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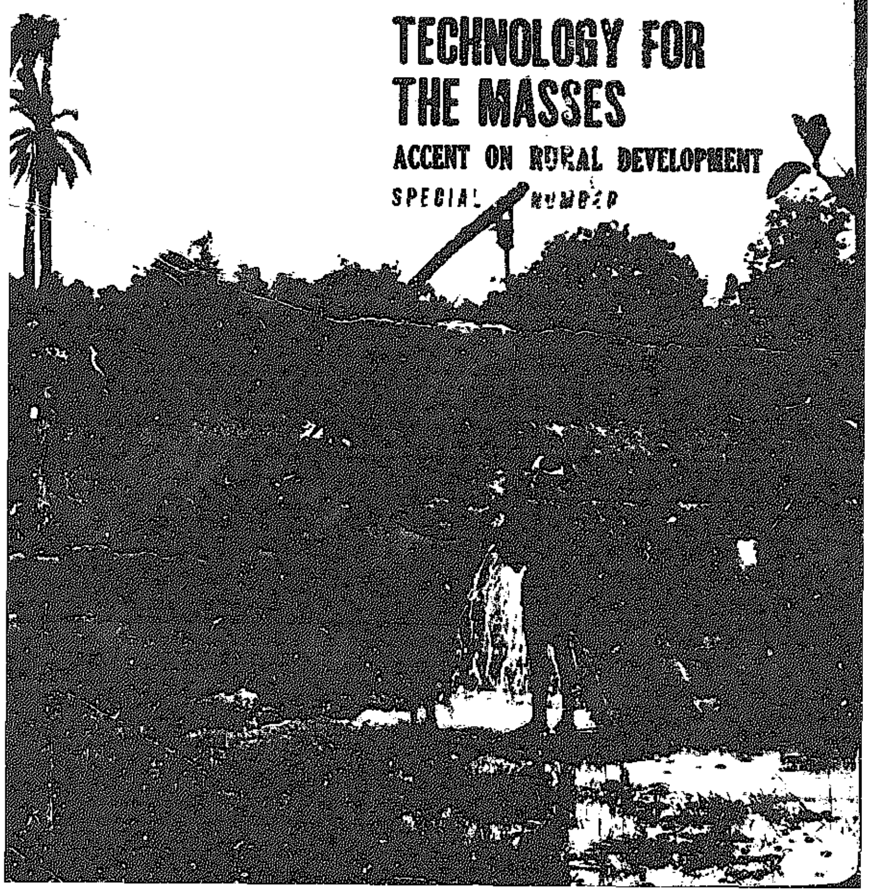

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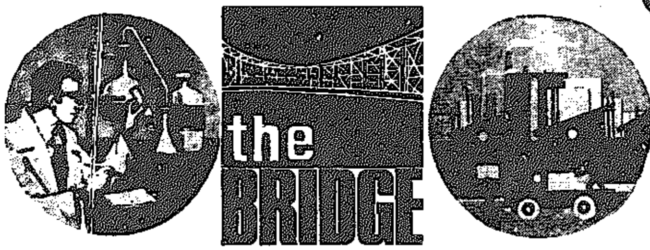

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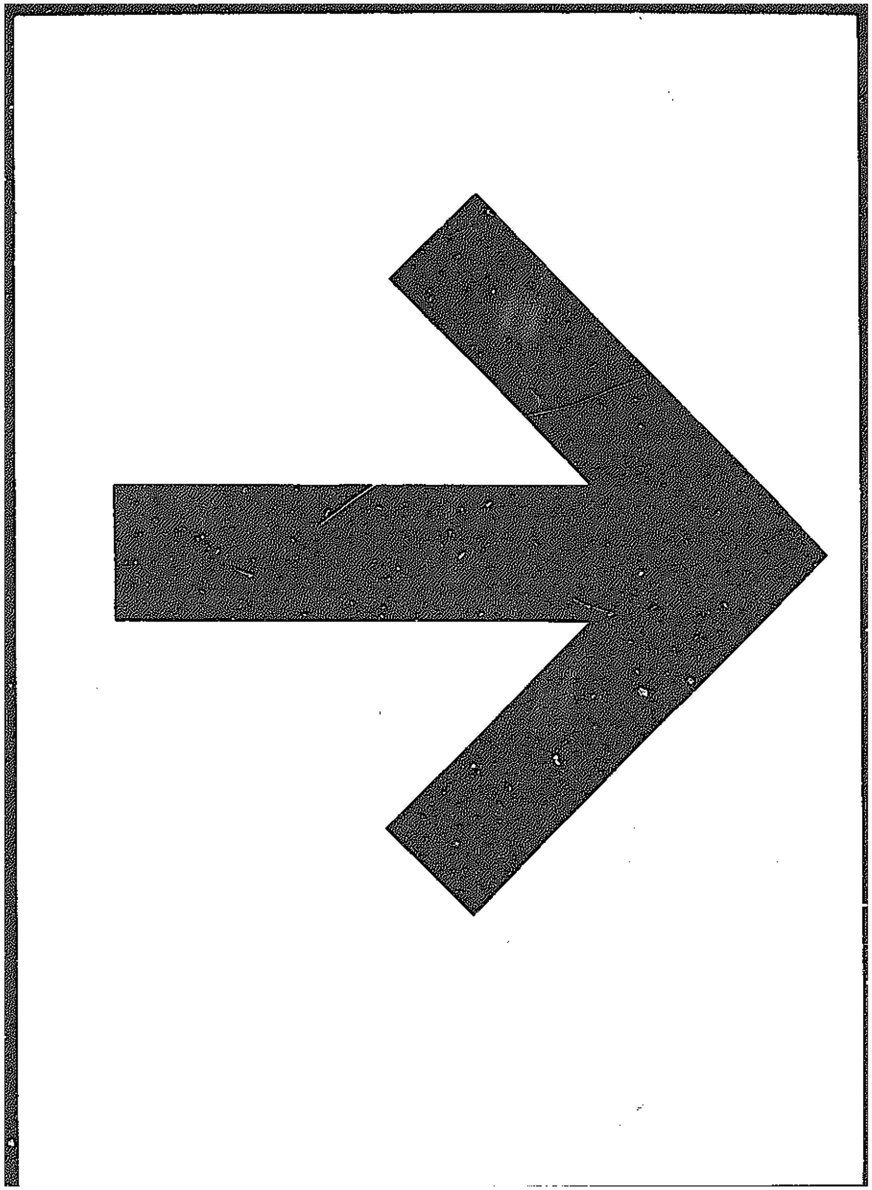

Invention Intelligence

Technology for the Masses
Accent on Rural Development
Special Number

● *January-February 1977* ● *Volume 12* ● *Number 1 & 2*

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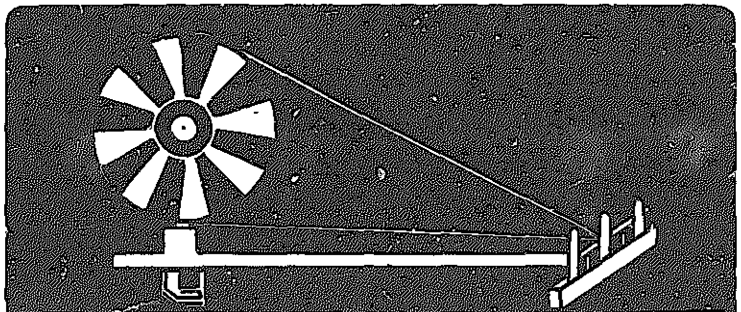
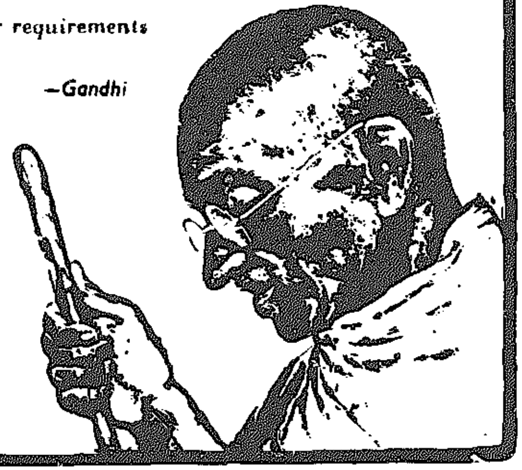
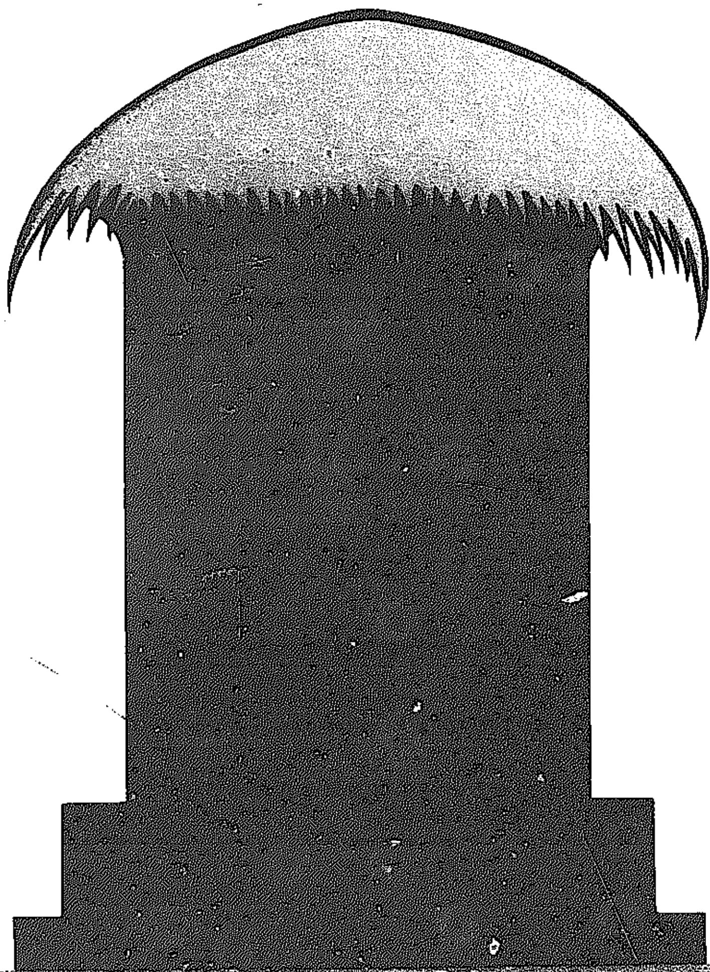
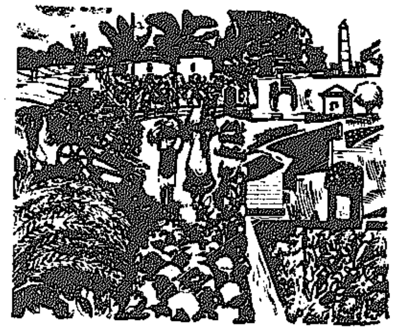


The problem of poverty will never be solved by an indiscriminate importation of machinery and technical skill . . . . What we need to do is to add to our capacity for labour with our hands and feet, the necessary technical skill, so that we may devise our own machinery suitable to our requirements

—*Gandhi*







Foreword

On technology for the masses

DR. C.V.S. RATNAM

NRDC is very happy to bring out this Special Number of **Invention Intelligence** dealing with a very important subject — Technology for the Masses.

When we speak of technology for the masses, we are thinking of the process of taking technology to the rural areas of our country where 80% of our people live and where the problems of poverty are most serious. Technology, per se, is not so important except as a tool for achieving the objectives of our Plans, namely, removal of poverty and development of self-reliance in the country. The problem of poverty, although prevalent all over the country, has to receive urgent attention in the rural areas because it is there that the bulk of the poverty-stricken people live.

What do we mean by the 'removal of poverty'? It obviously means that our people should be provided, to a reasonable extent, the essentials for a decent life: adequate food, health care, clothing, housing, education, entertainment, opportunities for intellectual pursuits and development. To achieve these objectives it would be necessary to utilize to the fullest extent whatever resources are available to us within the country. These resources are essentially of three kinds: (i) manpower, (ii) land with its flora and fauna, and (iii) mineral wealth. The strategy for removal of poverty calls for an effective utilization of all these resources. Obviously, such an effort demands a multifaceted approach designed to create conditions where the utilization of resources leads to amelioration of poverty.

Many examples can be cited of countries with approximately the same type and magnitude of resources having not developed to the same extent. It is the technological inputs that make all the difference. For the proper development of the rural areas, too, technology can be an important tool. However, as such, it cannot accomplish the goal. It has to be tailored to suit the proper overall environment to achieve the desired results. Depending upon the resources available, technology can accomplish the following objectives:

1. It can help produce goods and services to meet the needs of a particular population.
2. It can help produce goods and services not only to meet the needs of the immediate neighbourhood but also to cater, to some extent, the needs of others, both within the country and abroad.

The need of the hour is the development of relevant technologies for utilizing our resources to satisfy our immediate needs. What kind of technologies can accomplish this objective? The new technologies to be developed should meet definite criteria: they should—

(a) ensure effective utilization of available resources

(b) increase employment opportunities

(c) increase self-reliance

(d) enhance the quality of life

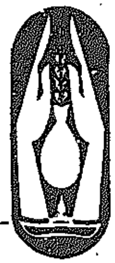
(e) ensure optimum consumption of energy

(f) ensure optimum costs

While emphasis has to be on utilization of local resources to meet local demands, it is of utmost importance to ensure that all able-bodied people who can be put to work are gainfully employed. Even if the basic necessities of the population are met in a local area, unless people are gainfully employed, it cannot be said that a satisfactory state of affairs has been obtained. Therefore, the technology for the masses should not only aim at providing the means of production of goods and services to the people, but also at solving the problems of unemployment and under-employment, ensuring proper environments, assuring reasonable costs, and improving the quality of life.

NRDC has a number of technologies which are being used for the utilization of the country's resources aimed at removal of poverty. The areas covered by these technologies include food, agro-industries, health care, mineral resources development etc. Over and above this, NRDC is very much interested in the development of relevant technologies for rural uplift.

NRDC has been very fortunate to have very eminent sons of India contributing to this issue. Our contributors include Dr. Y. Nayudamma, Dr. M.S. Swaminathan, Dr. Rajni Kothari and others. They discuss several issues concerning rural development and problems of taking technology to the masses. If this issue contributes to the great debate on this important problem and helps to some extent in finding solutions, the objective of this special issue would have been amply fulfilled. NRDC on its part will collaborate with R & D institutions, industry, Govt. departments and other agencies in developing technologies needed for the removal of poverty.



We would be failing in our duty if we do not put on record our grateful appreciation of the willing cooperation extended to us by all the contributors to this Special Number, as also by the management and staff of the Indraprastha Press (CBT), New Delhi, who have neatly executed its printing in record time.

Editor

Toward a rural utopia

Rural development is a 'must' not only to remove rural poverty but also to lay at rest the all-consuming demon of exponential growth let loose by the conventional model of economic management. It should ultimately lead to the emergence of a new form of human society that is more enduring and in which man's role vis-a-vis Nature shifts from one of parasitism to symbiosis, exploitation to nurture, dissipation to conservation.

BADIUDDIN KHAN

The sudden awareness of the existence of widespread poverty in the world is perhaps the cruelest paradox of the modern age. Cruelest, because this precisely is the result of the remarkable success of the techno-economic growth model that dominates the world's economic scene today.

While economic growth has brought unprecedented affluence to some of the industrialized countries of the world (the Americans, representing only 5% of mankind, now consume over 35% of world's resources), about half the world's population lives close to or below the poverty line. The bulk of this poverty stricken population is concentrated in the developing countries, with 80-90% of the people of these countries rendered useless for any meaningful economic activity. It is estimated that this population, mainly constituted of the rural poor and the strugglers for survival on the fringes of farms and factories, already numbers three quarters of a billion and is likely to surpass a billion by 1980, two billions by 1990, and four billions by the turn of the century!

There was a time, not many years ago, when conventional industrialism was considered the panacea of all ills of an under-developed society. It was quite natural, therefore, that most of the newly liberated under-developed countries, in their eagerness to 'catch up' with the developed world, implanted development strategies based on the conventional model. Today, however, these countries are dismayed to find that they have succeeded only in accentuating the inequalities within their own boundaries, leading to massive unemployment and under-employment and concomitant grinding poverty among the bulk of their populations. And, on the other hand, the gap in per capita real incomes between the richest countries and the poorest has not been bridged a whit — indeed it has grown from about 5 to 1 in the year 1700 to about 60 to 1 today!

What, if anything, went wrong? The conventional model of economic growth is based on technologies designed to suit easy availability of capital, scarcity of labour, cheap raw material prices forced on the developing countries, and the ethics of consumerism with built-in incentives to obsolescence of industrial products, materials, machines, techniques, even human skills. These capital and energy intensive and labour saving technologies are basically exploitative in nature, in so far as they thrive on the exploitation of man and of natural resources to the hilt. When these technologies were implanted in underdeveloped societies, they only performed the functions they were designed for and replicated in certain pockets the societies which had produced them. The result was that the limited capital, energy and other resources available in the developing countries tended to gravitate towards the metropolitan centres, where the big plants and factories were set up, to support the emerging societies of the industrial elites. And, simultaneously, the vast masses living in the rural areas began to sink into the morass of poverty due to neglect of traditional crafts and occupations and flight of capital and talent engineered by a manifestly exploitative system of economic activity.

Conventional industrialism, which had put the developed countries on the top of the world, had thus set the developing countries on the down-hill path of *de-development* and progressive impoverishment of the masses. And today, as Brazilian sociologist F.H. Cordoso says, the world is living "a civilization of poverty for most and of fear for all", dominated as it is by a small minority of men de-humanized by excess knowledge and technical skills. Indeed, the present concept of economic growth is fast coverting this planet into a *Blunderland* wherein you must run at breakneck speed to keep in the same place, or else you would be thrown out of the whirlwind of great transformations that are being wrought.

The Darwinian principle of the survival of the fittest now seems to operate with much greater treachery on the human plane than it did on the animal plane.

That conventional industrialism is no jewel of economic management is now being increasingly realized even in the developed countries. For, this exploitative model of economic growth has let loose certain most undesirable trends with global implications — reckless exploitation of fast depleting natural resources, lavish consumerism leading to waste, increasing pollution of air and water, and serious ecological imbalance caused by thoughtless encroachment on the domain of Nature. Unabated urbanization has made the city life in the industrially advanced countries a nightmare. With smog, pollution, slums, traffic jams, breakdown of civic amenities, violence, and degenerating human values, many of the so-called 'modern' cities (including some of our own) have become wailing symbols of crime and punishment. No wonder, therefore, that the countries which have gone too far on the road to industrialization and urbanization are now repenting this choice.

Exponential growth

There is now a growing awareness that conventional industrialism — be it of capitalist, communist or socialist variety — is taking mankind on a short-lived joy-ride on the back of the all-consuming demon of exponential growth, that is bound to end with a crash. For this globe is a finite system which cannot indefinitely support any activity that causes depletion of its limited resources or corrupts its environment irreparably. At the current rate of economic growth, man is approaching the limits of this planet dangerously fast, because the doubling times of population growth, resource depletion and pollution overload are very short and the base figures being doubled are already large. According to the authors of *The Limits to Growth**: "If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next 100 years". One could perhaps haggle about the *timing* of the collapse, but that it would come, sooner or later, if the present scheme of things continue, is certain. And when it does come, as it must, it would leave no warning time for man to cope with the consequences — because the very heart of this collapse would be the *suddenness* with which exponential growth approaches limits.

Exponential growth, by its very nature, cannot be an indefinite phenomenon — it must reach a point of crash, destroying the very system in which it operates. The multiplication of cancer cells is a case in point : growing exponentially, they eventually choke the patient to death— and with a suddenness that leaves no time for any remedial measures to be effective.

What a collapse could be like is very well exemplified by the following classic case. In 1907, the game wardens began removing the deer's natural predators — the mountain lions, wolves and coyotes — from the Kaibab Plateau of the Grand Canyon in western America. The deer population shot up rapidly from 4,000 to about 100,000 in 1924. This growing population quickly depleted the resources of its environment, then crashed : 60,000 deers died of starvation and disease in the winters of 1925 and 1926 alone, the population finally levelling off at about 10,000.

Recycling society

The above example only goes to show that man must move away from the present 'growthmania' and seek to achieve a smooth transition to an equilibrium state with his environment, in order to ensure a stable human civilization. Such an equilibrium state calls for complete scraping of the currently entrenched *pro-growth* economic models, based on ruthless exploitation of natural resources, and their replacement by an inherently dynamic *no-growth* economic system designed to ensure long term economic survival of mankind. Such a no-growth system will be necessarily tied in with a no-growth population policy and will have as its bed-rock the principles of conservation of non-renewable resources, recycling of wastes, and greater economic dependence on renewable resources like forest materials, agricultural and livestock products, solar energy, wind power, and biogas. In short, in this recycling society, man's role vis-a-vis Nature would shift from one of parasitism to symbiosis, exploitation to nurture, dissipation to conservation.

