during the year prior to the start of the longitudinal-monitoring exercise. During that exercise, however, only four of these homesteads actually used the technique. The homesteads were one of the five case-study homesteads that operated a multiple-output enterprise and all three of the operators of commercial-dairy enterprises in the village. The latter were the homesteads that used the technique during almost every week that they were interviewed.

The heads of these homesteads shared common socioeconomic characteristics that set them apart from the average villager, but, as is described below, they maintained greatly different local personal networks. Like 93 (70.5 percent) of the 132 homestead heads in the village, each of these three homestead heads had worked off-farm. All three were Muslims—a minority religion in the village—with greater than average sources of personal wealth. This was significant since the greater atomism of Islamic beliefs had historically been used amongst the Giriama to resist the claims of kin for assistance and to justify individual gain from production (Parkin 1972). With respect to reliance on other individual's feed sources, the three commercial-dairy operators, due to their use of the stall-feeding technique, once again shared a common fate that set them apart from the other cattle-enterprise operators in the village. As can be seen in Table 2, cattle-enterprise operators who used the stall-feeding technique relied on other individuals' feed

[3] One homestead did not want to participate in the exercise.

sources in only 28.8 percent of their use-instances, while operators who used the herder- and tethered-grazing techniques relied on these sources for 59.8 percent and 43.9 percent of the weeks that they used the techniques respectively.[4] The three operators of commercial-dairy enterprises did, however, vary in their reliance on the different sources of cattle feed, as is described below.

Table 2—Use of others' feed sources for all three cattle-feeding techniques

		Some Use	No Use	Missing	Total
		(weeks)			
Herder-grazing		361 (59.8)	217 (35.9)	26 (4.3)	604 (100)
Tethered-grazing		301 (43.9)	361 (52.6)	24 (3.5)	686 (100)
		(Use-instances)			
Stall-feeding	Individuals	332 (28.8)			
	Private Businesses	247 (21.5)	552 (48.0)	20 (1.7)	1,151 (100)
	Total	579 (50.3)			

Source: Longitudinal-Monitoring Exercise July 1992-94 (Swallow 1996).
Note: Figures in parentheses show the percentage of weeks that a technique was used (for herder- or tethered-grazing) or percentage of use-instances (for stall feeding).

One of the operators of a commercial-dairy enterprise was considered by other villagers to be an outsider. This person was one of the very few non-Giriama members of the village. He was also a relative newcomer, and neither he nor any other adult male homestead member actually resided in the village. This homestead head lived in Mombasa where he had been engaged in salaried employment for 10 years prior to the

[4] The commercial-dairy operator who also operated a multiple-output cattle enterprise used other individuals' feed sources far more for the latter—over 90 percent of

study. While a Muslim, he used his English name, suggesting a Westernized image. He had in fact attained one of the highest levels of formal education of the village's members. All of

these factors limited his personal network within the village. As a result, this cattle-enterprise operator rarely used cattle feeds obtained from other individuals. As can be seen in Table 3, he relied on feed produced on his own land, which included Napier grass, for 71.9 percent of his use-instances, and on private businesses for 22.4 percent. Although his use was minimal, he did purchase some specialized feeds. Thus, this enterprise operator obtained feed from other individuals in only 4.0 percent of his use-instances. For the remainder of this report, he will be called the "self-reliant outsider."

The second operator of a commercial-dairy enterprise, while an insider to the village, placed himself too far above others to be accepted within the village. He did this by creating an image of himself as a model cattle-keeper. He was frequently visited by extension agents, and had successfully attempted many of the innovations presented to him, including the raising of a pure dairy cow and the cultivation of specialized cattle feeds—Napier grass and *leucaena l.* He also used some specialized-purchased feeds. The infrastructure for his cattle enterprise was the most extensive of any homestead in the village. His was the only homestead in the village that owned a donkey—useful in transporting the substantial quantities of water required by pure dairy cattle. The head of this homestead also showed his dairy cow at the provincial agricultural show. The extent of this homestead head's personal network within the village was limited not only by this

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weeks—than the former enterprise, which suggests that this practice is not individual reputation, but also by the fact that a good portion of his land—the portion used for cultivating specialized cattle feeds—was fenced such that other cattle-keepers could not use it. The jealousy of his neighbors caused them to spread rumors that he was crazy to take land out of food for humans, and put it into feed for cattle. His neighbors also thought that his use of a formal-sector loan to purchase his pure dairy cow was too risky. As can be seen in Table 3, this homestead head relied on his own sources of feed for 42.1 percent of his use-instances, and on private businesses for 29.2 percent, leaving 26.4 percent of use-instances in which feed was obtained from other individuals. This homestead head will be called the "model cattle-keeper."