Viewed from this perspective, the imperatives of rural development assume a new significance. Rural development becomes a 'must' not only to reduce the poverty and misery that now reside in the rural areas, but also to lay the foundation of a new society that is essential for the very survival of mankind on this planet. Obviously, a recycling society as conceived above cannot be built up in the concrete jungles of urban conglomerates. The villages offer the best locations for the development of such a society, because it is there that human intervention with Nature has been the least and, therefore, much virgin resource and unspoiled human genius still abound.

Relevance of Gandhi

The back-to-the-village call is not new to India. When the great debate was on just before Independence as to which pattern of economic development would suit the country best, Mahatma Gandhi had expressed his opinion thus : "If India is to attain true freedom, and through India the world also, then sooner or later, the fact must be recognized that people will have to live in villages not in towns, in huts not in palaces.... I must not fear if the world today is going the wrong

* Donella H. Meadows, Dennis L. Meadows, Jorgen Randers & William W. Behrens. *The Limits to Growth*. Universe Books, New York. 1972.

Gandhi on Technology for the Masses

★ As a moderately intelligent man, I know that man cannot live without industry. Therefore, I cannot be opposed to industrialization. But I have a great concern about introducing machine industry. The machine produces much too fast, and brings with it a sort of economic system which I cannot grasp. I do not want to accept something when I see its evil effects which outweigh whatever good it brings with it. I want the dumb millions of our land to be healthy and happy, and I want them to grow spiritually. As yet for this purpose we do not need the machine. There are many, too many idle hands. But as we grow in understanding, if we feel the need of machines, we certainly will have them. We want industry, but let us become industrious. Let us become more self-dependent, then we will not follow the other peoples' lead so much. We shall introduce machinery if and when we need them. Once we have shaped our life on *ahimsa* we shall know how to control the machine.

★ Granting for the moment that machinery may supply all the needs of humanity, still, it would concentrate production in particular areas, so that you would have to go about in a round about way to regulate distribution, whereas, if there is production and distribution both in the respective areas where things are required, it is automatically regulated, and there is less chance for fraud, none for speculation...Oh yes, mass production certainly...but mass production (on individual basis) in people's own homes. If you multiply individual production millions of times, would it not give you mass-production on a tremendous scale?...Your mass-production is production by the fewest possible number through the aid of highly complicated machinery....My machinery must be of the most elementary type which I can put in the homes of the millions.

★ I would prize every invention of science for the benefit of all...Every machine that helps every individual has a place...Labour has its unique place in a cultured human family...Simple tools and instruments and such machinery as saves individual labour and lightens the burden of the millions of cottages, I should welcome.

★ What I object to, is the 'craze' for machinery, not machinery as such. The craze is for what they call labour-saving machinery. Men go on "saving labour" till thousands are without work and thrown on the open streets to die of starvation. I want to save time and labour, not for a fraction of mankind, but for all; I want the concentration of wealth, not in the hands of a few, but in the hands of all. Today machinery merely helps a few to ride on the backs of millions. The impetus behind it all is not the philanthropy to save labour, but greed. It is against this constitution of things that I am fighting with all my might.

★ The supreme consideration is man. The machine should not tend to make atrophied the limbs of man. Take the case of the Singer Sewing Machine. It is one of the few useful things ever invented, and there is a romance about the device itself. Singer saw his wife labouring over the tedious process of sewing and sewing with her own hands, and simply out of his love for her he devised the sewing machine in order to save her from unnecessary labour. He, however, saved not only her labour but also the labour of everyone who could purchase a sewing machine.

way — it may be that India too will go that way. But it is my bounden duty up to my last breath to try to protect India and through that the entire world from such a doom. The essence of what I have said is that man should rest content with what are his real needs, and become self-sufficient". He had even given the outline of a model village : "My ideal village will contain intelligent human beings. They will not live in dirt and darkness as animals. Men and women will be free and able to hold their own against any one in the world. There will be neither plague nor cholera nor small-pox. No one will be idle; no one will wallow in luxury. Every one will have to contribute his own quota of manual labour".

Gandhi's vision encompassed the old and the modern. The village of his dream was to be evolved through the integration of some of the basic amenities of urban life with rural living. Since such a village could not be based on subsistence agriculture alone, Gandhi pleaded for emphasis on decentralized industrial production through small and cottage industries. "I want a miniature mill in every home", he said. But he was not against the Big Machine concept: he only objected to the "craze for machinery, not machinery as such", for he considered it "a sin and injustice to use machinery for the concentration of economic power and riches in the hands of the few". Gandhi appears more radical than Marx when he says : "I hate privilege and monopoly. Whatever cannot be shared with the masses is taboo to me". He feared that the indiscriminate introduction of the Big Machine will lead to further impoverishment of the masses, as the levers of production, and hence the economic power, will rest in the hands of a privileged minority. And he therefore implored : "My machinery must be of the elementary type which I can put into the homes of the millions". In his scheme of things, every man or woman was to be an entrepreneur, every home an enterprize.

Gandhi was no economist of sorts. Yet he had an earthy sense of logic, an uncanny perception of emerging

Gopalpur—from poverty to prosperity

Gopalpur, a small village in the 24-Parganas of West Bengal, only three years ago presented a dismal picture of poverty, unemployment and barrenness. Today it is pulsating with life. The sound of looms at work can now be heard from a distance. While the farmers work in the fields their women look after poultry and goatery. All the people are now fully employed : it is now difficult to get labourers in the village and hands have to be hired from outside.

How did it happen? The United Commercial Bank extended their pilot scheme of comprehensive assistance to Gopalpur which changed the fate of the people.

The area had been suffering from sweet water scarcity for a long time. The monsoon rains helped the *aman* crop, but during other seasons the available saline water was no good for cultivation. The Birlapur branch of UCO came to the help, and in close cooperation with *Kalyan Sahayika*, a non-profit-making organization, prepared a comprehensive program for the area. The branch felt that if sweet water supply could be assured to the area it would be possible to produce three crops : *aman, kharif* and *boro*. A field officer was deputed to examine the soil and he found that sweet water could be stored in tanks which might serve double purpose ; irrigation as well as fishery. The project was immediately taken up and Rs 75,000 was sanctioned for 26 such tanks. The experiment was successful and the pattern of cropping has now changed from mono-crop to triple-crop.

Encouraged by the initial success, the branch took up other development programs one by one: weaving, vegetable growing, goat rearing, and poultry farming. The project for weavers now covers 700 families (initially 27 families were selected for assistance). They lived in neighbouring villages of Gopalpur and used to produce napkins and mosquito-nets. Their knowledge of the craft is hereditary. The young weavers today are introducing new designs to their products. Vegetable

trends. He was not enamoured by the economist's credo of 'economy of scale' which inevitably led to mass production by latest techniques to prop up the perpetually unstable and vicious cycle of consumption, inflation, recession, and more production by still advanced techniques — which, as we have seen, eventually leads to resource exhaustion and pollution and, in a country like ours, also to mass unemployment and under-employment. He considered production by the masses, as opposed to mass production by machines, more important and a prerequisite to any developmental process for a country like India. "Mechanization is good when the hands are too few for the work intended to be accomplished", he said. "It is an evil when there are more hands than required for the work, as is the case in India .... The problem with us is not how to find leisure for the teaming millions inhabiting our villages. The problem is how to utilize their idle hours, which are equal to the working days of six months in the year." For him, increasing the Gross National Product (GNP) through increased industrial production by sophisticated machines was not as important as increasing the Gross National Happiness (GNH) by providing opportunities for gainful employment to those who have nothing to do for a living.

The 'marginal man'

And that is the crux of the Indian situation today — massive unemployment and under-employment and consequent grinding poverty among the bulk of our population. Every second person in India is poor. Most of them belong to rural areas — even the urban poor are an overflow of rural poverty. The problem, therefore, is essentially rural. And "rural India is real India", as Gandhi said, because 80% of our population lives in villages. How important the rural sector is to India, even under the present degrading state of affairs, is apparent from the fact that the farmers, constituting 70% of our population, contribute almost 50% to our national income through agricultural production. And the national income which stood at Rs 13,300 crores in 1960-61 almost quadrupled in a little over a decade to Rs 49,300 crores in 1973-74. Yet, unemployment has been rising, pockets of destitution proliferating, misery multiplying — diminishing the very utility of man as a useful being on a massive scale.

The development of this *marginal man* with diminishing utility has to be our prime concern. But this cannot be achieved by the conventional growth process — for the very soul of this process is rapid obsolescence of human skills, knowledge and techniques leading to redundancy of all but the highly skilled. The present trend of increasing unemployment and under-employment among the masses is in fact the result of this very phenomenon. We will have, therefore, to adopt a radically different approach to development and to generate technologies primarily designed to meet human needs rather than to satisfy the forces of supply and demand of the free market; to enhance the utility of man to the society he belongs to rather than to devaluate him through increased dependence on the machine; to elevate him as an asset rather than to degrade him as a 'reject'.

yet save Rs 13.05 crores on capital cost, conserve Rs 60.90 crores of foreign exchange, and generate employment for 130,750 rural poor (as against for only 1,000 urban elites in a fertilizer complex); besides, while each fertilizer complex would *consume* approximately 0.1 million Mwh of energy per year, the biogas plants would *generate* energy, rather than consume it, to the tune of 6.35 millions Mwh per year!

It is estimated that the aggregate investment in bullock cart transportation in India is of the order of Rs 3,000 crores as against Rs 2,500 crores in public goods road transport (automobile) and Rs 4,000 crores in the railways. It is thus the second biggest transport system in the country, providing direct or indirect employment to almost 20 million people — which, incidentally, is the entire work-force in the organized sector. According to an estimate, the 13 million bullock carts operating in India today transport as much as 2,250 million tonnes of farm produce every year as against only 220 million tonnes transported by the railways.

The significance of the bullock to rural India is thus self-evident. It is at the very core of the agriculture-livestock-energy nexus that must be promoted to the fullest extent. Here we will not only have to make appropriate technological inputs at the various levels of this nexus — waste recycling, energy (fuel gas) generation and utilization, fertilizer production and application, ploughing and other farm operations, different aspects of animal drawn haulage, dairy farming, livestock improvement etc — but also ensure their vigorous implementation as part of our planning process. We must also ensure that other developmental programs do not have any deleterious effect on this nexus.

Agriculture is essentially the organized trapping of solar energy in crops and crop residues. This process can be taken a step further to create a forest economy based on energy plantation and silvi-pastoral systems to ensure regular supplies of fuelwood, timber, fodder, and other forest materials of economic importance. Large scale adoption of these systems will not only bring considerable economic gains to the rural communities but also bring home the message of ecological sanity.

Direct conversion of solar energy and wind power into useful work can go a long way toward bringing about rural prosperity. Both these sources of energy are freely and locally available at the point of use and do not suffer from the problem of pollution or other limitations as do the conventional sources of commercial energy. Development of low cost conversion devices for harnessing these energies is essential for the type of recycling society that we envisage for the rural areas.

Summing up

To sum up, the movement toward a new socio-economic system and the strategies for achieving it must be informed by the following realities:

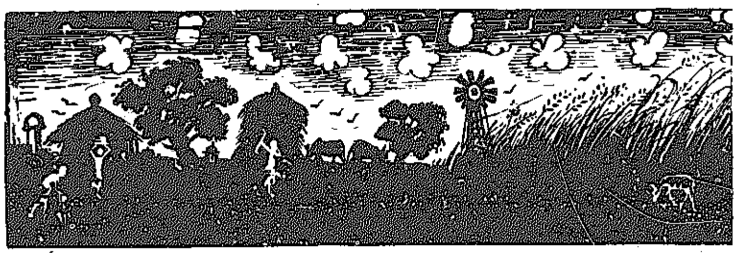
★ The existing economic model with built-in incentives to obsolecence, waste, pollution, and environmental destruction is coming to an end and is, therefore, not worth imitating.

★ The pro-growth technologies designed to satisfy the requirements of the concept of 'economy of scale' are biased in favour of the rich and, therefore, lead to the situation of 'the rich becoming richer and the poor poorer' — as is amply clear from the experience of the developing countries.

★ The best escape-route from the impending *disutopia*, being ushered in by the existing techno-economic model, to a new socio-economic order in which man could live at peace with himself and in harmony with his environment, is through rural development based on peoples-oriented technologies designed to ensure: (i) the development of man as a useful being; (ii) conservation of limited resources; (iii) greater economic dependence on renewable resources; (iv) recycling of all wastes and byproducts, and (v) preservation and enrichment of the environment.

Utopias are never achieved. For they define a goal, a conceptual design of a *preferred future*, that may change with a shift in the human value system. But the utopian goal does help us chart out strategies to avoid at least some of the more obvious dangers and pitfalls of existing systems. The movement toward a Rural Utopia, too, represents one such design.

India is perhaps much better placed than other countries of the world to make a breakthrough on the rural front. Our national ethos combined with the visions of men like Gandhi and Nehru and the dynamism of the informed leadership at the helm of affairs today sets us apart among the comity of nations for this role.



of the Registrar-General) that to ensure mi... num desir-
able nutritional standards for all, the country will need
to produce 210 million tonnes of foodgrains -- an
increase of 100 million tonnes in 25 years. Given the
structural characteristics mentioned above and the
inevitable resource constraints, this seems most difficult
to achieve. This means one of two things : We must
either import large quantities of food and surrender
our aim of self-sufficiency in food, which we consider
crucial to our independence as a nation, or give up the
quisite nutritional standard that we have set before
r nd indeed even reduce the per capita intake of food
us, may, for a large number of people, mean a step
which starvation.
toward here are serious limits to the population that
Also, alone can sustain. Given the fact that there is
agricultur e of any significant progress on providing
little evide ral employment in rural areas, this means
non-agricult a further growth in rural unemployment
two things. re sharpening of under-employment (which
and still mo wer than 100 man-days per year for a vast
is already lo eople), and a big boost to outward migration
majority of p d mostly metropolitan areas. Given the
to urban a f industrialization and the relative paucity
slow pace resources, the urban areas are unlikely to be
of investibl vide employment to the growing volume of
able to pr and what we will get is the phenomenon
in-migrant overty and unemployment producing still
of rural verty and unemployment in the urban
greater p ultaneously — given the dominant life-style
areas. Si h-consumption elite and the middle class
of the h also set the norms for rest of the population —
strata wh of inequality and social injustice will grow
the degree al and urban areas, perhaps more conspi-
in both r he latter.
cuously in le, standards of health are likely to decline
Meanwh e needed expansion in health services will
further as r reach, and in any case the large majority
be beyond c ements will be both inaccessible to public
of village se d subject to a breakdown of sanitation
health services ses that normally go with over-
and a spread of y.
crowded pockets of pove overty and unemployment,
Such a convergence of ies life chances to the
disease and illiteracy that ged can only pro-
vast periphery of the under-priv growing incidence
duce a climate of extreme tension, a hat can be held
of crime, and not a little public violence lice and the
down only by growing repression by the p ario of not
paramilitary arms of government. This is a sce but also
only extreme misery, inequity and injustice, he social
one of breakdown of authority and indeed of vable at
fabric itself. Such a scenario may be inconce eed un-
the present moment, but it is quite likely, ind
avoidable, on present reckoning.

The main issues

ecessary to

If such a scenario is to be avoided it is that we have
reconsider the whole model of developmen

adopted, which has produced and will continue to produce mass poverty and inequity co-existing with high affluence and waste. It is necessary to provide an *alternative path of development* which produces minimum conditions for the rural masses, stops (or at least keeps within limits) the influx into urban areas, and gives rise to an integral approach to both rural and urban development, each sector supporting the other (instead of the present parasitic relationship) and both becoming part of a common continuum of human settlements and productive relationships that have one single focus : the well-being and dignity of all individuals irrespective of location or class.

Central to this shift from a negative to a positive scenario are the following three major aspects of development strategy and an optimal inter-relationship between them :

1. *Life styles :* While retaining a good deal of diversity of cultural and individual kind, there is need to have a consensus on such matters as desirable and undesirable consumption standards, use and distribution of resources for gratification of needs, and norms of minima and maxima in income and wealth.

2. *Organization of space :* There is need to move away from present concepts of 'rural' and 'urban' as separate entities and to think of them as a continuing structure of city, town and countryside, of agriculture and industry, of hinterland and metropolis. India has unique opportunity of developing a social continuum in which, while the romantic utopian dream of village self-sufficiency may be left behind — for which there should be no regret as it has very many negative features— we may also be able to avoid the scenario of huge metropoles draining the resources of the countryside in a parasitic manner. The scenario best suited to us — and to civilized life — is one in which the country is studded by a few thousand localities (regions), each clustering around a medium-size town, sharing in its amenities and its economy in a relatively egalitarian manner, in which all strata of society gain from the benefits of modernity but avoid the ills of post-modern consumer societies, that are prisoners of highly concentrated production complexes.

3. *Production system and technology :* Such a structuring of space will need to be supported by a corresponding continuum of productive orientations and technology relevant to each of them. The strategy that we shall have to evolve will need to be integral to the development of the country as a whole — in which both production and administration are decentralized to medium-size towns and their rural hinterlands; city growth rates are arrested from becoming grotesque; employment opportunities in agriculture (which have some natural limits) are supplemented by employment in small and widely diffused industries; educational institutions are located close to where the jobs are and restructured from the present emphasis on widely scattered training institutions based on short duration courses

for middle range technicians; and the economy derives its strength from the purchasing power of great numbers of people and not from expansion of middle class consumer industries and their 'export orientation'. Implied in such a restructuring of rural-urban and agricultural-industrial relations is a new techno-economic model for our society which will enable us to reach the goals set out in the Directive Principles of our Constitution. Rural development must be conceived as part and parcel of this model as a whole. a model in which we talk less of rural development in our usual segmental fashion and more of development of individuals and communities -- *all* of them irrespective of distinctions of locale or class. It is only in this overall context that 'rural development' will make sense.

Scenario for the future

It is from an optimal inter-relationship of the above three parameters that our design for the future emerges. It has to be a comprehensive design of which rural development becomes an integral and crucial part. The essential components of such a design are as follow :

1. *Principal focus :* The prime concern of economic policy for a just social order ought to be to generate employment that is able to absorb at least the new additions to the adult population, and where there is a substantial backlog of unemployment and under-employment, to absorb that as well. The major source of injustice today is to be found not so much in a condition of general scarcity as in the fact of diminishing marginal utility of man as such, in that millions of people find themselves idle and useless, often in their very prime of youth.

2. *Agricultural transformation :* The major impetus for such employment will have to come from a transformation of the agricultural sector, converting it from an area of stagnation to a catalyst of growth. This can be achieved, first and primarily by introducing and rapidly implementing new agricultural technology on a wide enough basis. The new technology does seem to us to have provided a major breakthrough in our aim of achieving self-sufficiency as well as in raising the status of agriculture in national priorities. However, there is need to adopt these practices with conscious care and try to adapt them to fulfil social goals. They must substantially raise employment and incomes of the poor, not just aggregate output. This, in turn, calls for the other package of measures known as land reforms, so that the benefits of the so-called green revolution are widely dispersed instead of being pre-empted by well-to-do farmers, as has occurred in so many countries, so that the rural socio-economic structure becomes more egalitarian and the available land is able to provide employment and minimum income to millions of more families than is the case at present.

3. *Rural industrialization :* It is safe to predict that the sum total of reforms involved in the new agricultural technology and redistributive legislation will not be enough to sustain a growing population on land. Studies on manpower absorption by different sectors of the economy show conclusively that, except in few places with very low density and large surpluses of land, there comes a stage when agriculture begins to absorb a diminishing proportion of the rising population. This critical stage will be reached in our country between 1980 and 1985. It does not follow from this, however, that those not engaged in agriculture should take off to the cities for jobs in modern industries, for the latter are not as great employers of men as they are of machines; and, in any case, the investment needed to generate the needed employment through modern industry is of a scale that we just cannot afford — except by large-scale import of foreign capital, which is neither feasible nor desirable.

If we consider various other trends in resource use, congestion, breakdown of city life, and growth of crime and violence, it is necessary to restrain large-scale migration to the cities. There is need, therefore, to provide non-farm employment in the rural and semi-rural areas. This can be done, first. through massive public works programs for constructing durable community assets (roads, canals, wells, and other infrastructural facilities for rural development) for which there is great scope in our millions of villages and tribal settlements. Employment in these public works can take on a role quite different from short-term relief operations; they can become a basis for long-term investment and reduction of costs in such spheres as water use, land consolidation, and marketing of farm output, in turn generating more productivity, employment, and incomes. A large part of these activities can be supported from increased food output, thus also restraining inflationary tendencies. Improvements in agriculture can also be used as a stimulus to a whole line of processing and refining industries in rural areas.

Secondly, such a combination of increased farm output and increased employment on land and public works should provide the basis, through its stimulation of demand for consumer necessities, for the growth of small towns close to rural areas where medium and small-scale industries can be located. The usual haphazard growth of towns and cities that takes place in absence of conscious policy renders them essentially parasitic spots where middlemen bring the flashy output of industries from large cities (and imports from foreign lands which, of course, continue to tantalize men and women in our country) and tempt villagers into buying them at exorbitant prices. This should give place to a conscious policy of decentralized industrial development and location so that urban growth becomes complementary to rural development and contributes further to the growth of employment and incomes of poorer strata. The chief casualty of the colonial period was a whole range of rural and semi-rural industries and a number of non-agricultural occupations that gave livelihood to large sections of the people — and which in fact made for a society that was far less unequal and unjust than is the case now. It may not be possible to revive the whole

Rural development programs

Rural industries merit an important place in the economic development of our country in view of their capacity to create employment opportunity in rural areas at a low capital cost. The Department of Science & Technology (Government of India) has, therefore, decided that plans for improvements in technology (hitherto largely conditioned by the needs of the large-scale sector) should now be increasingly turned towards the rural sector.

Traditional village industries declined due to stagnant technology in comparison with that of the organized sector. Their products were, therefore, found inferior in quality and costlier. Hence, the imperative need to improve their level of technology and to make them economically viable. The leeway to be made up could be gauged from the fact that the entire expenditure on research on khadi and village industries in the past 20 years (from the commencement of the First Five Year Plan to the end of the Fourth Plan) was less than Rs 15 million, whereas the value of production of goods of these industries in one year alone (1973-74) was of the order of Rs 1,500 million.

The projects identified on cotton *khadi* are typical of the other materials as well. For obtaining uniform laps from pressed cotton bales, a pre-opener with a lap former is to be designed. To eliminate neps and short fibres, suitable carding machines are to be developed. The fly frames and draw frames are to be improved to cater to increased capacities. On the weaving side, arrangements are to be designed to stop weft automatically when there is any break in the weft yarn in the semi-automatic looms.

Another important project identified concerns improvement in the performance of the Indian honey bee in view of its utility in increasing crop yield through cross pollination. This project assumes importance from the point of view of increasing agricultural productivity.

Cow dung which is a valuable manure, is now being used as fuel in our villages. Projects on gobar gas have been identified which would utilize both the fuel and manure components of the cow-dung. The materials of construction for the gas plants at present are beyond the reach of the ordinary villager. Devising cheaper materials of construction is to be investigated. There is also an All India Coordinated Project on biogas technology and utilization aimed at giving major thrust to bio-gas technology by improving and evolving economical designs of bio-gas plants, domestic and industrial burners, insulation techniques, etc. In the contest of the present energy crisis and the acute shortage of inorganic fertilizers,

spectrum of these occupations, but it is possible and necessary to provide a new basis for fulfilling the same economic functions, namely, making available jobs other than farming. Encouragement of self-employed artisans, cultivation of finer arts and crafts in line with our rich and complex traditions, and growth of new and small-scale industries to manufacture goods needed by the local people can provide the basis for this regeneration.

4. *Social continuum :* Socially, the above policies mean that the present duality of city and countryside must give place to a continuum in which the agricultural revolution (and its necessary concomitants in livestock and horticultural development) regenerates the villages, small-scale and medium industries are located in the towns, and large-scale industries that necessitate heavy inputs of capital and high technical efficiency are located in the cities. And as such, a fusion between industry and agriculture will take place, and further intermediate links in this continuum — rural social structures in towns, urban amenities in villages — will develop, thus combining the best traditions of both rural and urban life and producing a composite, integrated culture.

Our preferred world should not be one made of millions of self-contained villages but, rather, one of thousands of small nucleating towns towards which the rural landscape gravitates, thus doing away with both the present duality of metropolitan and rural cultures, limiting the large size and concentrated location to just the industries that cannot do without them, while at the same time enlarging the size and horizon of rural communities, and providing them with the necessary infrastructure of welfare and communication facilities. Such a spatial structure — supported by a decentralized structure of community decision-making as argued below — would provide the necessary framework for the techno-economic alternative to the present dualist model of city versus countryside.

5. *Policy on education* . It is not simply by altering the economic basis of rural urban relationships that a more just social order will be created. We also need to alter the cultural under-pinnings of the present patterns of dominance and disparity. An important aspect of the sharp duality of life styles and living standards found in

this project has assumed added significance.

Another project aims at increasing the utilization of non-edible oil seeds by removing some of the technical difficulties in its efficient processing and standardizing the process of extraction of non-edible oils. These can substitute the edible oils used in soaps, thus releasing them for human consumption.

The Environment Research Committee (ERC) of the DST has accorded its approval to a major study on integrated rural development. The first such study is being undertaken in Shahdol district of Madhya Pradesh.

This study is to be conducted by a team of voluntary young workers under the guidance of the Environmental Engineering Department of the Indian Institute of Technology, Kanpur. The major objective of the team would be to study the various developmental aspects of district Shahdol. One end-result of the proposed study would be the formulation of an integrated development plan that will benefit and organize the poorest sections of the community in the district.

The DST has formulated a number of other projects on rural development. These include support to two research studies : (i) a survey of rural domestic energy consumption in the northern regions, comprising Punjab, Haryana, Rajasthan, Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir, to determine the changes in the pattern of domestic energy consumption in households and to examine the possibilities of meeting rural domestic energy needs locally through firewood and gobar gas plants; and (ii) a study of village agricultural ecosystem to understand how agricultural ecosystems respond to purturbations in the environment, and how the character of this response is affected by various technological innovations in agricultural, and to develop such innovations as could contribute to its stability.

The DST is also supporting a project on the improvement in the design of the bullock-cart. And there is an All India Coordinated Project on algae technology--a multi institutional, time bound, result-oriented program aimed at studying the use of algae as a protein food for man and animal, and also as a source of fertilizer.

The DST is also making efforts to work out a collaborative program for improving the living conditions of women folk in rural areas through the application of science and technology in their day to day work.

To study and to help resolve the technological problems of the village industries, a central laboratory with all modern facilities is necessary. It has, therefore, been suggested that the existing laboratory at Wardha should be upgraded and fully equipped for this purpose.

most poor countries is the nature of the educational system whose aim continues to be to produce colonial-type gentlemen, disoriented from large society and constituting a class apart.

In most ex-colonial countries, formal education was initially meant to produce an *elite*, mainly to fill the ranks of bureaucracy, law-and-order establishment, and technical positions in public administration and private enterprize. This orientation still persists in spite of the achievement of independence and the political elite's commitment to democratic and socialistic ideals. Education, far more than property or income, is the basis of privilege in our society.

Meanwhile, majority of the population continues to be illiterate and unskilled while the ranks of the highly educated in the urban areas keep swelling. Studies in this area suggest that whereas expansion of literacy and primary education produces very rich and rapid dividends, after a point higher education turns out to be a huge waste. Acquisition of a minimum educational level greatly raises a person's skills and capacity to enter the employment market; his sense of potency and ability to relate himself to the outside world; and his sense of political efficacy, self confidence, and dignity. In contrast, an undiscriminating expansion of higher education beyond the absorptive capacity of the economy produces an alienated class that is unable to relate meaningfully to the rest of society, rapidly inhabits various levels of the bureaucracy making it increasingly inefficient and insensitive to the needs of the people, and, with growing unemployment in its ranks, loses self-respect and becomes aggressive.

This polarization between, on the one hand, a large mass of illiterate and totally unskilled and *hence* unemployed people and, on the other, a class of people who are over-educated and *hence also* unemployed, is a natural culmination of the hiatus between the elite and the people — and between parasitic cities and a depressed countryside — discussed earlier. We must alter this condition by a major allocation of resources to mass literacy, primary education, and adult education programs, by giving special attention to economically weak and socially handicapped strata whose major avenue of mobility seems to be education, and by a reorientation of the job market so that employment to a large spectrum of non-technical jobs is available to those without college degrees, thus deflating the importance of higher education and minimizing the disparities that result from insistence on degrees.

It is necessary to strongly emphasize the importance of widespread literacy in generating massive social and economic transformation. Poverty, more than anything else, is cultural condition, and if poverty breeds poverty and perpetuates itself, it is because it is located in a cultural milieu — of ignorance, distance, segregation, and a very low self-image of the poor who suffer, exploitation without protest. This situation cannot be changed except by a basic cultural attack, the primary precondition for which is literacy and minimum education. This point cannot be overemphasized.

Finally, higher education itself needs to be reoriented, by restricting university education to what its logical role is, namely, to provide basic grounding in main sources of theoretical knowledge, and to develop a vast network of functional education located in the vicinity of institutions and enterprizes where knowledge is to be used. Except for a few advanced courses for specialists, these should impart intermediate skills through short-duration programs, for use in rural and semi-urban areas where the real work is. Only thus can the present spectacle of the highly educated queueing up for jobs in the cities while the villages are starved of technical manpower be brought to an end. Several commentators appear to dismiss higher education (and institutionalized education generally) as largely unnecessary. We do not share this view. There is urgent need for a very large number of doctors, engineers, geologists, architects, designers, managers, even economists and sociologists. What is at fault is not their availability but their placement and location. Most of them are unwilling to go where the real jobs are, the institutions where they learn are unwilling to train them for use in local conditions, and the leadership is unwilling to tell them candidly about their duties and responsibilities. There is need to look upon education as a political process, attainment of degrees or diplomas as a social good that must be capable of being socially used, and the relationship between educational output and available work as part of a conscious plan of development. Higher education, instead of becoming an instrument of class privileges and exploitation and a source of disparities, must be made an integrator of human resources and needs.

There is also need to undertake a major review of the whole institutional approach that has accompanied the modern view of education — classroom-based, bookish, graded, and located in large campuses in large cities. This approach needs to be replaced by a closer relationship between education and work — including intellectual work where education is sought for scientific and literary pursuits—and by bridging the gap that divides the location of one from that of the other. City-based education must be largely for city folk. For others, schools and other institutions must go where the people are, not the other way around. Unless these aspects of the educational scene are approached with some perspective on the changing social reality, it is difficult to see how the deep cultural barriers that divide different classes and accentuate economic disparities can be overcome. Education can be made to bridge or accentuate these gaps. The need is to move from the latter orientation to the former.

There is need to give special attention to the education of women. In our country, as in most parts of the developing world, women are less educated than men and within the depressed social strata and ethnic minorities the gap is even more pronounced. Meanwhile, daughters of the rich are flocking to the universities and some of them are leading women's lib movements (aping their counterparts in affluent countries), which in our country means liberation of the privileged. These gaps in education among women and between them and men are an important source of the persisting duality of cultures, economic levels, and consumption standards, the latter more often than not being a direct function of the perennial shopping to which the educated women are so addicted. These differences also account for the wide divergences in the way children of the rich and the poor are brought up, thus perpetuating sharp disparities for generations to come.

Lack of education of women is an important cause of the exploitation of women which is a marked characteristic of our society. The main basis of this exploitation is economic and it is found at its worst in the lower classes and among the scheduled castes — wives and daughters working outdoors from dawn to dusk while their menfolk indulge in drinking, gambling and wife-beating. The only way of breaking out of this 'culture of poverty' is education for all — but most of all for women. As a matter of social policy, there is need to pay special attention to raising the educational levels of women and mothers from poor, under-privileged, and conservative strata of society to spin off a major process of social reconstruction.

6. *Ethic of consumption :* Even more fundamental than the gaps in the literary culture are the gaps in the material culture that divide the urbanized upper and middle classes from the people. Perhaps the most important and glaring contrast of today is caused by the extraordinary consumption levels and material possessions of richer and high-status groups, following almost *in toto* the standards set by high-consumption societies. The lust for things and for more and more things has become so myopic that it has given rise to all kinds of unethical practices, chief among these being a large incidence of corruption among public officials and a thriving black money economy that is sustained by the availability of a large array of consumer goods.

Apart from the vulgarity of such ostentatious living in a society characterized by massive poverty and malnutrition and apart from the creeping corruption to which it gives rise, such standards of consumption also undermine the whole fabric of economic policy. If a massive program of employment and social welfare is to be generated, a high rate of savings and capital accumulation will be necessary. This implies a high rate of savings among those with large incomes besides restraints on salary and wage increases among the employed, including the working class, so that resources can be transferred to employing the unemployed (in a poor country to be employed is itself a privilege) and raising income levels of the poorly employed and the underemployed. There is also need to encourage voluntary savings among the working class, farmers, and lower-middle classes who have already reached an income level that provides for basic consumption needs. At the same time, the consumption of the really poor sections must be raised substantially both for increasing productive efficiency and for equity.

There is need for an *ethic of consumption* that discourages ostentatious living, cuts down production and consumption of non-essential items, and shifts production priorities toward fulfilling the needs of the poor. It is, of course, necessary to encourage saving among the peasantry, the lower-middle classes and even the labouring classes, as mentioned above. But this will be an impossible task unless the *pace-setters of society* themselves adopt a consumption ethic that encourages austerity and reduces the gap in material culture between the different classes. Gandhi put his finger on the most crucial dimension of moving toward a just social order when he called for a *limitation of wants* and warned his countrymen against falling prey to an industrial machine that not only reduces a majority of men into labouring slaves but also dictates what and how men should eat, dress, sing, and dance. Today his insights are even more relevant than when he lived. If there is to be an end to exploitation and inequity in our society, the present norm of a high-consumption ethic must give place to one that, on the one hand meets the minimum needs of all men and, on the other, limits the needless expansion of wants that have no relationship with the basic requirements of body and mind.

7. *Nature of production :* Built into such an ethic of consumption is also an ethic of production that is critical to the achievement of justice in society. An economic ethic that seeks to meet the consumption needs of all while limiting the flow of inessential commodities involves a simultaneous increase in the incomes of the poor and the output of goods that they will need to buy with those incomes. This means that, instead of conceiving production and consumption as two separate activities, one aims at an economic system that (to repeat Gandhi) not only produces for the mass of the people but one in which the mass of the people are also the producers

Like all visions, perhaps this, too, is an ideal type. All that one can hope to initiate is a movement toward such a state. In practical terms this calls for a location policy that, while permitting large-scale organization *where it is unavoidable,* will encourage the growth of small-scale, labour-intensive, decentralized pattern of industrial development. A combination of such a production system and the consumption ethic outlined above will lead to a climate in which progress toward dispersal and decentralization of economic power becomes possible. As this happens, the orientation to social justice will become less technocratic and more political, and thus capable of initiatives from below.

8. *Minima and maxima :* The above analysis provides the elements of an alternative model. The objective of development, according to us, should be to achieve minimum conditions of material welfare for all the people, the *minima* being defined according to local conditions and norms, but formulated *to provide at least* a package of minimum items of human necessities — like food, clothing, shelter, nutritional needs of children and mothers, and socially approved minima of health, education, drinking water, and public transportation for all. The extent to which these minima should be translated into personal or family incomes or be combined with social welfare and social security programs of the government will depend on local conditions and nature of the future political system. But it should not be difficult for any system to work out a minimum-income policy as a basic component of developmental planning.

A policy of minima entails of *maxima.* Indeed, without the latter the former is, in practice, impossible to realize in reasonable time. Also, beyond a certain point, incomes ought not to be allowed to grow nor human wants artificially stimulated by aggressive salesmanship of modern industry or the demonstration effects from rich capitalist countries. There are two reasons for this limitation, one relative and the other absolute. No one has the right to amass more and more income and riches when large sections of the population live below subsistence standards. Also, it is morally undesirable to go beyond a certain level of fulfilment of human needs. For an unlimited gratification of wants leads to individual decay and social disharmony, unnecessary destruction of natural resources, fouling of the human environment, and hence bartering away of health and happiness of future generations for present pleasures and lust of a few. Hence the emphasis on 'limitation of wants' as a necessary principle of our preferred world.

9. *Issue of participation :* Implicit in our preferred model for social and economic justice are also a number of other issues. The norms of minima and maxima are not mere economic formulations; they are part of a certain conception of a good and desirable life. Not only should an individual be entitled to a minimum level of living; he should also be able to participate actively — but not forced to do so — *in the way things* are produced or decisions made. It is not just a minimum wage that one thinks of here, in some kind of contractual relationship, alienated from the work process and the total scheme of ownership, production, and distribution

of the means of livelihood; rather, one thinks of an apparatus that man himself controls, finds meaningful, and derives a sense of personal power and significance from. Furthermore, to the extent that economic activity is managed and mediated by political and administrative agencies, the whole problem of effective participation in decision-making, at the desirable *level* and in optimum *units*, becomes real. Without such participation, economic aims may indeed be difficult to achieve.

Similarly, we may also question the norms of centralized government, large-sized states, and big bureaucracies as necessary instruments of national integration and political accountability and as we question these, we may begin to answer with greater clarity the problems raised about local autonomy, about decentralization of functions, powers, resources, and talents, and about optimum size for genuine participation of the people. Perhaps there is something to be gained in the very short run from large-scale enterprizes, modern communication media, and centralization of planned initiative, although the real issue here is less of scale than of control. But it is also necessary not to close all options for the generations to come concerning the quality of life they would like to have. As the prospects of the future are vitally affected by what is done in the present — it is no longer possible to think in terms of just a few months or even a few years ahead — it is a matter of considerable responsibility that these various consequences of present actions are borne in mind.

Our model of a participatory system is not conceived in terms of simple political reforms. Rather, it is expressed in a number of sectors — concerning economic organization and its governance, nature of education, location of work and enterprize, choice of technology, size of units (economic, political, demographic, communications), and the nature of work. Participation is not some process of involving everyone and reducing all to a common denominator. Rather, it consists in evolving institutional structures from which the masses of India get a sense of dignity and self-respect, as beings able to determine their own destinies. (Poverty and inequality are themselves reflections not just of prevailing relations of production but rather of structures and values that deny dignity to man).

It would be folly, however, to look upon such a perspective as in any way smooth sailing on some neat path. Nothing is more difficult to realize than changes in the social framework of politics — except for the worse. Every step on such a path needs to be fought for, by organizing for it and building sustained pressures from below in the form of social and intellectual movements. And it is, of course, clear that these will need to be conceived and carried out in not one but many spheres, at not one but many levels. But we are firmly convinced that it is only on the basis of a clear acceptance of a decentralized and highly participant democratic structure that social justice can be realized.

These, then, are the issues that arise when specific problems of economic strategy, political structure, educational policy and the reconstruction of the human space are considered from the integrated perspective provided by a set of values and the criteria that follow from it. Involved in such an approach is what may be called a design for living in which reason, compassion, and a regard for equal worth of all men are joined in the cultivation of a truly civilized life. And as we do this, the distinctions between economic and political issues disappear and we begin to see the real linkages that underlie any effort to produce a better world. Our conception of alternative strategies entails such a comprehensive perspective on the future.

Gearing science and technology for rural uplift

What can technology do for the masses? And what could be the mechanics of its application for rural uplift? The authors discuss the fundamental issues involved in harnessing science and technology to common good and suggest a multi-faceted approach for amelioration of rural poverty.

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The division of society into Classes and Masses has come down the ages. The exclusive elites have constituted the nobility. And the struggling, interacting, multitude has always formed the base on which national prosperity was built up.

This division into the noble and the base, the class and the mass, may be found even in the world of science. Certain elements are esteemed as noble. Most others are termed base. The noble metals like gold, silver and platinum are characterized by their comparative inactivity. So are the noble gases like helium and neon. Their participation in normal interactions is marginal. Metals other than the noble, or precious, are called base metals. They participate extensively in the day-to-day processes going on endlessly in nature's chemical cauldron. They form the vast mass of elements. Their interaction is at times catalyzed by the presence, in relatively small amounts, of the noble metals.

Who constitute the 'masses'?

The term 'masses' is thus used in a somewhat derogatory sense. Lack of individuality in a mass often leads to refusal to recognize its very existence. The ruling class consists generally of men and women who have distinguished themselves in some way or other. The ruled form the dumb masses. The representative of the masses in India is *Daridra Narayan* — the two-in-one symbol of poverty and goodness. Mahatma Gandhi created this prototype Indian long before Independence.

The majority of Indians are poor. They form the masses. They form the basic strength of the nation. Let us examine the broad characteristics of the masses in India, of which *Shri Daridra Narayan* is an illustrious representative.

Rural India, where three-fourths of the population lives, may be taken as more truly representative of the masses than any other segment of our population. More than half the male population and one-eighth the female population in rural India was classed as workers in 1971. This did not include the millions engaged in domestic work. Eighty to ninety percent of the male and female workers were engaged in agriculture. Seven men out of ten and four women out of ten engaged in agriculture were cultivators; the rest were agricultural labourers.

Two-thirds of the men and nine-tenths of the women cultivators in rural India were illiterate. In actual terms, out of 76 million cultivators in rural India over 50 millions were illiterate in 1971. Not even 2 percent were matriculates. Only one in a dozen had passed the middle school level. Among 45 million agricultural labourers in rural India, 80% of the men and 95% of the women were illiterate.

Household industries come next to agriculture in terms of workers in productive endeavours in the rural areas. Here again, 55% of the men and 95% of the women were illiterate. Out of 3.5 million men reported to have been engaged in household industries in 1971, only one in 60 was a matriculate. Not even one in a dozen had passed the middle level. Out of a million women in household industries only one in 500 was a matriculate, and one in 50 had passed the middle school.

Apart from agriculture and household industries, which are the areas of largest individual endeavour, about a tenth of the workers, both male and female, in the rural areas are in the Services, Trade and Commerce, and Manufacturing. These are the better organized areas, where the Classes are in command. The literacy of workers, both male and female, in these areas is gencome next to agriculture in terms of workers engaged in productive endeavours in the rural areas. Many products of our cottage industries have demands in international markets. The extent to which traditional practices have been bettered by the introduction of new tools, techniques, and materials made available by modern technology is far from being satisfactory. The Industrial Revolution in the West was initiated through organized efforts at increasing the quantum and quality of production of traditional craftsmen. Any revolution in the productive application of science and technology based on mass participation can take place only through deliberate upgrading of technological competence of technicians and skilled workers at all levels. The technological revolution of Japan was the result, not of any spectacular discoveries or inventions, but of the contributions made by a multitude of craftsmen, each one of of them making some marginal improvement in the item he was concerned with. The same is true of China, where innovation was promoted at the grass-root level as part of a co-ordinated national endeavour.