Table 3—Source of stall-fed feed items by homestead, percentage use-instances

	Private Businesses	Other Individuals	Own	Missing	Total
Multiple-Output Enterprise Operator	0	110 (78.0)	31 (22.0)	0	141 (100)
Self-Reliant Outsider	67 (22.4)	12 (4.0)	215 (71.9)	5 (1.7)	299 (100)
Model Cattle-keeper	145 (29.2)	131 (26.4)	209 (42.1)	12 (2.4)	497 (100)
Moderate Innovator	35 (16.4)	79 (36.9)	97 (45.3)	3 (1.4)	214 (100)
Total	247 (21.5)	332 (28.8)	552 (48.0)	20 (1.7)	1,151 (100)

Source: Longitudinal-Monitoring Exercise July 1992-94 (Swallow 1996).

The third operator of a commercial-dairy enterprise started his enterprise after first successfully establishing his multiple-output enterprise. This enterprise was, in fact, based on one of the largest herds of cattle in the village. This homestead head had an extensive personal network within the village because he maintained an image of being

specific, but rather enterprise and technique specific.

one of the villagers, and he had more moderate investment in and success with his dairy enterprise. Although he was a Muslim, he used his Giriama name. He had no formal education and had worked off-farm for only six years. The very fact that he kept zebu cattle contributed to his image of being like the others in the village. No infrastructure was used for the commercial-dairy enterprise, no forages were planted, and only a negligible amount of specialized-purchased feeds were used. As can be seen in Table 3, this cattle-enterprise operator's reliance on his own feed sources—45.3 percent of his use-instances—was about the same as that of the model cattle-keeper, but he obtained feeds from private businesses in only 16.4 percent of his use-instances, and from other individuals in 36.9 percent of use-instances. This homestead head will be called the "moderate innovator."

4. COMMODITY AND BARGAINING TRANSACTIONS

COLLECTIVE SUPPORT FOR COMMODITY TRANSACTIONS

Collective support for transactions over cattle feed that took place in one of the collectively-defined transaction sectors came in the form of a set of expectations about ownership rights and the structure of the transaction in terms of incentives for cooperation, the extent of personalization of the transaction, and the *quid pro quo* or non-*quid-pro-quo* nature of the transaction. Rights of ownership of feed sources were based on the principle that individuals owned the product of their labor. This principle lead to the traditional belief that fallow growth belonged to God (Mkangi 1975) since he was its producer. Two types of collectively-sanctioned incentives were used in transactions:

utility and normative-voluntary incentives. Sanctioning of utility, or the merits of personal gain, as an incentive came in the form of a commonly-held belief that individuals should reap the benefits of their labor. Normative-voluntary incentives included beliefs about good neighborliness, an ethos of sharing, and expectations of the rights and duties of personal relationships, especially those of agnates, affines, and matrilineal kin. Desirable behavior was encouraged through complements, the greatest of which was the ability to help others in need. Undesirable behavior was discouraged through diffuse infliction of guilt and shunning of errant individuals.

In general, information-gathering costs were reduced through the creation of reputations and gossip, as well as the existence of multiple spheres of interaction of villagers. Contracting costs were reduced through the maintenance of expected contracting procedures such as the use of witnesses. Enforcement costs were reduced through the use of fines, the sanctioning of some types of right-holder enforcement (such as certain uses of physical force), and stipulations against theft and physical violence. In extreme cases, support for enforcement could be found through *ad hoc* councils of village elders or the national government via the subchief.

Herder- and Tethered-Grazing Techniques

Transaction Sectors. Understanding of the appropriate sector for collective support of herder- and tethered-grazing transactions can be gained through examining the physical-technical characteristics of land in the case-study village at the time of the study. As was described above, intensification of land use had gradually increased to the point that competition over use of fallow growth for crop production and cattle enterprises was beginning to be evident such that rivalry over land-based benefit streams was rising. With respect to the costs of excluding use of land for grazing, since only two of the plots in the village were fenced, the costs to landowners of physically excluding others' use was prohibitive. Thus, the least-cost area of collective support for transactions to access land for herder- and tethered-grazing was the gray area between the community- and the reciprocal-transaction sectors.