Upgrading traditional skills

In India, our talented scientists are yet to react creatively with the tools and techniques of our craftsmen. This aspect deserves special emphasis. As Prime Minister Indira Gandhi said on the occasion of the presentation of the prestigious Bhatnagar awards of the CSIR, "We should make a conscious effort to develop processes more suited to out local conditions and which could be easily adopted even by artisans and craftsmen".

The possibilities of development even in a traditional industry are immense. Let us take the leather industry as an example. Here is a case of two million people, traditionally engaged in the so called untouchable trade, with age-long experience and rich skills on their finger tips, working mostly in a cottage and small scale industry. One way of promoting the industry is to close down the uneconomic units and set up modern, organized, leather and footwear factories. But this would mean uprooting of the engaged labour force. Another, more rational way would be to enrich the skills of the traditional workers and improve their living and working conditions by bringing science to their doorsteps, and thus help them to produce quality leathers and leather goods to meet the demands of both national and international markets. This approach would lead not only to wider industrial growth and larger export earnings but also to speedier social development : it would ensure better utilization of not only national resources but human resources as well. The least that science could do for this industry was to remove the bad odour associated with it, and thereby the stigma attached to its workers. This is what the Central Leather Research Institute, Madras has attempted to do.

India contributes 80% of the world trade in mica and enjoys a virtual monopoly in meeting world demand, yet mica continues to suffer a buyers' market because it has remained a traditional item and has not become a technological product. The export of some of our potential resources at throw away prices may be reminiscent of the distress sale of babies by impoverished villagers in times of famine. The possibilities of imaginative technological innovations in the use of tea, jute, coir, lac and other natural products exported in large quantities are yet to be properly exploited.

Indigenous expertize available in abundance in certain fields has also to be properly geared to meet the modern needs. A variety of processed foods, preserves, and pickles have been traditionally prepared, which can tickle the taste-buds of the most fastidious gourmet or provide wholesome sustenance to the undernourished. But they could not become viable industries in the absence of a thriving packaging industry.

We have yet to make properly documented studies on our traditional skills and practices and systematically explore the possibilities of both learning from them and contributing to them, in order to evolve appropriate technology for the masses. Take, for example, the technology of building materials, machines, and methods, utilizing local resources and skills, both for the hills and the plains, in different regions and under various climatic conditions of India. An exercise of collection, collation and analysis of the vast information on traditional building technology of India could be extremely useful, and this is what the CSIR has recently undertaken as the first step towards upgrading our traditional building skills.

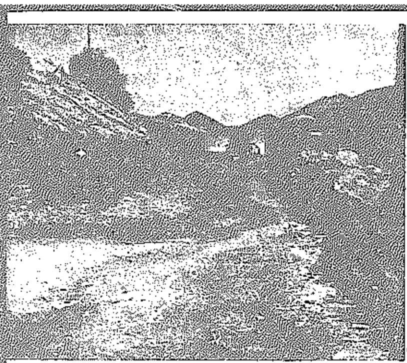
The almost total disregard of our traditional arts and crafts, and of the technology for the masses in our educational systems may be judged from the inability of most of us to name even three or four common tools of the cobbler or the mason.

A multi-faceted approach

The great challenge facing us today is that of harnessing the potential of science and technology for optimum utilization of all our natural assets — human, animal and physical — for the amelioration of poverty. What is called for, according to the paper on "Strategy of Integrated Rural Development", presented to Parliament by the Finance Minister along with the annual budget, is "a systematic, scientific and integrated use of all our natural resources enabling every person to engage himself in a productive and socially useful occupation, and earn an income that would meet at least the basic minimum needs".

A systematic attempt at tapping all locally available mineral, forest, water and other resources based on the integrated inventory is the need of the hour. A new orientation to our industrial policy in line with the Gandhian philosophy of production by the masses is also called for, wherein scale-down — instead of scale-up — of technologies becomes the heart of our planning process. For example mini-paper plants and mini-urea plants are now proved to be economical.

GLIMPSES OF KARIMNAGAR PROJECT

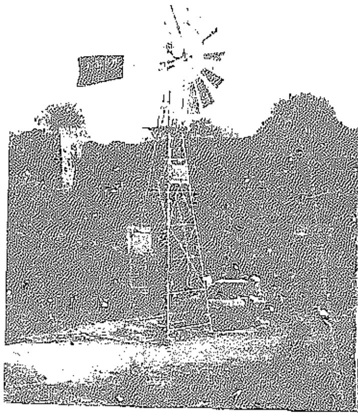


A typical village street in Karimnagar district with inadequate drainage.

The Karimnagar Project has introduced improved drinking water supply schemes for villages. Here a village belle is seen taking drinking water from a tap.

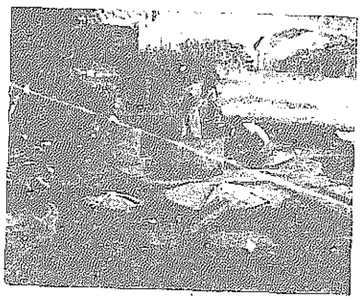
In the absence of adequate cross-drainage works on roads, loaded bullock-carts have to experience much difficulty in crossing streams that flow over the roads.

A Harijan colony with 42 low cost dwelling units and internal streets built with improved CSIR technology in Karimnagar.



A wind mill installed by CSIR at Manakondur village in Karimnagar district for drinking water supply.

Demonstration housing structures built with improved building technology by CSIR.



Ferro-concrete dome construction in progress—for Gobargas plants etc—using improved CSIR design.

Encouraging such units of appropriate sizes will go a long way in *carrying the benefits of industrialization* to much larger sections of our population. We may still use sophisticated technologies and large scale plants where necessary, but the emphasis should be switched to relevance — to technologies relevant to our resources, *environment, native skills* and genius, so as to provide gainful employment to our people. Technology is culture specific.

It is only by providing economic power to the craftsmen and skilled workers that they can be liberated from wasteful efforts and enabled to concentrate on more creative endeavours. To quote a practical instance, the provision of mechanical blowers to the wandering smiths in Delhi smetime ago was found to completely change the life style of the women, who had earlier to work the whole day playing the bellows to keep the smithy hot, which now even a child can do with the blowers

The provision of 'neighbourhood workshops', with adequate supply of mechanically operated tools, especially in electrified villages and towns, should greatly aid the craftsmen and even interested students in their creative pursuits. Patterns and *specifications with life* size models of components, which could be prepared and assembled to make socially usefull items, would enable the users to find ready market for the goods. Such workshops could provide facilities also for practical work by *students in the vicinity*. We could also have 'agro-science workshops' on the same lir·s

The problem of cartage and transport . also important in the proper exploitation of technology at the mass level. The bullock cart, which carries more load *over short distances* than even the railways in India, has not been a subject of innovation or study till very recently. Even marginal improvements in efficiency in such items of extensive use can make a tremendous contribution to national well-being. The mechanization of the *rickshaw* and the cycle with fractional horsepower engines will greatly increase the range and scope of fruitful exploitatian of technological innovations at the mass level

Most of our workers, self-employed or wage-earning, are illiterate. If science is to interact with their personal efforts, then it is essential that lines of communication are established with the average worker. This could be done through organizations of the working class, by the active use of imaginative literature for neo-literates, and through proper exploitation of the school students to reach those who would otherwise be inaccessible. Programs for joint participation of students and their parents in the rural areas, in the study of emerging technologies of special relevance to them, can help maximum utilization of available literacy and traditional understanding to meet the problems of development. Only then will science become real to the vast majority of the people.

Technology in action

One of the most significant efforts at harnessing top-class technology to gear up the productive potential of the masses has been pioneered by the Karimnagar Project of the CSIR. Undertaken in association with a variety of other agencies and groups, the project seeks to develop a manifestly backward area by applying appropriate technology at the grass-root level. The experiment essentially centres around 'Man'. The goal is to enable the common man to utilize neighbourhood resources speedily and effectively for producing wealth, so that he can live in dignity and harmony with his environment.

The methodology adopted for this project is to start with an integrated survey of human and natural resources, and engineer their effective coupling. The activities are carried out through the existing organizational structures at the State, District and *Panchayat* levels. There are no financial inputs by CSIR as such, except in terms of free technical expertize. Lack of familiarity with new techniques, traditional conservatism, and hesitation to be involved in apparent risk, were the main problems that came in the way of adoption of innovations. Discussion meetings and training programs, however, helped overcome these reservations.

Some of the significant contributions already made are :

1. Identification of 150 locations for tapping ground water in drought prone areas.
2. Initiation of a dozen water supply schemes with effective and economical designs.
3. Scientific designs for about 500 km of roads using local materials.
4. Introduction of improved techniques for construction of low cost housing.
5. Significant improvements in a number of existing technologies relating to rice-milling, processing of hides and leathers, and pest-proof grain storage.
6. Installation of a wind-mill and a number of biogas plants.

Implementation of some of the schemes had tended to suffer to some extent because of entrenched interests in older methods. One of the methods adopted to introduce change in attitudes to the application of technology for the masses was the involvement of the local schools. Students and their teachers are intimately associated in such programs as resources surveys and rural sanitation, as part of school work. Help of social welfare agencies is also being sought to integrate literacy programs with economic activities.

Based on the experience and expertize gained at Karimnagar, it has now been decided to adopt one backward district in each State in the country for similar coordinated and comprehensive exercises in the expeditious utilization of technology to suit local conditions.

The intimate interaction of the leading scientists with the problems of the people is expected not only to ensure greater utilization of the work of the scientists themselves in the service of the common man, but also to engender more relevant researches in our laboratories. Development of alternate technologies, and their utilization, should thus lead to greater professional satisfaction, and speedier rural development, through rapid application of technology for the masses.

A package-deal

Technology for the masses in India has therefore to be a package-deal, aimed not only at the improvement of skills and productivity, but also at the promotion of a rational out-look, and a will for achievement, leading to fruitful and satisfying endeavour.

The introduction of technology may be catalyzed by appropriate interaction of the educated elite with the talented workers. It may be accelerated by setting in motion a chain reaction through an auto-catalytic action of the available talent among the masses. Or it may be achieved through mass action, a gigantic coordinated endeavour involving all appropriate agencies acting with adequate speed, to mobilize the national potential of men and materials. Which of these could be most effective, individually or collectively will depend on the local situation. The time has undoubtedly come, for every man and woman of talent, to make maximum possible contribution towards dissemination of useful knowledge, and the spread of scientific rationalism, to enable best returns from new technologies for the masses.

Towards the next phase in Indian agriculture

What must be done to convert the scientific breakthroughs now taking place over a wide spectrum of Indian agriculture into 'production advance' leading to rural development and prosperity? The author discusses some of the basic steps being taken to transform the results of research into self-replicating models of growth.

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As a result of the various initiatives taken by the national leadership since Independence, India today has achieved the third position in the world in respect of scientific and technical manpower. On the other hand, at the World Food Congress held in Rome in 1974, we were counted among the "most seriously affected" (MSA) countries with regard to food, the first requisite in the hierarchical needs of man. Why this mismatch between our position in the world of science and the quality of life of majority of our people?

Our past experience suggests that human resources can not be effectively utilized by traditional approaches to 'creation of jobs', which often tend to degenerate into doles. What is needed is an overall strategy of resource utilization designed to convert sunlight, soil, water, mineral, plant, animal and other resources into wealth meaningful to the people. The starting point for such a strategy is obviously the village, where both untapped assets and native brains exist.

Almost 80% of our population now lives in rural areas; this percentage may go down to 71% by 2000 AD according to some experts. Even with this drop in percentage, our rural population is expected to grow in number from 441 millions in 1971 to 662 millions by 2000 AD. Out of the existing rural population almost 50% is believed to suffer from poverty. It is in this context that rapid development based on scientific utilization of all our resources, both natural and human, becomes a must.

Linking research with development

If one were to draw a balance-sheet of our rural assets and liabilities, the assets would be found to be immensely impressive. It is an irony, therefore, that we should still find it difficult to provide for the basic minimal needs of our people and be confronted with problems of unemployment and under-employment, both in rural and urban areas. Is there a way out? In my view, the scientific breakthroughs now taking place over a wide spectrum of Indian agriculture hold a great promise in this regard, as it is only through the proper harnessing of the knowhow coming out of our laboratories that we can turn the corner in respect of population-food supply equation as well as population-employment equation, both of which are equally important and inter-dependent.

The problems involved in linking research with development in industry are frequently discussed and are also dealt with by institutes of management. In contrast, R & D management does not receive similar attention in the field of agriculture. This is all the more unfortunate since in some important respects our agricultural and industrial growth patterns differ. Firstly, agriculture is by and large based on the technology of production by the masses in contrast to the mass production technologies being increasingly used in industry. For example, the production of an additional million tonnes of rice may need the active involvement of several thousand farming families, while the production of additional tonnes of steel could be accomplished by a small group of competent engineers with adequate supporting staff. Secondly, depreciation cannot be permitted in the basic assets of agriculture like soil and water, while industries have compulsorily to deploy depreciation regulations. Continuous improvement in ecological strengths is necessary to sustain agricultural productivity and to ensure adequate food under conditions of diminishing man-land ratio. Thirdly, agriculture is based to a great extent on recycling principles, while modern industry is usually based on an increasing consumption of non-renewable forms of energy. And fourthly, farming is mainly a rural occupation while industry tends to get concentrated in urban and semi-urban areas. These few contrasting characteristics should be adequate

Technology for rural based industry

Rural based industrial projects should be amenable to integration with rural culture, skills and resources. Technology should lead to greater sophistication of production to ensure higher returns from agricultural produce, by-products and wastes. And agriculture should be considered as an industry and reorganized according to the demand for the end-products. The author exemplifies the underlying philosophy through various technologies and projects developed and initiated by the CSIR.

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The concept of rural based industry is not a new one. The handicrafts, the handlooms and the projects initiated by Khadi & Village Industries Commission (KVIC) have already been there for quite sometime. Later, the Small Scale Industries Organization came up with its 'rural industries projects', and subsequently agro-industrial complexes were initiated and some engineering industries also sub-contracted certain manufactures and ancillaries in nearby rural areas. Industrialization was given considerable importance in our planning process. Yet, the impact of these schemes on the villages has been negligible, especially in the least developed areas. And this resulted in unequal distribution of wealth and in the rich becoming richer and the poor poorer.

The above situation drew the attention of planners, scientists and engineers towards the application of science and technology in the exploitation and utilization of rural resources like agricultural produce, agro-wastes forest materials, livestock, mineral resources, essential oils and aromatics, medicinal plants, fibre crops, commodity and economic plants. Recycling of the waste materials and their conversion into suitable forms as prospective raw materials for other industries and introduction of such projects which may have a direct bearing on socio-economic transformation and distribution of wealth in favour of poorer sections of society are the main planks of the new strategy.

Rural based industrial projects

The limitations of the above mentioned efforts, on the one hand, and the need for a wider and long term perspective, on the other, necessitate consideration of the following aspects of this subject:

1. Regional development as a concept
2. Criteria for selection of economic projects
3. Feasibility study of projects based on social benefit/cost ratio
4. Marketing management
5. Integrated approach to an economic project

These factors will be briefly dealt with here as an introduction to the main theme. The whole idea is the identification, application and extension of technological solutions to meeting the minimum needs and demands of the people of rural areas. Application of science and technology in this context has to be considered as a package deal designed to ensure that the whole developing society derives socio-economic benefits.

Project area: The rural industries projects based on the produce and raw materials available in rural areas could be of small to medium scale requiring regular daily supply of several tonnes of raw materials and investment of requisite capital available in those areas. The selection of 'project area' should be based on the means of sustaining the supply of inputs, production, handling and supply of raw materials and, above all, the social considerations affecting the people and their participation to run the industry. There should, therefore, be no rigidity in confining the project to a *taluka*, block or district; instead it should be based on the development of a region or a natural zone.

The project site should be selected keeping in view the availability of minimum infra-structures like roads, electricity, water supply, rail heads, and communication services, and should ensure that the people are not dislocated from their homes.

Criteria for project selection: The decisions regarding needs, project areas and location of project units would have to be based on certain studies which, ob-

*The views and statements made in this paper are those of the author and do not necessarily reflect that of the organization he belongs to.

viously, would differ from one project to another. However, following criteria could be considered as guidelines for such decisions:

1. The project should be acceptable to the people of the area where it is promoted—it should not in any way disturb the rural environment.

2. The project should be labour intensive, involve a larger number of people in productive activity, provide scope for utilization of local skills and talents, and expand employment opportunities for the people of the area.

3. The project should meet minimum needs and demands and provide social benefits to the people of the area.

4. The project should be based on the utilization of rural raw materials and produce and should provide scope for promotion of new technologies and appropriate industrial processes.

5. As far as possible, the project should be an integrated venture wherein the organization and management from production and collection of the raw material to its processing and distribution is knitted together and even the growers of the raw material become the partners in production, profit and loss.

6. The project should consume minimum energy per unit of production.

7. The project should be a decentralized viable unit.

8. The efficiency criteria of the project should be linked with social benefits versus cost ratio.

9. The project should, as far as possible, fall within the guidelines set by the Government for such developmental efforts.

While selecting projects for rural areas, the following points should be kept in view: (i) selection of right (appropriate) type of technology and its effective application; (ii) pre-investment survey and study of rural resources linked with the project and the availability of technology; (iii) involvement of financial and scientific institutions from inception, if required; and (iv) utilization of equipment for testing and quality control.

Feasibility report: Keeping in view the above points and also the factor that technological and financial inputs should match locally available skills and resources, a feasibility report should be prepared—*whatever be the scale of production*—on the lines adopted for any industry or project. However, the basic stress should be on selection of the right type of technology ensuring its application in a simple, cheap, effective and practical manner, oriented to socio-economic development of the rural poor. This feasibility should include cost-benefit study and should also reflect the likely social impact of the project on the local poor and the participating community.

Marketing: Particular importance should be attached to marketing of the products in the face of competition from similar schemes and projects initiated nearby with a similar objective or from other established industries. This could be obviated by : (i) a careful planning of industries in rural areas of a State under a ten-year development plan; (ii) keeping a vigilance and continuous observation of market behaviour at all stages of operation with a view to improve off-take rates to avoid overstocking; and (iii) ensuring that the projects selected are in accordance with priorities and are useful to the consumers.

The horizontal linkages of such schemes with other States in the country promoting industrialization in rural areas should also be kept in view.

Integrated approach

Agriculture is the main occupation of rural areas. It covers not only production of crops, vegetables and fruits but also animal husbandry, dairying, fishery, etc. Therefore, under the philosophy of integrated approach to the application of science and technology for socio-economic development through rural based industry, various aspects of culture, technology, employment and management should be planned together and integrated into one system.

Let us take the example of paddy, which is grown almost in every part of the country. If we consider 'paddy' as an industry, it will have the following segments of science, technology and management:

1. Production of paddy in the field involving improved crop husbandry, including soil and water management, plant protection, harvesting and storage.

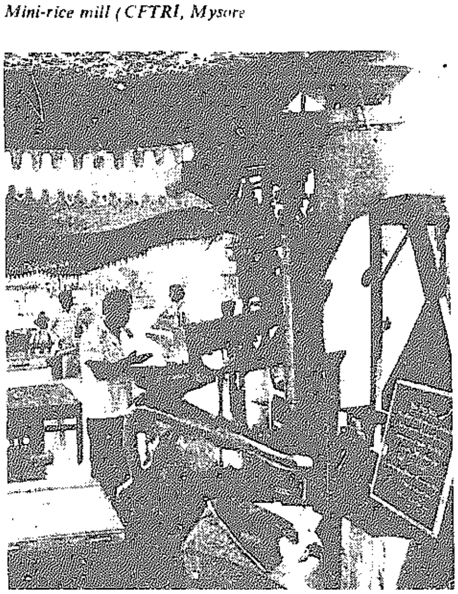
2. Post-harvest treatments to prevent losses in storage.

3. Agricultural implements and tools.

4. Paddy as industrial raw material for rice mills, involving improved technology to enable larger production of unbroken rice.

5. Utilization of by-products and waste materials: (i) paddy straw can be used as cattle feed and for grow-

Mini-rice mill (CFTRI, Mysore



ing of mushrooms, (ii) paddy husk* can be used for the manufacture of sodium silicate, activated carbon, particle board, cement for masonry mortar, detergent for dishes and floor washing, oxalic acid, xylose and derivatives, and (iii) rice bran can be used for extraction of oil** and the deoiled bran can be used as cattle feed.