Data from the longitudinal-monitoring exercise support this finding. As can be seen in Table 4, others' land was accessed without seeking permission during the majority of the weeks that others' land was used by the eight case-study homesteads for herder- and tethered-grazing. However, it was accessed with permission but without payment during a significant minority of those weeks. The relative position of transactions for the two techniques within this gray area is indicated by the different preference for use of impersonal[5] relationships for the two techniques. Since most of the case-study homesteads had personal relationships with most of the homesteads within the usual grazing area, the result shown in Table 4, that the percentage use of personal and impersonal relationships was equal for the herder-grazing technique, suggests that the case-study homesteads actually preferred to use impersonal relationships for herder-grazing transactions. After all, by definition, an impersonal relationship meant that these homesteads were ones with which cattle-keepers did not relate in any other sphere of interaction, such that retaliation for unfavorable behavior was less likely than in personal

[5] Personal relationships were relationships defined by respondents as that of relative, friend, or neighbor.

relationships. This meant that herder-grazing transactions took place closer to the community- than to the reciprocal-transaction sector. The homesteads that used the tethered-grazing technique, on the other hand, appeared to be indifferent about the degree of personalization of the relationship with the landowner since the percentage use of impersonal relationships more closely reflected the percentage of those relationships in the usual grazing area.

Table 4—Means of access to others' feed sources by relationship with the feed owner for all three cattle-feeding techniques

		Pay	Ask-No-Pay	No-Ask	Missing	Total
				(weeks)		
Herder-Grazing	Impersonal[a]		22 (41.5) (11.8)	164 (53.2) (88.2)	0	186 (51.5) (100)
	Personal		31 (58.5) (17.7)	144 (46.8) (82.3)	0	175 (48.5) (100)
	SubTotal		53 (100) (14.7)	308 (100) (85.3)	0	361 (100) (100)
Tethered-Grazing	Impersonal	0	23 (47.9) (21.3)	85 (35.4) (78.7)	0	108 (35.9) (100)
	Personal	13 (100) (6.7)	25 (52.1) (13.0)	155 (64.6) (80.3)	0	193 (64.1) (100)
	SubTotal	13 (100) (4.3)	48 (100) (15.9)	240 (100) (79.7)	0	301 (100) (100)
Stall-Feeding[b] (Use-Instances)	Impersonal	52 (67.5) (54.2)	21 (13.7) (21.9)	23 (24.7) (24.0)	0	96 (28.9) (100)
	Personal	18 (23.4) (8.2)	131 (85.6) (59.5)	70 (75.3) (31.8)	1 (11.1) (0.5)	220 (66.3) (100)
	Missing	7 (9.1) (43.8)	1 (0.7) (6.3)	0	8 (88.9) (50.0)	16 (4.8) (100)
	Sub-Total	77 (100) (23.2)	153 (100) (46.1)	93 (100) (28.0)	9 (100) (2.7)	332 (100) (100)

Source: Longitudinal-Monitoring Exercise July 1992-1994 (Swallow 1996)

Notes: figures in parentheses refer to percent of weeks that a technique was used, or percent of use-instances, with column percentage above row percentage.

[a] Personal relationships were relationships defined by respondents as that of relative, friend, or neighbour.

[b] These figures include only cases in which other individuals' feeds were used. They do not include cases in which private businesses' feeds were used.

The single exception to the finding that transactions over land for herder- and tethered-grazing took place in the gray area between the community- and reciprocal-transaction sectors, was the case of these transactions when undertaken by operators of commercial-diary enterprises. These operators were twice as likely as operators of multiple-output enterprises to seek permission for the use of tethered-grazing spots. The only cattle-keeper who made *quid pro quo* payments for tethered-grazing spots was the operator of the commercial-dairy enterprise who made the most profit from his enterprise—the model cattle-keeper. Thus, tethered-grazing transactions by commercial-dairy enterprise operators took place in the gray area between the private- and the reciprocal-transaction sectors.

Bargaining Transactions. The position of herder- and tethered-grazing in the gray area between the reciprocal- and community-transaction sectors meant that cattle-keepers bargained with landowners regarding which of the two sets of expectations they would use to guide their transactions. Cattle-keepers' interests were largely to use the expectations of the community-transaction sector, whereas landowners' interests were to use the reciprocal- or, in the case of tethered-grazing by commercial-dairy operators, private-transaction sector. This type of bargaining was more reactive than proactive, however, in that a cattle-keeper would for the most part assume use of the community-transaction sector, and wait for a response, if any, from the landowner. Given the existing institutional structure, the burden of changing the situation rested on the landowner.

There were, however, some unique interests of cattle-keepers who used the tethered-grazing technique, as well as those who operated commercial-dairy enterprises.

For users of tethered-grazing, the reciprocal-transaction sector did offer some benefits in that, if a request had been made for use of the land, the cattle were more likely to be observed by members of the landowner's homestead while being tethered. This reduced the likelihood that they would get loose and damage crops, which would result in conflict and fines. There was also a greater assurance that the cattle would not be harmed while they were grazing. Also, if use was based on permission, a contract for exclusive access could be established. The moderate innovator negotiated one such contract. For commercial-dairy operators, the profitability of their operations meant there was greater value attached to a reliable supply of tethering points, and a greater cost of harm done to cattle.

Cattle-keepers used several methods to capture as much bargaining power as possible. First, cattle-keepers guarded the historical precedent stipulating that others' fallowed and harvested fields were open for grazing by all, such that transaction over this use belonged in the community-transaction sector. Second, much effort was invested in establishing reputations as assertive cattle-keepers. The moderate innovator reported that he had to keep landowners accustomed to the idea that he would use their land unless they made it clear that they would stop him. He did this by routinely returning to the fields of homestead heads who asked him to leave. He continued to do this unless these landowners asked him to leave more than three times or threatened to use force. And, third, cattle-keepers developed tit-for-tat relationships such that, if a cattle-keeper asked another cattle-keeper's herder to leave his land, the offended cattle-keeper would reciprocate. The moderate innovator had several tit-for-tat relationships with other cattle-keepers.

Noncattle keeping homesteads would stand to gain the most if access to their land were brought into the reciprocal- or private-transaction sectors. However, given the low-but-increasing level of intensity of land use described above, this interest was not very strong and the costs of acting on it could be great. On top of the actual costs of monitoring and enforcement that would be required to exclude unwanted use, there would be the social cost of going against the traditional norm of good neighborliness. Since most cattle-keepers had no choice—short of reducing their herd sizes—but to use the land of other villagers, this norm provided social pressure to support their access to others' land. In addition, almost every villager aspired to own cattle one day, and would want these norms to apply to themselves. A final cost was the possibility that beneficial relations with trespassing homesteads in one of the other spheres of interaction in this multiplex society would be curtailed. These norms tended to prevail over national ideologies of private land ownership, particularly in transactions between villagers who were not engaged in a commercial enterprise.

Even given these costs, if a landowner chose to defend his interests he could do so by fiercely protecting his land. He could do this by complaining to the local government representative—the subchief—or consistently or fiercely asking herders to leave his land. In one case, the moderate innovator's herd was chased away by a machete-wielding landowner. In the case of tethered-grazing, landowners' had several unique factors in their favor. Since exclusion was less costly, the overall cost of contracting was less than with herder-grazing. With tethered-grazing, incidences of trespassing were less costly to detect, and information about the owner of the cattle was easier to obtain. Enforcement was easier in that cattle could potentially be removed or harmed by the landowner since they were left unsupervised.

Stall-Feeding Technique

Transaction-sectors. Given their variety of physical-technical attributes, stall-fed items were transacted in a variety of sectors and gray areas. The feed items that were transacted in the private-transaction sector were copra cake and maize bran. Both items were obtained exclusively by *quid pro quo* payment. Copra cake was exclusively purchased from private businesses. Use of the private-transaction sector for transactions over maize bran was consistent with its physical-technical attributes. Since it was a by-product of human food preparation within the homestead, it had near zero physical-technical costs of exclusion. However, it did have an opportunity cost since it was used as a feed in the poultry enterprises that were operated on a subsistence basis by the majority of homesteads in the village. The preference for the use of impersonal relationships in maize transactions, which is shown in Table 5 to account for 78.6 percent of the instances in which maize was used, is striking given the prevalence of personal relationships within the village. Maize was also the only feed obtained from individuals that was frequently purchased from non-case-study villagers.

Table 5—Means of access to other individuals' stall-fed items by feed-type category and relationship to the feed owner

		Pay	Ask-No-Pay	No-Ask	SubTotal	Missing	Total
Maize Bran	Impersonal[a]	55 (78.6)	0	0	55 (78.6)	7 (10.0)	70 (100)
	Personal	8 (11.4)	0	0	8 (11.4)		
Banana Pseudo-Stems	Impersonal	7 (24.1)	2 (6.9)	0	9 (31.0)	1 (3.4)	29 (100)
	Personal	0	19 (65.5)	0	19 (65.5)		
Planted Feeds	Impersonal	0	0	0	0	0	4 (100)
	Personal	0	4 (100)	0	4 (100)		
Misc. Crop and Tree Residue[b]	Impersonal	0	2 (33.3)	0	2 (33.3)	0	6 (100)
	Personal	0	4 (66.7)	0	4 (66.7)		
Natural Vegetation & Maize Stalks	Impersonal	0	18 (8.1)	23 (10.3)	41 (18.4)	9 (4.0)	223 (100)
	Personal	0	103 (46.2)	70 (31.4)	173 (77.6)		
Total		70 (21.1)	152 (45.8)	93 (28.0)	315 (94.9)	17 (5.1)	332 (100)

Source: Longitudinal-Monitoring Exercise July 1992-1994 (Swallow 1996).
Notes: Figures in parentheses refer to percent of use-instances.
[a] Personal relationships were relationships with relatives, friends, or neighbours.
[b] Miscellaneous crop and tree residues and by-products include cassava leaves/peels, mango leaves, maize husks, and potato peels.