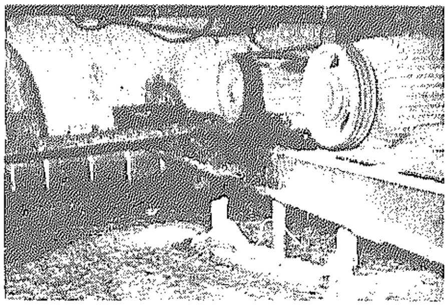
The area and scope of agriculture, the raw material producing industry, thus need to be reorganized according to the quantity of the end-product aimed for production, which may provide higher financial return and maximum social benefits. Let us assume that an economic rice producing unit can be set up for a production capacity of, say, 4 tonnes/hr. Taking 300 working days and two shifts a day, the requirements of paddy for this unit would be about 19,200 tonnes/yr. If we take the average yield of rice (say in Tamil Nadu) as 2,000 kg/hectare, a paddy area of about 10,000 hectare would be required to feed this unit. So, the crop area under paddy will have to be organized and co-related to the raw material required to produce the end-product of an economic production unit. This end-product may be anything from rice for food to rice bran oil or oxalic acid xylose. Here, the technology is involved in growing high yielding varieties, handling and preservation, improved rice mill machinery, processing and production of rice, rice bran oil, and the higher value-added products.

The planning of such integrated industrial projects should be done at an apex level taking into consideration: (i) the demand for the end-products in the country; (ii) the number, capacities, and distribution of socially and economically viable units required to meet the demand; and (iii) the needs of the least developed areas.

The chronic poverty in rural areas is due to the drain of such raw materials. The underlying philosophy of integrated approach is based on better utilization of rural raw materials, integration and coordination of all the scientific avenues of utilization and recycling of wastes, and setting up of related industrial units near the sites of raw material production. This will not only obviate material drain from rural communities but also provide them additional income, improve their standard of life, create faith in developmental activities, and foster scientific temper.

There are other examples of agricultural raw materials that could be commercially exploited through improved and appropriate technologies to usher in an era of rural based industries. Some of them are briefly discussed below.

Cotton: Growing of cotton for its fibre is one aspect of this industry, while the use of its other constituents for other products is another equally important aspect. Technology has made a creditable contribution in this direction. For example, cotton stock can be used for making particle-board; cotton leaf for extracting vitamin C; cotton seed for processing hydrogenated fats, fatty acids and cake; cotton linters as source of cellulose; and cotton cake for solvent extraction of oil, leaving a residue that can be used as animal feed. The Regional Research Laboratory (RRL), Hyderabad has developed the necessary technology for integrated production of cotton cut-lints, hulls, crude/refined oil, soapstock/fatty acids, de-oiled cake, edible flour, and tailings. The 'chemical cotton' thus produced is used for a series of chemical derivatives from which are manufactured rayon, plastics, protective coatings, films and foils. The cotton seed is converted into edible flour and other products by pre-processing and solvent extraction method. The crude oil is refined and the soapstock obtained during refining is converted into fatty acids. The hulls are compounded into cattle feed.



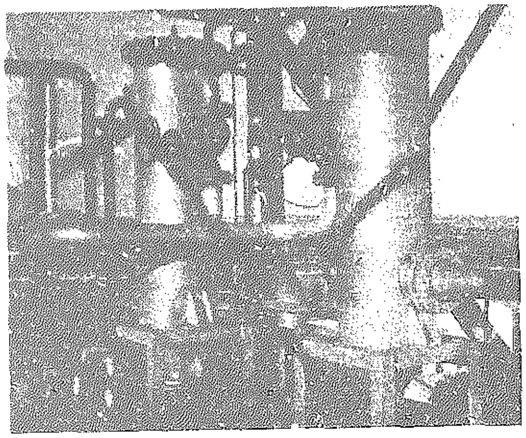
Manufacture of 'chemical cotton' (RRL, Hyderabad)

Spice oleoresins: Production of oleoresins becomes more economical in countries which produce spices because of the lower cost of raw materials and savings in freight costs. The Central Food Technological Research Institute (CFTRI), Mysore has developed technology suitable for production of spice oleoresins from pepper, ginger, chillies turmeric etc. There is, therefore, greater potential for such industry in India as the raw materials and solvents needed are readily available.

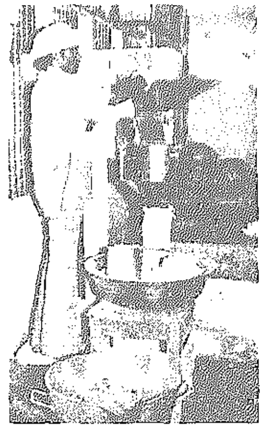
Dehydrated green pepper: Pepper is one of the most important plantation crops produced, processed and exported (47,534 kg worth Rs 5.28 lakhs in 1974-75) from India. Green pepper has so far been exported mainly packed in containers with either water or brine. The CFTRI, Mysore has evolved a technology to dry raw green pepper without diminishing its characteristic flavour and colour. As against the export price of Rs 15-18 thousands/tonne of black pepper, green pepper fetches a price of Rs 65 thousands to Rs 1 lakh/tonne.

*From the 65 million tonnes of paddy or 44 million tonnes of clean rice produced in India annually, the quantity of paddy husk available amounts to about 15 million tonnes.

**A major portion of rice bran oil is not utilized for human consumption because of the rapid development of rancidity; CFTRI, Mysore has now developed the technology to prevent rancidity and for recovery of oil for edible purposes.



← *Fatty acid distillation plant; RRL, Hyderabad*



A stage in the manufacture of energy food (CFTRI, Mysore) →

Non-edible oil complex: Mini-plants of 4 tonnes/day expelling capacity for non-edible oil seeds could be set up in rural areas based on the technology developed at RRL, Hyderabad. The cake could be locally sold as manure while the oil could be sent to a central fat-splitting and fatty acid distillation and glycerine recovery plant. The simplification of technology and equipment leads to lower capital costs and better profitability. The oil complex would provide direct employment to 338 persons giving the investment ratio/person of only 0.17 lakh. If a cooperative venture is conceived, a viable project with an investment of Rs 56.25 lakhs will give products worth Rs 0.887 lakh/day with an annual return of Rs 209 lakhs/yr. This project is perhaps the only practical method of utilizing the otherwise unutilized resource of minor oil seeds and manpower engaged in the collection of such seeds.

Livestock-based projects: Let us now take examples of livestock resources. An integrated, self-help project of this type would involve: (i) veterinary services and vaccine production; (ii) feed and pasture development; (iii) animal genetics, breeding (artificial insemination); (iv) organization of collection and delivery of food and raw materials for the factory (eg. milk, egg, meat, wool) from the growers, including sale of whole livestock (lamb, sheep, pig etc); (v) processing, storage and packaging technology; (vi) setting up improved abattoir, utilization of slaughter house by-products and wastes, and recovery of valuable biological medicinal products; (vii) leather technology involving curing, processing and utilization; and (viii) production of milk and milk products, meat and meat products.

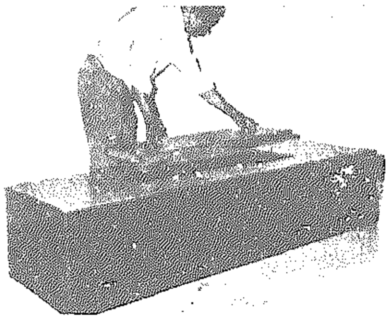
Taking the poultry bird as an industry, the CFTRI, Mysore has developed the knowhow for an egg powder making plant. To feed a minimum economic unit of one tonne/day capacity we would need about 1,25,000 eggs/day. The waste egg-shells could be converted into poultry feed. Under this venture, the growers of the raw material (eggs) would have to be so organized as to obtain the maximum socio-economic benefits. For this purpose, the egg powder plant could be integrated with a poultry feed plant and satellite poultry farm units. The poultry litter could be used as manure and the unproductive birds for table purposes.

Need-based projects for rural areas

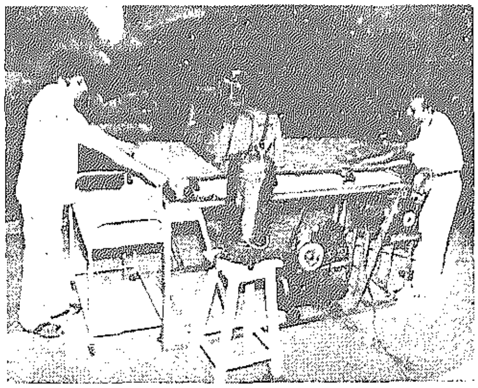
The common needs of the rural poor are: (i) food; (ii) drinking water; (iii) housing provisions; (iv) assured daily wage.

Food technology: Due to lack of purchasing power, the people of rural areas generally suffer from dietary deficiencies leading to malnutrition and low working capability. There is, therefore, an urgent need for setting up projects aimed at improving their nutrition by augmenting the available supply of nutritious foods, promoting supplementary diets (baby/weaning/energy foods), fortification and enrichment of essential foods. Industrial units* under this category could be set up for: (i) increasing the production of perishables; (ii) preservation by cold storage and other methods; (iii) dehydration, canning, processing and other methods of conservation; (iv) modernization of pulse milling and increasing the yield of split pulses by 10-12%; (v) modernization of rice milling and increasing the yield of head-rice by 2-5%; (vi) development of maize processing unit; (vii) protein production based on oil cakes, edible groundnut flour, and other low-cost protein-rich materials; (viii) production of edible cottonseed meal by liquid cyclone process; (ix) processing of buffalo milk to make nourishing food for babies and children; and (x) processing of high

*For detailed study of such projects refer to: (i) *Encyclopaedia of technical know-how and services* (CFTRI, Mysore); (ii) *Research, Development, Design & Testing Facilities in Andhra Pradesh* (RRL, Hyderabad).



An indoor grain storage bin of 3 quintal capacity. It costs Rs 200 and can also be used as an item of furniture (IPRI, Bangalore)



→ *Insect-proofing machine (CFTRI, Mysore)*

quality products based on fish, meat and poultry.

Post-harvest processing and preservation of food is an equally important aspect of the socio-economic development of least developed areas. Among the technologies developed under this category, mention may be made of the following:

1. Storage bins: Several indoor and outdoor storage bins have been developed and tested by many institutions in India, including Central Building Research Institute (CBRI), Roorkee, Structural Engineering Research Centre (SERC), Madras, Indian Plywood Research Institute, Bangalore, and Indian Grain Storage Institute, Hapur (U.P.). These bins could be made of mud, bomboo, earthen-ware, masonry, metal and wood, individually or in combination.

2. Pest-control processes*: The CFTRI, Mysore has developed following processes in this area: (i) 'durofume process' for protecting commercial stock of foodgrains; (ii) pest-proofing of jute gunny bags, used for storage of foodgrains, by means of a portable machine (400 bags/hr); (iii) low-cost fumigant tablets called 'Minifume' (one tablet costing about Re 0.60 is enough to treat 100 kg of foodgrains); (iv) an integrated technique of eradication of domestic rats involving fumigation of rat burrows and combined use of repellants, attractants and poisoned baits.

3. Food preservation flasks: Costly refrigerators used for preservation of cooked food, fruits and vegetables are beyond the purchasing power of the common man. The RRL, Bhubaneswar has developed a 'food preservation flask' in which cooked food can be preserved for a period of three days without refregeration.

4. Solar cabinet drier: This low-cost device developed by the RRL, Jammu for dehydration of fruits and vegetables, has been successfully tried for drying apricots in Ladakh for one full season and has established its efficiency under field conditions.

Drinking water: Almost 70% of the diseases in rural areas are attributed to drinking water. Following water-treatment technologies suitable for rural areas have been developed by CSIR Laboratories.

1. Disinfection of water: The National Environmental Engineering Research Institute (NEERI), Nagpur has developed a technology for defluoridation and disinfection of drinking water by treating it with lime, alum and bleaching powder followed by flocculation and sedimentation. The NEERI has also developed chlorine ampoules and tablets for disinfection of rural domestic drinking water. This process has been released for commercialization.

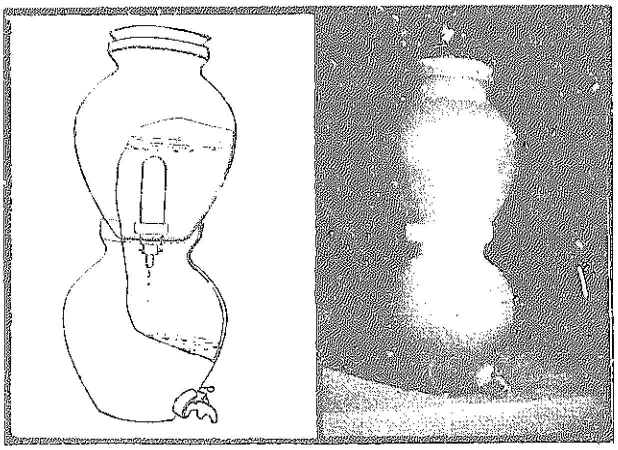
2. Desalination: The Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar has developed a process for desalination of brackish water to produce drinking water and a plant of 15,000 litres/day capacity has been commissioned in Rajasthali, a draught affected village in Amreli district of Gujarat State.

3. Water filter candles: The RRL, Jorhat and the Central Glass & Ceramic Research Institute (CGCRI), Calcutta have developed a process for manufacture of inexpensive water filter candles, which can be fitted to domestic water containers, including earthen pitchers, to meet the daily requirements of an average family. It gives clean water by removing suspended impurities and bacteria.

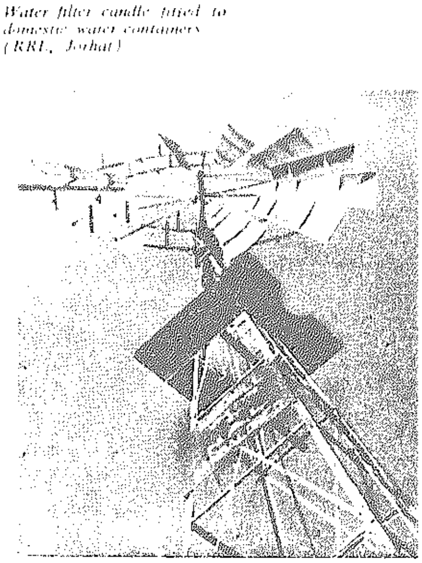
4. Low-cost wind mills: The National Aeronautical Laboratory (NAL), Bangalore, has developed and installed low-cost windmills for drinking water supply in rural areas.

5. Solar stills: The CSMCRI, Bhavnagar and the Central Building Research Institute (CBRI), Roorkee have developed and put to use solar water stills and domestic solar water heaters.

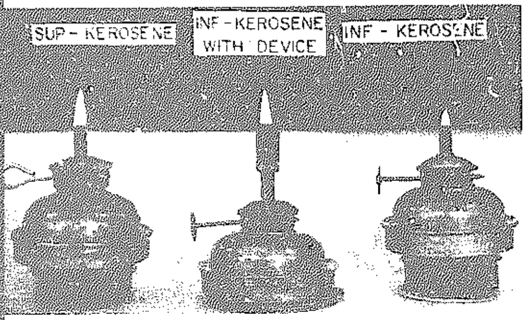
*Refer to the CFTRI publication, *Towards a Pest-free Village*.



Water filter candle fitted to domestic water containers (RRL, Jorhat)



Low-cost wind mill (NAL, Bangalore)



Low excess air burner for hurricane lanterns and deva. The photo shows the device fitted to a deva (centre) using inferior kerosene (IIP, Dehra Dun)

6. Deep-water hand-pump: This deep-well hand-pump, also called 'Bangalore pump' is quite suitable for rural areas. Developed by Mechanical Engineering Research & Development Organization (MERADO) at Madras, its main advantages are use of non-metallic raw materials, which minimize damage due to corrosion, and improved design of pump head and lever mechanism to ensure minimum human effort during operation.

Housing provisions: The CBRI, Roorkee and SERC, Roorkee are actively engaged on the problem of cost reduction on rural houses and structures through improved design and economy in materials with added comforts. The CBRI has also developed processes for water-proofing of mud-walls and pest-proofing, and fire-proofing of thatched roofs of rural houses. The NEERI, Nagpur has developed technology for designing appropriate rural sanitary latrines (to avoid the age old habit of easing out in the open), with arrangements for hygienic and easy disposal of night-soil and its conversion into useful manure through biogas technology. The Indian Institute of Petroleum (IIP), Dehradun has developed a low excess air burner for hurricane lanterns and a *deva* which could utilize poorer quality of kerosene; this technology helps reduce smoke and char formation on the wick and gives more initial candle-power.

Assured daily wages through socio-economic projects: Some of the economic projects* having scope for improving existing/traditional occupations, promoting new occupations/self-employment, and generating labour intensive industries based on technologies developed by research laboratories have already been mentioned in this paper. A few more examples of tried and proven technologies having linkages with rural culture and environment will be described here. Introduction and promotion of such projects in rural areas would not only generate additional employment and income to the

*For detailed information refer to the following publications of the CSIR (Rafi Marg, New Delhi-110001): (i) Indian Technologies Developed by CSIR Laboratories; (ii) CSIR Technologies in the field of Agro-based Industries; (iii) Training Facilities in CSIR Laboratories and Cooperative Research Associations; (iv) Facilities and Incentives for R&D in Industries (in Press); and (x) Technology Awareness Service (quarterly).

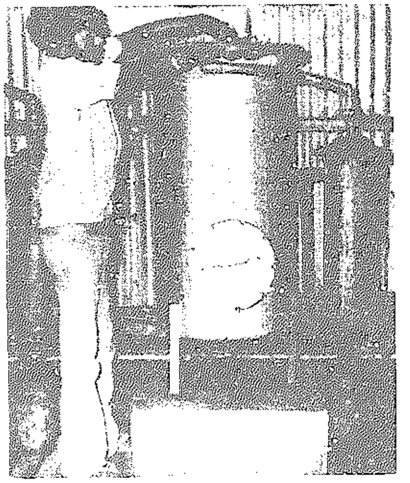
people but also check the migration of the rural poor to the cities, by providing seasonal employment to landless labourers and opportunities for the local artisans to improve their engineering and entrepreneurial skill.

1. Essential oil and aromatic plants: The cultivation of aromatic and essential oil bearing plants has to be planned according to local and external demands. The area under cultivation will depend on the quantity of the raw material required to meet the needs of an economic unit. The refining of essential oils by isolation of the active ingredients would further enhance the returns but would call for sophisticated technology and expertize. For example, lemon-grass could be fractionated to oil and converted to citrol by chemical reaction. The organization of lemon-grass cultivation would, therefore, depend on how much citrol has to be produced in an economic production unit. Similar projects could be taken with regard to citronella plantation and distillation.

2. Paper-slates: Conventional slates meant for writing purposes by school children and made out of slate-rock suffer from the disadvantage of being highly brittle. The RRL, Jorhat has developed a slate made of paper-board coated with a special chemical mixture. It can be prepared in a cottage small scale industry.

3. Jute blending: The Indian Jute Industries Research Association (IJIRA), Calcutta has developed the technology for suitably blending jute wool and jute/viscose to make woollens. The project is heading towards commercial success in turfted carpets.

4. Dry cell batteries: The Central Electro-Chemical Research Institute (CECRI), Karaikudi has recently made a breakthrough in dry cell technology, using indigenous raw materials and machinery. The cells produced are comparable to other cells marketed in the country. The dry cell being a consumer product, its district wise demand is estimated at 2 lakh pieces/month. Using CECRI technology, it is possible to put up an integrated unit of 10,000 cells/day capacity.



Small scale distillation unit for essential oils (CIMPO, Bangalore)

5. Marine algae: This project of the CSMCRI, Bhavnagar is particularly suitable for coastal rural people, especially the fishermen. It involves cultivation of *Graciularia* to produce good quality agar for use as food and industrial raw material.

6. Pottery: The pottery articles at present made by the village potters are porous, very brittle, have very short lives, get easily contaminated, and have to be discarded after use. The CGCRI, Calcutta has developed improved technology for making impervious pottery articles almost similar in quality to ceramic utensils, at a much lower temperature. This technology can also be used for making vitrified pipes/channels for drainage of household waste water, tiles for walls, roofs and floors, and artistic articles.

7. Agar oil: It is one of the costliest products (Rs 10,000/kg). The traditional way of distillation of agar wood is very crude and inefficient. The RRL, Jorhat has designed and fabricated an improved condensing unit for this purpose.

8. Pine needles: The RRL, Jammu has developed a process to produce fibre-boards from pine needles. Packing cases made of these boards have been found useful for packing and transporting fruits over long distances. These packings are cheap and durable and easy to assemble or dismantle.

9. Handloom: This traditional industry of rural areas has been restricted to the use of natural fibre and production of coarse and traditional cloth. The South India Textile Research Association (RITRA), Coimbatore has developed technologies which can expand the scope of the rural handloom industry to polyester cotton blend fabrics and poly-silk fabrics. The Ahmedabad Textile Industries' Research Association has developed a process to convert tamarind seed, an agricultural waste, into a product that can be used as a substitute for starch for sizing of cotton yarns.

10. Fish industry: In rural areas, both in the plains and in coastal regions, the aquatic resources could be exploited for increasing fish production and development of new products like fish wafers, minced fish for making fish cutlets and bergers, and fish powder. Low priced fishes could be used for the preparation of fish feed for feeding high demand and high price fishes like prawns and murrels. Prawns, which have much demand both in India and abroad and pay much higher price, can be grown in rural ponds, instead of being harvested from the sea. Science can provide information on variety, seed multiplication, formulation of special feed, optimization of conditions for growth processing, storage, packaging, transportation and utilization of waste

Spawns of mushrooms under preparation (RRL, Jammu—branch Srinagar)

materials as fish meal etc. The RRL, Jammu, the CFTRI, Mysore, the Central Fisheries Research Institute (ICAR), Barrackpore and the Central Institute of Fisheries Education, Bombay are the main institutes that have made contributions in this area.

11. Mushroom: The RRL, Jammu has been able to make a remarkable impact on the mushroom growing industry in the Kashmir valley by developing spawns of mushrooms and supplying them to villagers who grew mushrooms by traditional methods. The laboratory also provided training and advice to the growers in the application of the new technology.

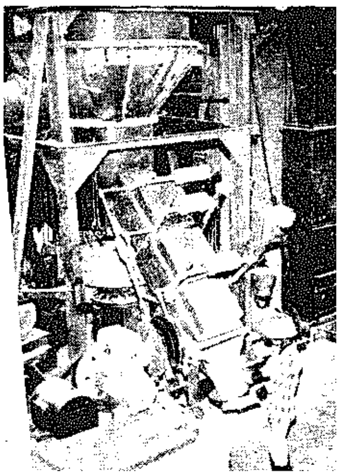
12. Leaf cups and plates: Forest and agricultural byproducts like dry leaves, sheaths and spathes, which otherwise have little commercial value, are traditionally used for making cups, *donas* and plates for serving food. Most of these items are poor in physical strength and cleanliness. The CFTRI, Mysore has developed a simple technique of making these package forms more functional, stronger, hygienic and attractive, so that they fetch better prices.

13. Bamboo baskets: This is another traditional craft of rural areas. However, the traditionally made baskets fail to withstand the hazards and abuses of packaging and handling, leading to spoilage of fruits or other perishables. The CFTRI, Mysore has improved the design with a view to eliminate such losses.

14. Decentralized production of cement: The RRL, Jorhat has developed a novel process for small scale production of cement which has considerable scope in lime stone areas. The laboratory has developed vertical shaft kilns of 2 tonnes/day, 30 tonnes/day and 200 tonnes/day capacities for this purpose. The Cement Research Institute (CRI), Ballabgarh, Haryana has also perfected the technology for a 'mini cement plant' of 25 tonnes/day capacity to produce well-burnt clinker which is converted to cement conforming IS: 269-1967. The CRI has also prepared two regional maps on cement grade limestone deposits in India.

15. Open-pan sugar industry: Production of *gur* and *khandsari* is an age-old technology for processing sugarcane in India. The Planning Research & Action Institute, Lucknow has perfected the technology for small-scale sugar production in open-pan sulphitation

Mini cement plant: a portion of the bottom of the shaft kiln showing the discharge gates and the grate shaft (CRI, Ballabgarh, Haryana)



Processes available for licensing

The following CSIR processes for rural based [illegible] are available for commercial exploitation [illegible] the National Research Development [illegible] of India [illegible]

1. Pa[illegible]
2. Paddy husk [illegible]
3. Paddy husk for a[illegible] Hyderabad)
4. Paddy husk for cement for maso[illegible] (RRL, Jorhat)
5. Paddy husk for detergent for dishes (RRL, Jorhat)
6. Rice bran (CFTRI, Mysore)
7. Spice oleoresins (CFTRI, Mysore)
8. Dehydrated green pepper (CFTRI, Mysore)
9. Castor-oil—hydrogenated (RRL, Hyderabad)
10. Sal seed processing (RRL, Hyderabad)
11. Weaning foods (CFTRI, Mysore)
12. Fortified (iodized) salt (CSMCRI, Bhavnagar)
13. Pulse milling (CFTRI, Mysore)
14. Protein isolate (CFTRI, Mysore)
15. Grain storage bins (SERC, Madras)
16. Durofume process for pest control (CFTRI, Mysore)
17. Pest-proofing of gunny bags (CFTRI, Mysore)
18. Chlorine ampules and tablets (NEERI, Nagpur)
19. Desalination of water including brakish water (CSMCRI, Bhavnagar)
20. Water filter candles (RRL, Jorhat & CGCRI, Calcutta)
21. Solar water heater (CBRI, Roorkee)
[illegible] slate for school children (RRL, Jorhat)
[illegible] (CECRI, Karaikudi)
[illegible] agar (CSMCRI, Bhav[illegible]
[illegible] Mysore)
25. Garli[illegible] powd[illegible]
26. Tama[illegible]nd based [illegible] NCL, Poona; CLRI, Madras; [illegible]
27. Coconut based technologies (CFRI, Dhan[illegible] CBRI, Roorkee; NCL, Poona)
28. Cashewnut based technologies (RRL, Hyderabad; NCL, Poona; CBRI, Roorkee)
29. Molasses based technologies (CFTRI, Mysore & RRL, Jorhat)
30. Sawdust based technologies (RRL, Bhubaneswar & RRL, Jorhat)
31. Tapioca based technologies (NCL, Poona & CECRI, Karaikudi)

*Enquiries for the above processes may be addressed to: **Managing Director, National Research Development Corporation of India, 61, Ring Road, New Delhi-110024, India.**

*Enquiries for the other processes mentioned in this article may be addressed to: **Chief, Technology Utilization, Council of Scientific & Industrial Research, Rafi Marg, New Delhi-110001, India.**

units. The sugar produced by these units compares favourably with average mill-sugar.

16. Leather industry: The Central Leather Research Institute (CLRI), Madras has made significant contributions in this field. Some of the important technologies developed relate to production of special leathers, like tie-and-dye leathers, wet-heat resistant leathers, crust leathers, upper and industrial leathers from buffalo hides, watch-strap leather from bandicoot skins, and leather from frog skins. The CLRI renders assistance in the establishment of leather based industry and in carrying out sponsored techno-economic surveys.

Gaps in transfer and application of technology

The gaps in the transfer application and of technology to rural and least developed areas are generally due to: (i) the gaps in the technology itself, if the research work has not been done up to the stage from where it could be easily exploited; (ii) non-availability of the type and scale of technology as demanded by the entrepreneur; (iii) bottle-necks in the availability of engineering designs, equipment, essential raw materials, risk capital etc; and (iv) stringent requirements of financiers and banking institutions.

There are also gaps in the channel of technology transfer, especially when it is an integrated project involving agriculture, industry, employment and social development. These gaps may be in the nature of: (i) identification of entrepreneurs, preferably local; (ii) technical and entrepreneurial information; (iii) communication problems, (iv) coordination between planners, industry and the government; (v) sense of responsibility, priority and climate around commitment; (vi) objective versus profit; and (vii) team spirit with a multi-disciplined integrated approach.

To bridge these gaps, the Council of Scientific & Industrial Research, with its 46 constituent research establishments in varied disciplines, has initiated a number of steps, under which the CSIR laboratories are preparing themselves to: (i) provide technology in a form that could be easily utilized/commercially exploited; (ii) help entrepreneurs in identifying competent consulting engineering firms, preparing feasibility reports, training personnel, and providing other assistance aimed at successful implementation of projects; (iii) undertake specialized testing and analysis work; and (iv) encourage consultancy services, sponsored and collaborative researches. A Civil Engineering Consultative Agency (CECON) has been formed to undertake multi-disciplinary projects covering public utility services like roads, buildings, structures, public health and environmental engineering, and landscaping, by teaming together the concerned CSIR laboratories (CRRI, CBRI, SERC, CRI, NEERI and NBG). A Technical Information & Industrial Liaison Centre for chemical and allied industries, set up in Bombay with financial participation of the Indian Chemical Manufacturers' Association, disseminates technical information from research laboratories to concerned industries. Polytechnology Clinics are being set up in each State to ensure that the technical problems of the industries of the region are referred to and got resolved by appropriate CSIR laboratories or other institutions and organizations in the country.

The CSIR has initiated yet another experiment on the 'adoption of a developing area' for its socio-economic transformation through the application of science and technology. The idea is to take science and technology to the people who need it; to use local resources, men and materials; to priovide gainful employment and to accelerate the development process for amelioration of poverty. One such experiment is already in progress in district Karimnagar in Andhra Pradesh State.

Conclusion

Rural based industrial projects should be amenable to integration with rural culture, skills and resources.

To quote Prof. Y. Nayudamma, Director-General of the CSIR: "The projects for rural based industry and [illegible] at rural development should be science based, need [illegible] people based, social and culture based, with the ob- [illegible] the face of under-development through [illegible] science and technology at the grass- root levels, to [illegible] the bare necessities of life, the appl[illegible] science and technology, for demonstrating the [illegible] people to get involved people to have faith in sc[illegible] effect." and for the project to have a [illegible]

Cost-benefit and feasibility stu[illegible] be undertaken to evaluate all those factors that [illegible] utilization of local raw materials, manpo[illegible] preneurial and engineering skills, and the end-pro[illegible] Scientific management, organization, marketing and other related aspects need special attention.

To create a proper atmosphere for the acceptance of new technologies in rural areas, a begining should be made with a most catching economic scheme that may provide an early dividend to the participating community in the form of assured wages, self- employment, additional income, and subsidiary occupations. The multiplicity of the requirements of different areas of the country demands a selective approach. We should introduce the right type of project in the right locality to make the greatest impact on the local people. This approach would generate a confidence among the people in their own competence as also in the promotors of the new technologies.

To make the people more enlightened and responsive to new ideas, we should take the prospective entrepreneurs of under-developed areas on a *safari* to our research laboratories, show them the work being done by our scientists, and remove their psychology of miracle and magic.

We should also take them to small and rural industries to show them how the industrious have set up industries, and to provide them the needed orientation and management training.

The role of roads, housing, structures, power connections, communication systems, engineering workshops, and other facilities and infrastructures cannot be ignored. These will have to be created for successful implementation of rural based projects. Assistance in technical information, tackling the teething troubles in product or process knowhow, testing and analysis, product and process improvement, standardization, and linkages with the concerned laboratories should be the responsibility of scientific organizations.

To make any headway in [illegible] industries in rural areas based on technological innova[illegible] in accomplishing national goals, a greater respons[illegible] will have to be borne by Government ad[illegible] planners and policy makers. The Government should decide as to what extent it wants to proceed in this direc- [illegible] and initiate steps for regional planning, organiza- [illegible] production and distribution, and reservation of [illegible] for rural and least developed sector. certain [illegible] These indus[illegible] be planned on the basis of geographically determined [illegible] market projections for the entire country, beca[illegible] always have the danger of facing unhealthy co[illegible] leading to sickness and ultimate death.

Some unsolved problems of appropriate technology

Appropriate technology is neither intermediate technology nor miniaturization of production process: it is a radically new approach in which production technique becomes subordinate to social needs. Solutions of unresolved problems in the realm appropriate technology must be inspired with this basic concern for the masses.

BEPIN BEHARI

Joint Director, Appropriate Technology Cell, Ministry of Industry & Civil Supplies, New Delhi

In recent days ... national and international forum ... ication of poverty and balanced ... lopment has discussed with great enthusiasm ... question of technological appropriateness, especially in relation to local socio-economic milieu. Many eminent persons have written on the subject. Nevertheless, much remains to be done to clarify its various implications with a view to provide effective guidelines for formulating 'appropriate' industrial policy.

Problems of appropriate technology are often discussed in a contradictory and elusive manner without any attempt to clarify basic concepts. On occasion, terms like intermediate technology, convenient technology, soft and hardware technology, modernization, miniaturization, and scaling down of technology are used as synonymous with appropriate technology. Many of these are certainly related to it, but are not necessarily the same: there is a common ground between these terms but they have their own individual characteristics which are often overlooked.

Even the word technology is often talked ... it in vaguely. It is certainly one of the most alluring ... ients the dictionary of development, but its basis ... only the are not yet spelt out. If technology referred ... ded for mechanical innovations—the equipment ... the evaluation fabricating a given item, for instance—... ally different tion of its appropriateness would be ... comprehensive from what it could be if it ... ation of science package of all the related art and ... er sense, it would for obtaining a given result. In the ... ational mechanism, include industrial management, ... ction processes, skill sophistication of equipment, ... s, packaging methods, requirements, product ... Such a basic confusion and marketing arrangements ... blications circulated as underlines many of the ... nology, which could not in examples of appropriate ... er than manufacturers' catalogues. Once technic ... rocess, considered in isolation, it essence be considered ... is accepted to be neither equipment nor production ... as socio-economic and industrial opens out to ... ing the needs of a given community. overtones of ... iculties of this concept arise from its Much of the ... ifications. such wider ...

... appropriate technology?

What is appropriate technology is *a priori* a normative ... which implies that its delimitation can take ... only after the norms are decided. These norms ... ge with every shift in time and place. At the advent of the Industrial Revolution, technological innovations aimed at diversifying product design and lowering production cost to meet the needs of the rapidly expanding consumer market. Appropriateness of technology was then considered in terms of profit. Such goals are no longer sanctified in a welfare state: under this system, technology has the main objective of serving certain indentified social goals. Unless these goals are specified, appropriateness of any technology can not be established. To think of intermediate technology as appropriate to any given environment without specifying the technology norms merely adds to confusion. In certain conditions, a highly sophisticated technology may be appropriate, while in others, a primitive technology or an intermediate technology could be appropriate. The term by itself does not specify the scope of its operations, but once the goals are spelt out, appropriateness of technology emerges out from a wide spectrum of alternative technologies.

Many persons have argued that the question of appropriateness of technology is artificial; it is merely an

The views expressed are the author's own and do not in ... reflect those of the organization he belongs to.

administrative problem which became important because of interference by State in a big way; it aimed at achieving some socio-ideological goals when the national economic balance of the system was upset by the destruction of individual enterprize. When the Smithsonian Invisible Hand vanished from the market and administrative interference became extensive, technology choice became an instrument in the hands of the administrator to wield power over the industrialist. So the fundamental question is not related to technology as such, but to the society it has to serve. The complexity arising from this situation is not easily recognized and, therefore, every individual connected with various aspects of social engineering program begins passing judgement on technological appropriateness without taking a comprehensive view of the implications.

Full employment of human and natural resources, balanced regional development, and reduction in income disparity are assigned high priority in developing countries; fuller utilization of industrial capacity, maximization of gross national production, and achievement of the highest level of sophistication in production centres are emphasized to increase the quantum of distributable wealth; the goal of a favourable balance of trade underlines the importance of export promotion measures, quality control, and production of internationally traded output at competitive prices; ideological considerations demand encouragement to village and small industries; and defence production lays stress on efficiency, quality, strategic dispersal, and secrecy in production programs. But technology choice has an important role to play in all these cases. Some of these goals are contradictory, and to achieve all of them simultaneously is difficult. Unless the contradictions are reconciled, goals specified, and implications carefully worked out, it is futile to identify a few items of production for adapting their manfacturing processes to local market conditions in the name of appropriate technology, and expect a profound impact of it on the national economy.

Economists decide the appropriateness of technology on the basis of given market prices. The intersection of marginal and average cost curves shows the level and price of the output at which the unit could profitably enter the market provided the existing price line is higher than the point of intersection. When the price line is lower, the unit becomes "sick", and seeks financial support, market reservation and technological improvement. A glaring example is the sudden reversal in the appropriateness of oil exploration technology at the Bombay High after the spurt in oil prices following the international energy crisis. This shows the importance of market prices in deciding the appropriatness of any technology. But, at present, due to various compulsions, the market prices are engineered at different levels.

If the prices and the size of a given market are decided administratively, the degree of sophistication adopted in any industrial organization can not be considered an independent variable. Higher the level of prices and greater the extension of market, the more sophisticated the technology of production. Under such conditions, one can not take independent technological decisions.

In reality, there is neither an abundant supply of the factors of production nor a limitless expansion of the market; the scale of operation and the factor-mix are subjected to many restrictions, which induce the entrepreneur to seek alternative production technologies. The entrepreneur can hope to obtain equal amount of output on different points of his production indifference curve with a varying factor-mix. The adoption of technology would depend on the priority assigned to the extent of utilization of different factors of production. What proportion of labour should be employed in relation to capital is, however, a difficult decision to take.

If labour and capital were the only factors of production, employment opportunities would depend on the availability of the latter. As the different points on the production indifference curve would yield the same level of output with varying proportions of the factors of production, the precise factor-mix could be decided on the basis of availability of these factors and the national priority assigned to them, provided alternative technologises are feasible. Therefore, it is theoretically possible to achieve full employment for any factor, but the ideal is not always the real. Many difficulties arise in arriving at a fine balance. The shape of the isoquant is itself uncertain: on occasion, the curve may be such that the factors of production may function in a complementary manner indicating that any change in them should occur in the same direction[1], which would vitiate the very exercise being attempted. In such cases, the substitutability of the factors is limited only to a small portion of the convexity of the production curve. Even continuity of the curve is not a realistic assumption, specially for an operational exercise. Empirical data regarding production function are essential for taking a decision but these are difficult to obtain: unless comprehensive data on the spectrum of feasible technologies are available, appropriateness of any one of them cannot be evaluated.

Technology equilibrium

Any alternative technology adopted in a given situation must be consistent with its existing socio-economic environment; the marginal rate of substitution among the factors of production must harmonize with their relative rates of payment and the scales of operation must be such that the units are not considered "sick". Some of the difficulties encountered in achieving this fine balance are show in a very simplified manner in Fig. 1, where I_1, I_2, I_3....are different isoquants for different levels of production. The entrepreneur would be indifferent to the factor-mix at each of these curves, but he would always try to move on to the higher curve so long as economies of scale will allow. The actual decision about the level of production would be guided by technological possibilities and factor endowments.

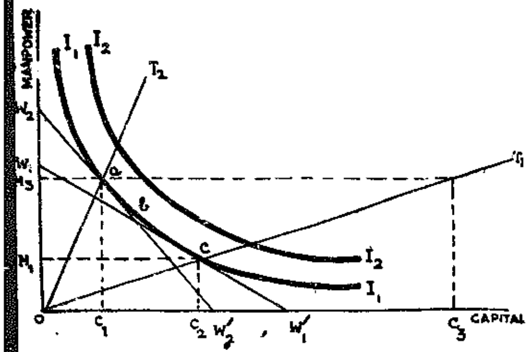


Fig. 1. Various complexities of technological adaptation.

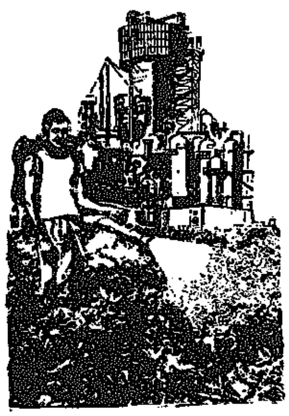
On isoquant I_1, all points—like a, b, c—are of equal significance to the entrepreneur, but the alternative technologies may not be available on all of them. If only two technologies, namely OT_1 and OT_2 are feasible, then—considering X-axis to represent capital and Y-axis manpower—OT_1 would be a capital-intensive technology whereas OT_2 would be a labour-intensive technology. Suppose OC_2 is the investible capital resource available in the economy under technology OT_1, then only OM_1 amount of manpower could be employed. In case OM_3 represents the available manpower in the community, then $M_1 M_3$ would be the quantum of unemployment. To provide full employment, technology OT_2 may be useful; but in this case only OC_1 amount of capital would be required—which implies that $C_1 C_2$, the surplus capital resource, may depress the rate of interest thus making substitution of labour by capital more plausible. For obtaining full employment with OT_1, the amount of capital required would be OC_3, indicating the need for additional amount of capital represented by $C_2 C_3$. The payments to labour and capital would be in accordance with their productivity, represented by tangents at the intersection of technology curves with the isoquant. The cost curves with these conditions operating in a production unit should be such that the average and marginal costs intersect at the desired level of production while the point of intersection is lower than or equal to the market price. In case the desired equilibrium is not attained, technological innovations will have to be made to get the appropriate factor-mix; arrangements will have to be made to harmonize productivity of the factors consistent with payments and so fix the market price that the efficiency of production at the desired level is profitable. Obviously, engineering of such a delicate balance of economic variables will be an impossible task in the existing economic system.

The decision to change from technology OT_1 to technology OT_2 would require much critical judgement on economic parameters and considerable administrative reorganization. Such changes to be effective and stable will have to be supported by technical training, managerial improvement, appropriate fabricating equipment, better entrepreneurial motivation, and workers' adaptation to the new production organization; restraint on militant trade unionism, changes in labour laws, readjustment in rates of interest and wage, and elimination of artificial support to one factor against another will also be essential. Much political overtones are inbuilt in these considerations which make the decision very sensitive to various non-economic influences.

The technology choice is often considered in relation to individual items of production, but such an approach does not meet the basic challenge of the economy. For the success of this program, it is necessary not only to forge a national wage-policy, inculcate industrial discipline, relate production to the needs of specified markets, and work out a proper consumption policy, but also to make the wage-productivity differentials existing between various lines of activities appropriately consistent with national priorities. As long as wage rates in house building, road construction, chemical engineering, mechanical workshops, consumption goods production centres, agricultural operations etc are not well coordinated, the foundation of a national wage policy would be insecure. To achieve harmonization of wage rates in different economic activities, both technological sophistication and a national consumption policy are essential. Here is a common area for economists, bureaucrats, technocrats and politicians to evolve a nationally acceptable approach; but in doing so, there is an apprehension that every one would pull in his own direction, without meeting at a central point.