As miscellaneous crop and tree residues, and by-products and planted feeds were the only items obtained exclusively by asking-but-not-paying, they were the only items that were transacted over in the reciprocal-transaction sector. However, as can be seen in Table 5, there were only 10 instances in which transactions over these items were actually undertaken. More often, they were obtained from cattle-keepers' own sources. Use of the reciprocal-transaction sector for transactions over miscellaneous crop and tree residues and by-products was consistent with these items' moderate rivalry of consumption and lack of opportunity cost. The physical-technical costs of excluding others' use of mango and cassava leaves were theoretically high as these plants were often far from homestead buildings. Once the plants were harvested, the costs of excluding others' use of maize husks, cassava peels, and potato peels was near zero as these items were by-products of crop processing that took place within the homestead. However, the self-reliant outsider did report a problem of theft of parts of maize and cassava plants. Planted feeds' high rivalry of consumption indicated that they would be most appropriately transacted over in the private-transaction sector, even though they were characterized by relatively high physical-technical costs of exclusion. Their exchange in the reciprocal-transaction sector during the longitudinal-monitoring exercise can be explained by the precedence of the particular relationship—that of matrilineal kin—between the transaction partners which may have carried more weight in determining the sector for these transactions than physical-technical characteristics. A summary of the analysis of the transaction sectors used to support transactions over feed sources used in all three cattle-feeding techniques can be seen in Table 7.

Table 7—Means of access to others' feed sources for all three cattle-feeding techniques by transaction sector

	Private-Transactio Sector (Pay)	Gray Area	Reciprocal Transaction Sector (Ask-No-Pay)	Gray Area	Community-Transaction Sector (No-Ask)
Herder-grazing				✓	
Tethered-grazing		✓[a]		✓	
Stall-feeding					
Copra cake and Maize bran	✓				
Banana Pseudo-stems		✓			
Planted feeds			✓		
Misc. crop & tree residues & by-products[b]			✓		
Natural vegetation & maize stalks				✓	

Source: Longitudinal-Monitoring Exercise July 1992-94 (Swallow 1996).
[a] This gray area was used by one commercial-dairy enterprise only.
[b] Miscellaneous crop and tree residues and by-products include cassava leaves/peels, mango leaves, maize husks, and potato peels.

Bargaining Transactions. Banana pseudo-stems, natural vegetation, and maize stalks were the stall-fed items that were transacted in institutional gray areas such that bargaining transactions were used to access them. In general, with bargaining transactions for stall-feeding, enterprise operators were more pro-active than with transactions for the herder- and tethered-grazing techniques, even when the feed items used were the same, as with natural vegetation and maize stalks. Bargaining transactions over stall-fed items were differentiated by several factors: (1) the physical-technical characteristics of the feed item; (2) seasonal scarcity of feeds; (3) the enterprise type; (4) the degree of commercialization of the cattle enterprise; and (5) the enterprise operator's personal networks.

The high degree of rivalry of consumption and low costs of exclusion of banana pseudo-stems favored the use of the private-transaction sector. However, their zero opportunity cost meant that they were transacted in the reciprocal- or community-transaction sectors except during the dry season when banana pseudo-stems were one of the only feed items available. This was the season when they were purchased by the self-reliant outsider who did not have many personal relationships in the village. As can be seen in Table 5, banana pseudo-stems were obtained by asking-but-not-paying in 72.4 percent of the instances in which others' sources of them were used; and, in 65.6 percent of these instances, personal relationships were used for transactions.