Inter-sectoral balance

In India, the large and small sectors of production have existed together for a long time, and this dualistic situation requires a careful examination of the inter-relation-



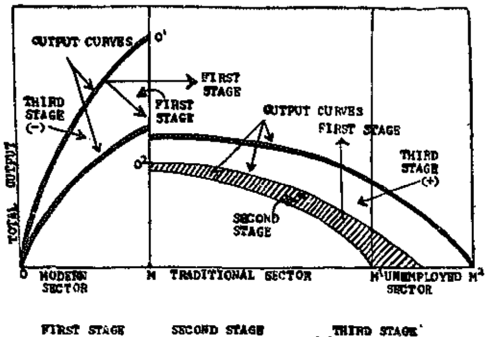


Fig. 2. Stages of technological upgrading in a dualistic economy (Ref : the author's **Rural Industrialization in India.** *(Vikas Publishing House, Delhi).*

ship between the two sectors[2]. Difficulties arising in this regard can be illustrated in a simplified manner as shown in Fig. 2. If workforce is represented on X-axis and production from a given level of employment on Y-axis, the output from OM work-force in the modern sector would be represented by OO^1M: economies of scale obtaining in the modern sector would yield a rising output curve.

The traditional sector might employ a work-force MM^1 to get an output MO^2M^1; the level of unemployment in this case would be represented by M^1M^2. As the traditional sector may not enjoy economies of scale, larger employment may lead to declining average output of the workers.

For their integrated growth, it is not adequate merely to reserve certain items of production for particular sectors; several other steps are also necessary. There could be three paths open to us: First, the modern sector may be expanded beyond OM level of employment which may augment total output and provide greater employment. Second, the productivity of the traditional sector may be increased without reducing the output of the modern sector; but if the output is increased without raising productivity of the unorganized sector, increase in work opportunities may not lead to any rise in wage rates. And third, the level of productivity in the modern sector may be reduced—but this could be harmful unless accompanied by other measures taken simultaneoulsy to increase the level of production in the unorganized sector. Unless reduction in output in the modern sector is less than the increase in the output of the traditional sector, the program would lead to impoverishment of the society; fresh employment generated in the traditional sector should also be more than any possible reduction in the modern sector. Unless the gain in total output and employment is favourable, technological adaptations of this kind may not be recommended.

Second-hand equipment

One is often beset with the baffling question of appropriateness of obtaining second-hand equipment already discarded in advanced countries. Similar situations also arise when new units in small or rural sectors contemplate purchase of second-hand machinery. There is no *a priori* reason why the second-hand machinery should prove socially or privately beneficial than new machinery.[3] The lower capital cost (said to be an important factor in favour of second-hand equipment) when considered along with transportation cost, productivity and sensitivity to the quality of workmanship engaged on them, is not always a favourable factor. The markets for such equipment are also not well organized, and the buyer, especially in absence of the equipment's history sheet can not be sure of his bargain. The entrepreneur may also like to know the reasons for the sale-off by the first user — which could be rapidly rising production cost with that machinery, shrinkage of the market which the machinery was expected to supply, or pure obsolescence. Which of these conditions could be overlooked by the second-hand buyer would depend on the type of market contemplated to be served and the time-horizon assumed for the production program. It is difficult to provide any general guideline to entrepreneurs in this matter.

Decentralization of production process

There is no special reason for considering any production process as an integral entity. Why should we not regard the output at different stages of production as independent items? Such an approach may require special drawings, blue-prints, production set up and marketing organization with a view to disperse the production processes. This point could be illustrated by two examples, one relating to fatty acids and the other to cement.

The production process of fatty acids and glycerine ordinarily involves three stages : extraction of oil, splitting of oil, and distillation of crude fatty acids and glycerine.[4] As a continuous process located at one site, these stages are very capital intensive, but may be made labour intensive and dispersed over a wide area, as shown in Fig. 3. For a 40 tonnes/day capacity distillation plant, extraction of oil could be carried out at 10 centres each of 4 tonnes/day capacity ; the cakes obtained could be supplied to neighbouring fields thus reducing transport cost on long haulage; the oil could be transported to five splitting plants each of 8 tonnes/day capacity where fatty acids and glycerine could be manufactured by a a process less capital intensive than the existing one; and finally, crude fatty acids and concentrated glycerine could be collected at a central plant for distillation. Such an integrated decentralization could provide employment at 16 locations and make the total cost very economical without compromizing on the quality of the final product.

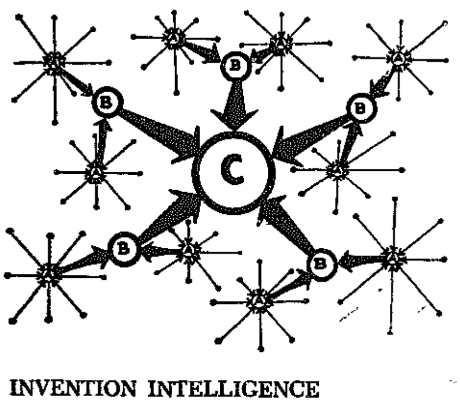
Such a technological decentralization may also be applied to cement production.[5] The quality of portland cement primarily depends on the heat transfer mechanism of the kiln. Rotary kilns of 700 tonnes/day capacity are common in India and attempts have even been made to set up 1,200 tonnes/day capacity plants. But mini-cement plants of 1 tonne/day capacity have also been technologically perfected. Based on this achievement, it is possible to isolate stone crushing, homogenizing and nodulizing at locations of mineral concentrations; such central operations could be based on 300 tonnes/day capacity. The nodules could be transported to decentralized mini-cement kilns for firing while the clinkers obtained could be ground at the places of cement utilization. Much saving in transportation, packaging and operational expenditure could thus be achieved, while providing greater employment opportunities on a dispersed basis.

Such centrifugal step-down and centripetal build-up of desegregated production processes would make a significant impact on the industrial scene of the country.

Necessary rural orientation

Modern scientific innovations need to be incorporated even in the rural technological system if malignant rural stagnation, gruesome income disparity, and entrepreneurial apathy are to be removed. The technologies so far adopted for rural development programs have failed to create a lasting impact, not because of their inefficient application, but because of certain basic shortcomings of modern industrial system. Rural industries have so far been organized to cheapen products that are primarily sold in urban markets. Geographical location of fabricating establishments in rural areas notwithstanding, their scales of operation and differing compositions of factor-mix do not ensure that increases in rural earnings resulting from rise in rural wage-rates would necessarily be ploughed back for self-generation of the local economy and improvement in the standard of rural life. To counteract the technological exploitation of rural masses, there is urgent need for a radically new approach.[6]

Fig. 3. Process decentralization with centripetal flow: A—4 tonnes/day capacity mini-oil mill. B—8 tonnes/day capacity fat-splitting plant-cum-crude furfural complex. C—40 tonnes/day capacity distillation plant.



Since we do not want rural conglomerations to remain stagnant, nor do we expect them to be poor replicas of urban societies, a renaissance of Indian villages must precede the technological breakthrough. How could this be done is difficult to visualize, except that the line of approach would have to be non-traditional. In the new socio-economic framework, the rural inhabitants may have well-integrated family organization with adequate educational opportunities, intellectual freedom and creative environment, and a sense of identification with the programs of village development.[7] Such a life-style in the new villages will have to be provided with necessary technological support : rural industries based on retrieval of village wastes; cow-dung gas plants used for production of fuel and manure; solar energy harnessed for simple applications; sugar production scaled down; mini-cement plants set up to meet local requirements[8]. Such production programs should be interwoven with the rural consumption pattern and resource endowment.

Penumbra zone of rural technology

The level of sophistication in rural fabricating system, specification and standardization of rural products, and managerial efficiency and accounting methods suited to village and cottage industrial system have not yet been concretized. Rural life-style is intimately inter-woven with agricultural operations : the size of land holdings, rotation of crops, pattern of cultivation, degree of mechanization, and such other aspects of agriculture influence the socio-economic pattern of village communities; subsistence farming, family system of cultivation, integrated agro-industrial establishments, differential wage-rates between agricultural operations and industrial activities, and other similar factors of rural economy influence the level and nature of rural technology. Agricultural processing equipment, technology of post-harvest agricultural operations, marketing arrangements for rural products, integrated organization of agro-based industries (crystal sugar, *khandsari*, *gur*, etc), and new types of rural-adapted industries like mini-cement plants can provide the necessary technological support, create employment opportunities and lead to rural economic regeneration. Such an approach demands an integral view of the rural society: norms of rural consumption, family system of employment, sex participation ratio, social stratification, and cultural opportunities.

Appropriate housing facilities, adequate network of roads, well-organized educational institutions, and diverse avenues for cultural expression may weaken the present trend of rural-to-urban migration. In providing these facilities, thoughtless copying of urban structures should be avoided; instead, these should be adapted to suit the basic needs of the rural population. To be effective, the technology for rural house construction should be linked with the natural habitat of the rural people, and should evolve from the existing systems by better sanitary and hygienic conveniences. Design specifications and quality standards for rural houses need not aim at lasting durability, as in case of urban constructions, but they should take into account the changing pattern of social organization and local availability of building materials. Bathrooms, latrines, kitchens, stores and other essential facilities ordinarily absent in rural dwellings, should be provided to inculcate improved healthy habits.

Such examples can be multiplied. However, the central direction of such efforts should stem from a realistic appraisal of rural needs. The village economy and rural industries need not be adaptations of urban technology; a vision of rural renaissance, with its own tradition, culture, and social characteristics, should decide the nature and role of technology.

Many unsolved problems of appropriate technology come to our knowledge as we proceed with the implementation of the program. It is now amply clear that appropriate technology is neither intermediate technology nor miniaturization of production processes; it is a radically new approach in which techniques of production become subordinate to social needs. Without clarity in regard to norms of production and social needs, one could have sophistication, modernization or scaling down, but not appropriate technology. Innovation and adaptation of appropriate technology is a must for an all round village development.

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A framework for rural industrialization

The divorce of the countryside from industrial activity has led to an unbalanced rural economy soley dependent on agriculture. This needs to be corrected by promoting appropriate and intermediate technologies aimed at 'production by the masses' rather than 'mass production' by a few.

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'India lives in her villages' — this has been repeated so often and so long that it has become a cliche. However, its significance today lies in the fact that the proportion of rural workers in the total working population of the country has remained constant at about 70% since 1901. There has not been any significant change in the proportion of non-agricultural workers in 70 years since the beginning of the century. And this is likely to be so till the end of the century.

The Finance Minister, in his paper entitled 'Strategy for Integrated Rural Development', circulated along with the budget for the year 1976-77, has stated that 75 million rural workers would have to be found employment in non-agricultural occupations to relieve the pressure on land. Any additions to the agricultural labour force, according to the Finance Minister, would no more be productive.

Whereas this indicates the magnitude of the problem of population and its bearing on employment in the primary sector, in industry 75-80% of the employment is in small, cottage and household industries. In handlooms alone about 7 millions out of 20-22 millions workers in the industrial sector are employed, some of them on part-time basis. The framework of rural industrialization has to be conceived in the context of these vital facts — the predominance of workers in rural areas, rural unemployment and under-employment, and the predominance of small units in terms of their number and employment potential in the industrial sector.

Production-wise, 50% of the national income originates in agriculture. In the industrial sector, where the public industrial sector has shown an impressive progress and today accounts for 21% of the production in the organized sector, small scale units share nearly half of the total production in the private industrial sector.

One point that needs special emphasis, when considering the framework for rural industrialization, is that agriculture has been shouldering the responsibility of a social insurance, sustaining a growing population (and a working force) that has limited openings in other economic activities.

Production by the masses

Of relevance here are the economic historian Vera Anstley's words : "At a time when the West of Europe, the birth-place of modern industrial system, was inhabited by uncivilized tribes, India was famous for the wealth of her rulers and the high artistic skill of her craftsmen." However, rural skills, handicrafts and village industries declined with the colonization of the country by foreign rulers. The major facts responsible for this destruction of Indian skills and industries were : (i) drying up of indigenous demand which switched over to imported articles; (ii) loss of patronage from the royal courts; and (iii) apathy of the foreign rulers toward the revival of Indian handicrafts.

The Father of the Nation, Mahatma Gandhi, had time and again emphasized that Indian industrialization should aim at production by the masses rather than at mass production by a few through the aid of highly complicated machinery. He was misunderstood and misrepresented in spite of his categorical utterances that he was not against large scale production as such, but against large scale production of things that villagers could produce without difficulty. He was of the opinion that industrialization should subserve the development of the villages and their crafts. He further believed that centralization of the necessities of life would not be conducive to the common welfare, and that their monopolization by any particular country or group of persons would be unjust.

Much water has gone down the Ganga since Mahatma Gandhi expressed his views on rural industrialization. Somehow, may be due to the Industrial Policy Resolution or the implementation of the various schemes included in the Five Year Plans (not all of them successful in equal measure), some of the decentralized industries have been able to hold on to and maintain their positions in the economy. For example, the handloom industry is even today next only to agriculture in terms of the number of people employed. In drawing up the framework for rural industrialization, therefore, one could justifiably list rural and small scale industries as a whole next only to agriculture in terms of their employment generating potential. Agriculture, small scale industries, and rural industries form the backbone of the Indian economy and society.

Viewed differently from the angle of investment, the framework of rural industrialization could be brought into sharper focus. According to the Annual Survey of Industries 1974-75, the investment in fixed capital required for employing one person in the large scale industry is about Rs 29,000. Therefore, to provide employment to 75 million rural workers in the large industry, the investment required would be five times the Fifth Plan outlay. In this context, a statement from Schumacher's book, *Small is Beautiful*, though somewhat exaggerated, would be very illustrative. He says : "Just imagine you could establish an ideology which would make it obligatory for every able-bodied person in India, man, woman and child, to do that little thing — to plant and see to the establishment of one tree a year, five years running. This, in a five year period, would give you 2,000 million established trees. Anyone can work it out on the back of an envelope that the economic value of such an enterprize intelligently conducted, would be greater than anything that has ever been promised by any of India's five year plans. It could be done without a penny of foreign aid; there is no problem of savings and investment. It would produce foodstuffs, fibres, building materials, shade, water, almost anything that man really needs."

Industrialization in India has followed, historically speaking, a strange course, though today the Indian industry could be claimed to have imparted some degree of self-reliance to the country. Whereas the decline of the village industries and crafts was brought about by the foreign rule, the *Swadeshi* movement brought into the villages the products of large scale industries. The divorce of the village economy from industrial activity led to an unbalanced rural economy solely dependent on agriculture. The principal objective of rural industrialization should be to reverse this process, not by encouraging outdated technology but by promising appropriate and intermediate technologies which would help employment of larger and larger numbers of our people for mass production of high quality goods at prices within the reach of the rural masses.

Decentralized production

Some of our major industries depend on agricultural/rural raw materials — for example, sugar, textile, vegetable oil, edible oil, and cement. Though possible, no concerted efforts were made to spread the production processes leading to the final products through the intermediate stages of processing of these basically rural raw materials in rural areas.

We have now received some waves of ideas again from the West which emphasize that mankind's greatest capital are air, water, tolerance margin of nature, and human substance as reflected in the quality of life. This shows that even the developed and industrialized countries now foresee the danger of destruction of the natural capital.

Rural industrialization cannot be brought about on the basis of any pre-determined model of growth. Proper deployment of the natural resources and skills and disposition of the social structure could be the starting points for development of rural industries. Discouragement of small industries in metropolitan cities and big urban areas and protection of rural industries could be other measures.

It is much simpler to convert a small scale industry into a large scale unit by bringing thousands of small units under one shed and under one ownership. Large enterprizes of this nature may have advantages of scale, but these advantages accrue mainly from bulk purchase of raw materials and bulk monopolized marketing of the finished products. All processes whose technological investments are divisible, could be farmed out in small units. The advantages of scale could be obtained through cooperative associations of these small units. Where necessary, Government managed quality control and common services could ensure investment of capital in such facilities as the small units cannot afford. Marketing of rural and small industry products should not be the responsibility of the small units; the self-employed operators of these enterprizes should be left to concentrate on the production activity and utilization of input for the purpose. There must be an agency that may ensure pre-emption of certain proportion of products of the small scale and rural industries up to the break-even point of the unit. The stores purchase programs of the Central and State Governments and of public enterprizes, both manufacturing and commercial, could lend a helping hand at least in respect of some lines of production. But, in the final analysis, the demand for rural industrial products must originate largely from rural areas and only for some products from the urban and export markets.

Larger rural income through income irrigation from urban areas to rural areas and larger agricultural productivity would secure for the rural industries a sound foundation and an expanding market. The self-employed cultivator and the self-employed operator of rural and small industries would form the foundation of India's future economy and society.

Meeting the energy needs of rural India

Analyzing the various factors that have implications for energy planning for rural areas, the author suggests greater stress to be laid on renewable energy resources like energy plantation, solar energy and biogas, and revival of water-borne transportation through canals.

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"How to meet the energy requirements of rural India" is a question that raises a few other questions begging *prior answers: Which kind of energy is suitable for which* type of function in rural India? What are Nature's endowments to India as sources of energy? And what is the pattern of r..ral society we aim at, in this country ?

The answer to a *part* of the first among the *derived* questions is rather simple. Rural India needs energy for: (i) domestic use—water supply, cooking, lighting etc; (ii) preservation of balanced fertility of the soil which sustains all life; (iii) agriculture and all that goes with it —irrigation, drainage, fertilization of soil, tillage, protection of crops, harvesting, storage and marketing; (iv) industries which are natural to rural setting; and (v) other activities—education, sanitation, medical care, cultural pursuits etc.

Before we start examining which of the above functions in rural India should take on which forms of energy, we must take a fundamental decision about the level of energy use. *This demands of us to be absolutely free* from the influence of ideas which underlie the wrong categorization of countries into 'developed' and 'developing' as it sets in motion a train of thought which inclines the poorer countries towards adopting agricultural and industrial practices/techniques of the richer nations. Such categorization, moreover, conceals a truth—that the high-energy-intensive societies are also high-waste societies: they produce goods which, in the successive stages of their production, absorb more energy than they finally produce. By rapidly squandering the depleting-resources, these societies are heading towards a crash, which is the inevitable result of living in disregard of the current energy-income-flows. Their excessive use of *non-metabolic power pollutes the atmosphere, the* subsoil, and the water courses.

In trying to decide our pattern of energy use we have to remember both the advantages and the limitations of non-metabolic power. Below a threshold of energy use improvement of motors is essential to prevent overwork*ing of the limbs and is, hence,* a condition for progress. Above the threshold, energy grows at the expense of equity. Moreover, the higher a group rises on the energy *ladder, the more its members are in danger of atrophy* of their limbs from utter dysfunction.

A question is often asked: In our present state of per capita energy use, is it at all necessary to point out the dangers of high energy use? To be sure, it is. Once a society orients itself to a pattern of energy use, it becomes impossible to retreat from the particular type of development adopted: the burden of changing direction at a later stage is no less killing than of continuing with the wrong trend, possibly because the compulsions of the latter do not leave any scope for attempting the former.

Physiographic features and energy planning

Once we thus set our goals and decide to have not *only a floor but also a ceiling on the use of non-metabolic* energy, we should turn our attention to India's special physiographic and climatic features that have conditioned our supply of renewable energy resources as also to the nature of our energy demands for preservation of soil health and improvement of agriculture.

A unique feature of India is that on the north it is bounded by the world's *highest* mountain system and in the centre a compact block of mountains, hills and plateaus, known as the Central Highlands, separates the Great Plains of the Northern India from the plateaus and coastal plains of the Deccan. Perhaps it is because of this obstruction that there is no north-to-south river in India. These highlands have also prevented so far the building of an all-India system of inland waterways.

The Himalaya being the youngest mountain, its uncompacted rocks are also the most erodable; it also being the highest, *the glaciations from its high altitude* add to the erosion. This is one of the reasons why the rivers of Northern India get quickly silted.

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Another agent, wind, is very effective in removing fine soil from one place to another and causing further erosion.

The Eastern Himalayan range is an area of heaviest rainfall in the world. India as a whole, however, suffers from great ill-distribution of rainfall, which ranges from 11,000 mm in some areas to a trickling 100 mm in some others. Apart from being *unequal in geographic distribution*, this rainfall is also *ill-distributed between the seasons*, even in areas of high and moderate rainfalls. About 85% of the rainfall occurs during the three or four months of the South-West monsoons. This has serious implications in quite a few respects. The *average annual* rainfall in the whole of India is estimated at 3,000 million acre-ft. If all this rain were to fall at a time, it would drown the whole land area of India, some 800 million acres, under a water column of 45 inches. Since 85% of this rain falls in just three to four months, it inevitably causes flooding—and soil erosion. Thus, a far larger volume of water runs waste to the sea than can be utilized.

The months of heavy precipitation are, however, followed by long spells of dryness. Its impact on agriculture is obvious, for even moderate deficiencies of water can be disastrous during critical periods of plant growth

Although India has, broadly, a tropical monsoon-type climate, there is a great diversity in climatic conditions, ranging from continental to oceanic, from extremes of heat to extremes of cold, from extreme aridity and negligible rainfall to excessive humidity and torrential rainfall. As a result of this diversity of climate, there are wide variations between the regions in the availability of solar energy and winds.

In inland India, the winds are seasonal, occuring mainly in the pre-monsoon period for a couple of months. Wind speeds are also comparatively low: some 10-20 km/hr as against nearly 25 km/hr and above in Canada and Australia. The fierce cyclonic storms which occur in some parts of India during a particular time of the year provide a contrast with the generally low wind speeds, which are, however, greater on the coasts and near hills.