As can be seen in Table 5, natural vegetation and maize stalks accounted for the vast majority of use-instances[6] in which stall-fed items were obtained from other individuals, and they were the only stall-fed item obtained without permission. These feeds' rising opportunity cost in terms of lost benefits to the farming system and high costs of exclusion were the context of the bargaining transactions. Cattle-keepers who used the stall-feeding technique were less likely than those who used the two other techniques to obtain natural vegetation and maize stalks without permission. As can be seen in Table 5, cattle-keepers who used the stall-feeding technique obtained these feed items without permission in 41.7 percent of the instances in which others' sources of them were used. As can be seen in Table 4, the comparable figure for cattle-keepers who used the other two techniques was an average of 82.5 percent of the relevant weeks. In addition, cattle-keepers who used the stall-feeding technique were less likely to use

[6] One use-instance is one instance of use of a feed item by one homestead at least once during one week. Since no long-term storage of feeds was practiced in the case-study village—with the exception of feeds purchased in bulk from private businesses—an instance of use of another individual's feed item corresponded roughly to an instance of transaction over that feed item.

impersonal relationships in transactions over natural vegetation and maize stalks. As can be seen in Tables 5 and 4, whereas cattle-keepers who used the stall-feeding technique used impersonal relationships to access these feeds in 18.4 percent of the instances in which others' sources of the feeds were used, cattle-keepers who used herder- and tethered-grazing used impersonal relationships to access these feeds in an average of 36.8 percent of the relevant weeks. This greater reliance on personal relationships to access natural vegetation and maize stalks from other individuals for stall-feeding meant that a more extensive personal network was needed.

When the degree of commercialization of a cattle enterprise was analyzed, it was found to influence the cost of transactions for stall-fed items. The operator of the single multiple-output enterprise who used stall-feeding accessed feed through distinctly different means than the two operators of commercial-dairy enterprises who made consistent use of others' feed sources for stall-feeding—the model cattle-keeper and the moderate innovator. As can be seen in Table 6, the operator of the multiple-output enterprise used feed items without seeking permission in 50.0 percent of the instances in which he used others' feed sources, and he never paid to use a feed item. The two operators of commercial-dairy enterprises, in contrast, used feed items without seeking permission in an average of only 18.1 percent of the instances in which they used others' feed sources, and they paid to use feed items an average of 31.9 percent of those instances. The tradition of allowing the village's cattle-keepers access to natural vegetation and maize stalks without permission was called into question when these feeds were used in a nontraditional technique, especially if that technique was used exclusively to make profit as the commercial-dairy operations were.

The personal network of the cattle enterprise operator was another factor related to means of access to the feed items used in the stall-feeding technique. Given his limited local personal network, coupled with his relatively sufficient personal wealth, the self-reliant outsider only used three other villagers' feed sources, and he only used them during the severe dry season. As can be seen in Table 6, this enterprise operator paid in 66.7 percent of the instances of use of these feed items. The model cattle-keeper, while an insider in the village, had a limited local personal network and therefore less bargaining power with his neighbors. He also had less land than the self-reliant outsider did. As a result, he was the only cattle-enterprise operator who paid for tethered-grazing spots. This commercial-dairy operator relied on private businesses for 29.2 percent of his use-instances. As can be seen in Table 3, he only relied on feed obtained through transactions with other individuals for 26.4 percent of his use-instances, and, as can be seen in Table 6, he paid for the feeds in 35.9 percent of those use-instances.

Table 6—Means of access to other individuals' stall-fed items by homestead

	Pay	Ask-No-Pay	No-Ask	Missing	Total
Multiple-Output Enterprise Operator	0	55 (50.0)	55 (50.0)	0	110 (100)
Self-Reliant Outsider	8 (66.7)	3 (25.0)	0	1 (8.3)	12 (100)
Model Cattle-keeper	47 (35.9)	62 (47.3)	20 (15.3)	2 (1.5)	131 (100)
Moderate Innovator	22 (27.8)	33 (41.8)	18 (22.8)	6 (7.6)	79 (100)
Total	77 (23.2)	153 (46.1)	93 (28.0)	9 (2.7)	332 (100)

Source: Longitudinal-Monitoring Exercise July 1992-94 (Swallow 1996).
Note: Figures in parentheses refer to percent of use-instances.

The moderate innovator had personal networks and thus more opportunities to use multiplex relationships as sources of bargaining power. He was also highly motivated to use his personal networks for this purpose since he had less personal wealth than the other commercial-dairy enterprise operators. He was able to gain more access to other villagers' feed sources outside of the private-transaction sector than the two other operators of commercial-dairy enterprises. As can be seen in Table 3, while this homestead head relied on his own feed sources about as often as the model cattle-keeper, he only relied on private businesses for 16.4 percent of his use-instances and he was able to use other individuals' feed sources in 36.9 percent of his use-instances. In addition, as can be seen in Table 6, he only paid for stall-fed feed items in 27.8 percent of the instances in which he used other individuals' feeds.

5. INSTITUTIONAL TRANSACTIONS

In the previous section, it was determined that at the time of the study many of the transactions over cattle feed in the case-study village were conducted through bargaining transactions in the gray areas between the three collectively-defined transaction sectors. This was the case for all transactions over feed sources for herder- and tethered-grazing, and, as can be seen in Table 5, it was the case for 75.9 percent of the instances of use of other individuals' stall-fed items. That such a large number of transactions took place in the institutional gray areas can be attributed to the situation of techno-institutional change in the village at the time of the study. In that situation, expectations about the sectors that should be used to support transactions over some feed items had become dislocated. It is likely that bargaining transactions in these gray areas would, through repetition, create new collective expectations about the transaction sectors to be used for specific feed items and techniques. This is one means of changing collective expectations, or engaging in institutional transactions.

Centralized and more direct means of undertaking institutional transactions were not likely given the high transaction costs of organizing the village. These transaction costs were increased by village members' heterogeneity of values and beliefs about legitimate principles of leadership and processes for making collective choices. The main source of this heterogeneity lay in the religious make-up of the village: 41.7 percent of the villagers followed the more atomistic religions of Christianity and Islam (Swallow 1996). These atomistic beliefs presented a challenge to the legitimacy of the local leadership of homestead heads, the principles of social organization of gerontocracy and ascription based on Giriama custom, and Giriama views of land ownership.

The village's cost of institutional transactions was increased by the way that it nested organizationally with the national government. The national government involved itself in some local issues, but it did not involve itself in others; and, the distinction between the two was not clear to villagers. The national government provided an alternative, competing forum for dispute settlement and decision enforcement with respect to land ownership. Individuals could choose their forum and change forums if their first choice resulted in an unfavorable outcome (Spear 1978). Government officials were involved in keeping order by enforcing national laws and implementing public policy, but they neither effectively involved themselves in the day-to-day management of local resources nor delegated authority to the local level (Waaijenberg 1994). The national government lacked the resources and legitimacy to be effective in securing local expectations and in monitoring and enforcing laws and policies. Yet, lack of delegation of authority to the local level meant that there was confusion about which collectives' domain encompassed local resource management. Poorly defined and overlapping roles between local authority and the national government, as well as changes in land scarcity and commercialization contributed to a generalized state of instability of expectations about access to land-based resources in the village.

Finally, differences in production interests as well as personal sources of power—in terms of personal wealth and personal networks—made it difficult to create institutions to govern transactions over cattle feeds in particular. Those homestead heads with larger holdings of land and cattle were better equipped to engage in commercial production. While the remaining homesteads had a subsistence orientation (Thorpe et al. 1993), dependent on remittances to purchase the staple, maize meal, during the highest scarcity times of the year (Waaijenberg 1994). Personal sources of power were becoming more heterogeneous through conversion to one of the world religions and unequal access to education, income through off-farm employment, and the national governmental system.

6. CONCLUSIONS

The study found that, contrary to the pessimism reported in the empirical literature, cattle-keepers in the case-study village were intensifying their use of cattle-feeding techniques; however, they took different routes than anticipated. It was anticipated that cattle-keepers would respond to the need to intensify land-use with complete confinement of cattle, self-reliance in cattle feed, and use of the private sector for transactions. Particularly, it was anticipated that cattle-keepers would plant forages. However, amongst the villagers' varying responses to the need to intensify land use, the common thread was the choice of a middle road of marginal, step-wise change rather than the radical change that was anticipated.

At the village's low-but-rising level of intensification of land use, alternatives to complete self-reliance in feed were available: feed could be obtained from other villagers through secondary means. Use of these feed sources had the disadvantages of providing less nutrition and requiring higher transaction costs, but it also required lower inputs in terms of land, labor, and cash than the recommended feeds. Cattle-enterprise operators blended their use of the traditional, less intensive cattle-feeding technique of herder-grazing with the more intensive techniques and different types of feeds, which resulted in different levels of transaction costs. This choice of a marginal, step-wise style of technical change enabled learning on both the technical and institutional fronts.

Although the common thread was the choice of the middle road, the three cattle-keepers who had come the farthest along the road of intensification at the time of the study did so by making use of their varying sources of personal wealth and networks. The two cattle-keepers with the greatest sources of wealth but the most limited personal networks within the village were the least successful in their bargaining transactions with other villagers, but they could afford to rely on either their own resources or the private-action sector. The cattle-keeper with the least sources of personal wealth but largest personal network relied the most on secondary access to other villagers' feed sources, and he was able to use his personal network to bargain for favorable access to that feed. Contrary to the usual view of collective action as an organized effort, it was the cumulative effect over time of separate, one-to-one bargaining transactions of these cattle-keepers with their fellow villagers that constituted collective action in the context of this loosely organized village.

REFERENCES

Baland, J-M. and J-P. Platteau. 1996. Halting degradation of natural resources: Is there a role for rural communities? Rome: FAO.

Bromley, D.W. 1989. Economic interests and institutions: The conceptual foundations of public policy. Oxford: Basil Blackwell.

Gass, G.M. and J.E. Sumberg. 1993. Intensification of livestock production in Africa: Experience and issues. Draft. Norwich: University of East Anglia.

Jaetzold, R. and H. Schmidt. 1983. Kilifi District. Farm management handbook of Kenya Vol. IIC East Kenya. Nairobi: Ministry of Agriculture and German Agency for Technical Cooperation.

Maarse, L.M., F.T. Tesha, and G.M. Wainaina. 1990. Lessons from 10 years' NDDP experience at the Kenya Coast. Mtwapa: Kenya Agricultural Research Institute and International Livestock Centre for Africa.

McIntire, J., D. Bourzat, and P. Pingali. 1992. Crop-livestock interactions in Sub-Saharan Africa. Washington, D.C.: The World Bank.

Mearns, R. 1995. Community, collective action and common grazing. Paper presented at the Fifth Common Property Conference: Reinventing the Commons, May 24-28, Bodo.

Mitchell, J.C. 1973. Networks, norms and institutions. In Network analysis studies in human interaction, 15–35, ed. J. Boissevain and J.C. Mitchell. The Hague: Mounton and Co.

Mkangi, G.C. 1975. Land tenure, population growth, and economic differentiation: The Ribe Tribe of Kenya. In The paradox of poverty, ed. T.S. Epstein and D. Jackson. New Delhi: MacMillan.

Mullins, G.R. 1992. Dairy production, marketing and consumption in coastal Kenya. Proceedings of the All Africa Conference on Animal Agriculture, November 23-27, Nairobi, Kenya. In press.

Mullins, G., P. Tsangari, L. Wahome, and L. Maarse. 1994. Benefits or burdens?: The impacts of intensive dairy production on smallholder farm women in coastal Kenya. In Proceedings of a workshop on women in livestock development, sponsored by Heifer Project International, held in Mombasa, Kenya, 16-20, May. Mimeo.

Oakerson, R.J. 1986. A model for the analysis of common property problems. In Proceedings of the Conference on Common Property Resource Management, 13–30. Washington, D.C.: National Academy Press.

Ostrom, E. 1986. Issues of definition and theory: Some conclusions and hypotheses. In Proceedings of the Conference on Common Property Resource Management, 599-615. Washington, D.C.: National Academy Press.

________. 1990. Governing the commons: The evolution of institutions for collective action. Cambridge: Cambridge University Press.

Parkin, D.J. 1972. Palms, wine and witnesses: Public spirit and private gain in an African farming community. San Francisco: Chandler Publishing Co.

Platteau, J-P. 1995. The evolutionary theory of land rights as applied to Sub-Saharan Africa: A critical assessment. Research Series No.145 (3), CRED (Centre de Recherche en Economie du Developpement), Faculte des Sciences Economiques et Sociales, Facultes Universitairs Notre-Dame de la Paix, Namur.

Polyani, K. 1944. The great transformation. Boston: Beacon Press.

Sen, A. 1984. Resources, values and development. Cambridge: Harvard University Press.

Singleton, S., and M. Taylor. 1992. Common property, collective action, and community. Journal of Theoretical Politics 4(3): 309–324.

Spear, T.T. 1978. The Kaya complex: A history of the Mijikenda Peoples of the Kenya Coast to 1900. Nairobi: Kenya Literature Bureau.

Swallow, K.A. 1996. Economic development, institutions, and technique change: Intensification of cattle-feeding techniques by the Giriama of Kenya's Coast Province. Ph.D. diss., University of Wisconsin-Madison, Madison, Wisconsin, U.S.A.

Thorpe, W.F., R. Chabari, R. Muinga, G. Mullins, J. Mureithi, R. Nyambaka, and L. Otieno. 1993. Smallholder agriculture in Coastal Lowland Kenya: A farming systems survey in Kaloleni Division. Kenya Agricultural Research Institute and International Livestock Centre for Africa Collaborative Research Programme on Smallholder Dairy Production in Coastal Lowland Kenya, Mtwapa. Nairobi: International Livestock Centre for Africa.

Waaijenberg, H. 1994. Mijikenda agriculture in Coast Province of Kenya. The Netherlands: Royal Tropical Institute.

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