Short spells of excess water, long periods of water scarcity, floods, soil erosion from water and wind, variability of solar energy and winds, absence of a network of inland water-ways—all these have implications for energy planning in and for rural areas.

Renewable energy resources

The renewable, non-polluting energy sources are so pervasive and diffuse that they can be harnessed *most economically* only on small scales—to meet the needs of individual families or, at best, of individual villages. These have not lent themselves to commerce.

Besides the known renewable resources of solar energy, wind and water, there is another form of renewal —the process of recycling that operates in nature. For example, there is the nitrogen recycle, not only through thunderstorms and rainfalls but also through nitrogen fixation by bacteria. Similarly, animals contribute their excrements (faeces, urine) and plants their wastes to preserve the soil-plant-animal cycle. If these wastes are allowed to go through their natural cycle and not permitted to be oxidized by burning, there would be less need to degrade the scarce forms of energy. It is in these renewable resources, therefore, that the villages have a chance to build themselves up as autonomous republics and the farmers their sovereignty at least *as producers*. with the loosening of urban control over their inputs.

Non-renewable energy resources

The total reserves of all types of coal in India are 83,000 million tonnes, including 20,000 million tonnes of metallurgical coal. It is nearly impossible to estimate *recoverable* reserves of oil. Till recently, India's proved oil reserves were estimated at 150 million tonnes; the recent finds at Bombay High and Bassein would considerably improve this figure. Other areas in the continental shelf also seem to hold promise and more reserves are likely to be located on land, too. Yet, there is no doubt that the reserves of oil and natural gas would be much less than that of coal: the *most optimistic* guesstimates are 1,800 million tonnes of oil and 3.900 million tonnes oil-equivalent of natural gas

Both coal and oil are exhaustible natural resources. These assets need to be very sparingly consumed. Just as the inheritor who quickly exhausts the 'fixed deposits' of his parents soon comes to grief, the unscrupulous consumers of oil and coal will soon be left high and dry, the many bright ideas about new energy sources waiting to be tapped notwithstanding.

Energy needs of rural India

The Fuel Policy Committee Report (1974) had worked out the consumption of commercial and non-commercial energy for the whole of India for the years 1960-61, 1965-66, and 1970-71, as given in Table 1. It may be reasonable to infer that seven-eighth of the energy consumed under columns 4, 5 and 6 were used in the villages. The share of rural areas in the energy consumption under columns 1 and 3 is unlikely to be considerable, in spite of rural electrification of 16% of the villages by the end of financial year 1969-70. This conclusion is based on the Report of the Panel of the National Committee of Science & Technology (NCST) on Fuel and Power, which has estimated that larger towns and cities,

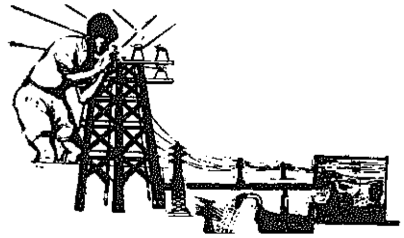


Table 1—Consumption of commercial and non-commercial energy in India

Year	Coal (million tonnes)	Oil (million tonnes)	Electricity (billion kwh)	Firewood (million tonnes)	Cow dung (million tonnes)	Vegetable waste (million tonnes)
0	1	2	3	4	5	6
1960–61	47.1	6.75	16.9	101.04	55.38	31.08
1965–66	64.2	9.94	30.6	111.82	61.28	34.41
1970–71	71.1	14.95	48.7	122.75	67.28	37.77

Source : Report of the Fuel Policy Committee 1974

with populations of five lakhs or more, accommodate only 6% of India's total population but consume about 50% of the total commercial energy produced in the country. There is, however, no doubt that the villages had a significant share in the consumption of kerosene and diesel (column 2). In villages, kerosene is mainly used for lighting, though its use for cooking also has been spreading in the semi-towns; diesel has been mainly used for passenger and cargo traffic and irrigation pumps.

India's population, which was about 530 millions in 1970, is likely to be 800 millions by the end of this century, even with a declining population growth over the coming years. Even if we assume that migration to cities in future would be checked by creation of more productive employment in villages—a tall but certainly not an impossible order—the energy requirements of villages by the turn of the century will have grown nearly twice *as much as the energy consumed in rural areas in 1970.*

Concept of rural development needs a change

Today 'modernization' of a village conjures up the picture of extension of motorable roads, electric poles connected to a far-away power house, tubewells seeking to lift water perhaps from a falling ground water table, and shops selling fertilizers and pesticides.

Since bus and truck routes are the centre of attention these days, the canals which in the past were interconnected as a means of travel and commerce are disappearing along with their *dinghies* (miniature boats). Though water-borne transport is the least energy-consuming of all modes of public transportation, the development of inland waterways, maintenance and inter-connection of rivers to the extent possible have received scant attention.

Inevitably, the country has now come up against a serious problem: the cost of electricity, beyond the reach of the poor and middle peasants, has led to its under-utilization. In any case, a large number of villages *with their small populations, will be bypassed for many* years to come. Or else, long transmission lines will have to be provided for the small loads of these wide-apart villages rendering power supply uneconomic.

The overriding emphasis on fertilizers without caring *to check on the organic matter status of the soil* and disregard of proper soil testing, are causing great damage to the soil. In consequence, there is now a greater run-off both of soil and water, cutting at the root of all developmental efforts. We cannot afford a situation where the soil becomes so poor in physical properties that it loses the water-yielding capacity or the power of balanced percolation, and the canals and tanks continue to dry up—and we look helplessly for more and more energy to get water from larger distances or deeper water tables.

How, then, do we meet the energy demands of rural India?

Energy plantation

India's saving grace lies in that her villages have not gone very far on the road to sophistication. Few among the rural *rich* have irreversibly taken to kerosene stove or even coal. They would still be content with dry twigs if these are available in sufficient quantities as fuel. ***To ask them to switch over to coal, even in the name of saving trees, is wrong.*** For trees can be, and ought to be re-planted at fifteen times the present rate, but coal reserves cannot be increased at will.

Perhaps the least expensive and the most immediately practicable measure ***for the benefit of the largest number*** is to have an energy forest in every village.

The most fundamental source of energy on earth is the solar energy: and photosynthesis by plants is *by far the most efficient means* known to mankind for tapping this energy. Therefore, the trees will have to be a major means of meeting the energy requirements of villages.

For decades we have been denuding forests without caring to replant. We have to atone for this sin by: (i) building a *permanent* forest belt in all dry areas and *wherever high-velocity winds are prevalent; (ii)* bringing *increase the temperature of the fermentation tanks during nights is also taking shape.* It appears that integration of the bio-gas plant with a solar-energy-driven steam generator would be the ideal solution: this would enable waste heat from the latter to be fed directly into the former. An innovator in Delhi is trying to produce an inexpensive solar collector-plus-steam-generator. But the main problem is: Can those who are now unable to afford Rs 2,500 for the bio-gas plant spend another Rs 5,000 or so on the solar collector-cum-steam-generator?

Efforts in cooperation, at the level of groups of families, are essential for the wide-spread installation and common use of bio-gas plants and other facilities. It is mainly the devoted work of the Khadi & Village Industries Commission that has led to whatever success we have achieved in this field. What is now called for is a mighty initiative in mass education and cooperation to fully cover our 5,70,000 villages with these simple devices of recycling and renewal.

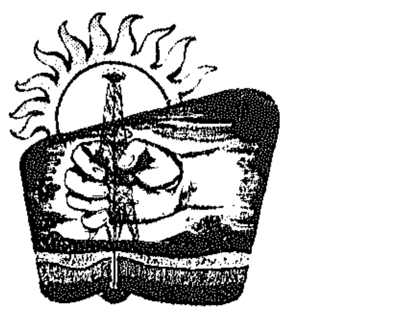
Solar energy

There is considerable scope for direct utilization of solar energy for solving many problems of rural India. Judging from the current status of this technology, however, its large-scale application within the next five years is improbable. Yet, there is no reason why direct use of solar energy cannot be undertaken on an extensive scale over the next 15 years. It all depends on how serious we as a nation are about using this inexhaustible resource.

Some of the promising solar energy applications of interest to rural areas are outlined below.

Solar cookers, which did not evoke much response in the early fifties from the urban housewife, may find acceptance with the rural womenfolk who have less inhibition against cooking outdoors. The development of a simple stove-type solar cooker, using mud and glass panes, will improve the prospects of solar cooking in rural areas. Such a solar cooker is reported to have been developed by N.K. Ghosh of Calcutta. Temperatures up to 12°C have been obtained in its insulated cooking space enclosed by two horizontal glass panes and a mirror reflector. *However, the success of any type of solar cooker will depend on whether or not its price is within the reach of the common man.*

Solar power generator would be far more advantageous than the centralized power system. The latter now does not give a fair return on its capital cost and requires high-energy consuming materials like copper for transmission lines, which are frequently stolen leading to frequent interruptions in power supply. Considering that the solar power plant will have no recurring cost except for an operator, it will be only the amortization cost plus the interest on capital that will need to be recovered. Therefore, the per-unit cost of solar power is unlikely to be higher than the present pre-unit price of fossil-fuel-based power. The National Committee of Science & Technology (NCST) has estimated that a village of 500 people will require plant/plants capable of generating



50 kw. Perhaps this estimate is based on the European standard of power consumption, for some others have put the estimate at a much lower figure. If we, for the time being, accept a modest target of generating only 20 kw and adopt the system developed by Tabor in Israel for a 10 kw power-pack, we would require only two such plants in a village of this size.

Solar engines and pumps are now available in India. Some of them are powerful enough to be used for lift irrigation. But their costs are prohibitive. Probably solar irrigation pumps will become economical only after solar power generation has made some headway in the villages.

Solar driers of mechanical type can speed up the drying process and eliminate wastage and contamination of paddy, tea, tobacco, fruits, vegetables, timber etc. The cottage-scale cabinet dryer developed by the Annamalai University for drying fruits and vegetables and the simple green-house-type kiln developed by the Forest Research Institute, Dehradun, which cuts off 40% of the time for air seasoning of timber, are examples of a good beginning in this field.

Solar stills for distillation of water could be very useful in areas which lack potable water for drinking. However, the capacities of the solar stills developed so far in the country are extremely limited. In dry areas like Rajasthan, the 'dew-pond' device seems to have much greater scope than the existing technique of solar distillation. It comprises a shining metal resting on wooden stands which serve to insulate the metal from the earth. At night, when the radiation is active, the metal becomes cooler than the air. The moisture-laden air reaches saturation in contact with the metal and then condenses into water: the greater the temperature difference between day and night, the higher the productivity of the device. Israel has adopted this device on a large scale, but it does not have much scope in humid areas.

Wind power

In India, wind speeds being generally low, the potential for economic generation of electricity from wind is said to be not too good, *except on the coasts and the foothills.* However, since India has a vast coastline as *increase the temperature of the fermentation tanks during nights is also taking shape.* It appears that integration of the bio-gas plant with a solar-energy-driven steam generator would be the ideal solution: this would enable waste heat from the latter to be fed directly into the former. An innovator in Delhi is trying to produce an inexpensive solar collector-plus-steam-generator. But the main problem is: Can those who are now unable to afford Rs 2,500 for the bio-gas plant spend another Rs 5,000 or so on the solar collector-cum-steam-generator?

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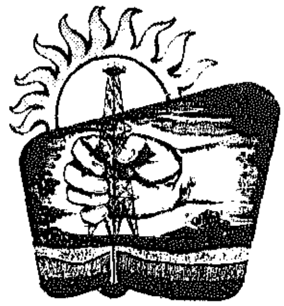

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Wind power

In India, wind speeds being generally low, the potential for economic generation of electricity from wind is said to be not too good, *except on the coasts and the foothills.* However, since India has a vast coastline as also a very large foothill area, the scope for windmills cannot be very small.

There is yet another point. Although it is generally held that electricity from wind could be economical only if the mean wind speed is not less than 10 miles/hr, there are reasons to believe that this calculation has been made only with some sophisticated wind turbines in view. It should be possible to find simpler devices to *economically* harness the energy of low speed wind. Already a 25-foot diameter 'sail-wing' type windmill has been developed and installed in a village in Madurai. Designed to harness *light winds* during the dry winter months, it can be used for irrigation of small fields and supply of water for domestic and cattle use. It is the outcome of joint effort of Indian Agricultural Research Institute, New Delhi, National Aeronautical Laboratory, Bangalore and the New Alchemy Institute of the USA.

Marcus M. Sherman of the New Alchemy Institute has rightly pointed out that cloth sails with wooden framework have been used for centuries to transform wind energy into labour-saving mechanical work, especially for grinding grains and pumping water. Therefore, *if we shed our craze for sophistication, there is no* reason why we cannot make use of even an ancient model of the wind mill.

The more we go in the direction of tapping the natural forces by *simple but economical* devices, the better for us. For therein lies utmost energy conservation, freedom from pollution and, above all, utmost diffusion of initiative for productive activities.

Energy use and soil fertility

The problem of energy is generally conceived in terms of providing energy for transportation, industrial activity, irrigation, refrigeration, and domestic use. But energy needs to be viewed in a wider context. To borrow an expression of R. Buckminster Fuller*, "the entire physical universe is energetic: energy associative as matter, energy dissociative as radiation; and one is convertible into the other." Viewed in this light, it would appear that some forms of our energy use are only hastening the degeneration of the soil, and that our neglect in the use of certain *types of matter has been allowing their inherent energy* to go waste and also to cause *avoidable* degradation elsewhere. In this broader perspective, we might find that we have the scope to *minimize* the decay

Unfortunately, soil science research in this country has been so heavily clouded by western thinking (which bears the imprint of their own climatic setting) and by the patented formula of chemical fertilizer being the general corrective to all kinds of declining soil fertility, that the fundamental problems of climatic zone-wise soils have gone by default. The nature of matter/energy input that is essential to the specific problem has also been overlooked

Let us take the following example. The heavy rainfall in the Eastern ranges has been destroying the soil's capacity to yield protein-rich food. The application of mere chemical fertilizer here will go waste—indeed, it may even accelerate run-off of the soil. What is most needed is liming of the soil and growing of legumes.

Awareness of problems like this is very important for energy planning in rural areas, for it has been estimated that the energy consumed by irrigation and chemical fertilizers together account for no less than 44% of the total commercial energy consumed in the villages.

Let us take, again, the example of the soil of Panjab, U.P. and Bihar—areas of moderate rainfall, which should normally be regarded as conducive to protein-rich food production. Here, too, if we force the soil to yield more and more in quantity or to give several crops every year, the nutritive value of the crops is bound to decline.

The Indo-Gangetic alluvial soil, which was once among the most fertile lands of the world, is now declining in fertility. And we are possibly trying to find salvation *in clinging to only irrigation and chemical fertilizers*, while thinking of organic manure as a mere supplement. That irrigation raises the salinity level of soil, that residues of different chemical fertilizers lead to formation of salts like sodium chloride/sodium sulphate, and that the soil must, therefore, be washed *liberally* with pure water before everything else, does not enter into our calculations. Use of chemical fertilizer in soils deficient in organic matter means some 70% waste of the fertilizer itself. It also means destroying the bonds of the soil. ***Without prior, or at least simultaneous, application of organic manure, the energy inputs in the form of inorganic fertilizers serve only to do permanent damage to the soil.***

Examples can be multiplied from other climatic zones. All that needs to be said here is that we must learn to *get* the *most* out of the *least* expenditure of energy; we must know the value of organic manure (ie, organic matter), which is also energy, in fact a far more beneficient form of energy than the inorganic compounds; and, above all, we must avoid spending more energy to *invite greater trouble*.

Energy-saving through navigation waterways

We have already referred to the absence of an all-India network of round-the-year navigable inland waterways, which could carry greater traffic for lesser fuel consumption, and also to the complete absence of any north-to-south river, due possibly to the existence of a Central Highland. Is there no way to develop an all-India waterways system which could save on energy?

A country should normally have all the three principal modes of transport—inland waterways, railways, and roads—properly developed, and *in that order*. Not to develop the potential of the mode which deserves the highest priority is a folly, as it amounts to extravagance in energy expenditure on traction and means undue

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*Fuller's introduction to Dinshaw J. Dastur's book, *This or Else: A Masterplan for Survival*, published by Jaico Publications.

Table 2—Cost and efficiency of different modes of transport

Mode	Cost/km		Load/hp	Cost/tonne-km
	construction (Rs lakhs)	maintenance (Rs/yr)	(kg)	(Rs)
0	1	2	3	4
Waterways	1.25 — 2.00	1,000	4,000	0.03 — 0.05
Railways (broad gauge)	8.00 — 10.00	9,000	500	0.05
National highways	1.50	4,500	250	0.10

Source: Report of the Inland Water Transport Committee, Government of India, 1970

burden—and dependence—on the other two modes of transportation.

Table 2 shows the relative economics of the railways, roadways and waterways in India as worked out by the Inland Water Transport Committee in 1970. Column 3 of this table shows that, per horsepower, the water transport can carry goods 16 times as much as the trucks (in weight) and 8 times as much as the trains; in terms of per energy unit, too, water transport costs less, even allowing for movements both for and against the current.

There is another set of figures recently worked out by some Indian specialists which reduces the waterways' margin of advantage in terms of energy consumption, *considering the two-way movement; but even this reduced* margin shows considerable advantage of waterways over other modes of transport. Moreover, a system of developed inland waterways brings more security.

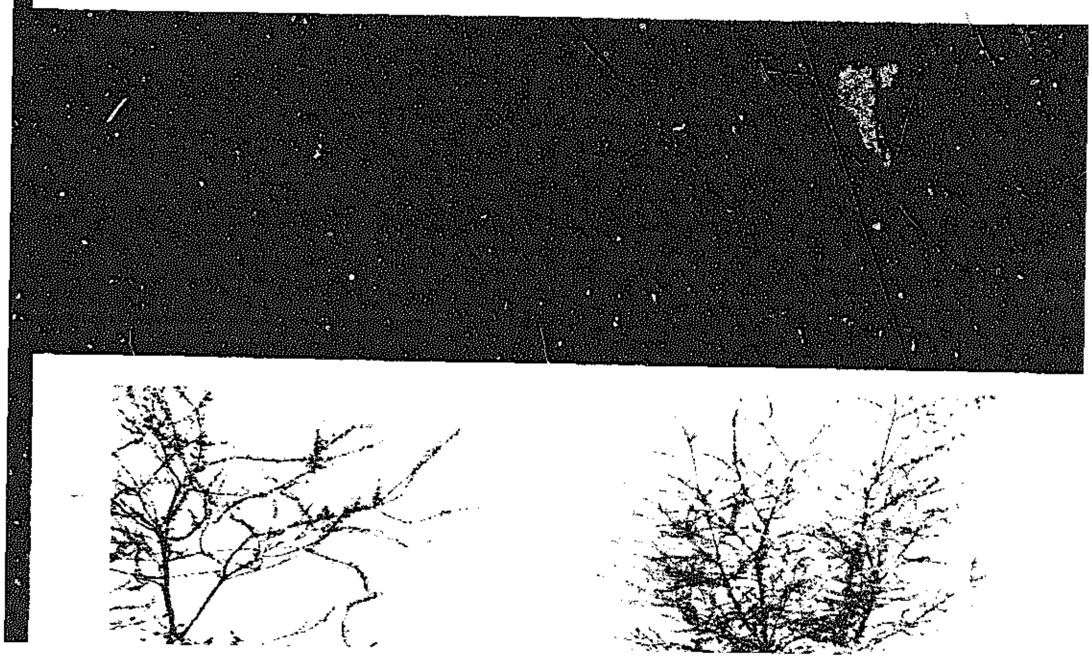
This brings us to the question of how we could develop an all-India network of round-the-year navigable inland waterways. The answer is a National Water Grid.

The two most important components in building this national grid are: (i) linking up of the Ganga with the Brahmaputra and (ii) linking up of the Cauvery with the Ganga. The former link-up is basically more important, as it would facilitate the latter. In addition to these two link-ups, there will also be need for some canals: (i) from the Narmada to Gujarat and West Rajasthan; (ii) from the Chambal to Central Rajasthan; and (iii) from the rivers of Western Ghats towards the east.

The Brahmaputra carries a discharge of 1.2—1.8 lakhs cusecs *even during* the dry summer months. This is considerably higher than the conceivable requirements *of this basin. On the other hand, there is a keen demand* on the waters of the Ganga during the dry months by the various upstream projects. These demands could be met if the supplies from the Brahmaputra could take care of the needs of the lower reaches of the Ganga during the lean months. The assurance of Brahmaputra water would help divert, near Patna, part of the *surplus discharge of the Ganga during the high-flow period*, to meet the needs of not only the drought-prone areas of the southern U.P. and Bihar but also of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Mysore and Tamil Nadu. And this will help keep almost all the Indian rivers navigable throughout the year.

Linking up of the Ganga with the Brahmaputra, in the the cheapest and the easiest manner, would require the construction of a canal through a 100-mile stretch of Bangla Desh. This canal could be beneficial to Bangla Desh, too, *as part of its water could be used to meet* the irrigation requirements of northern Bangla Desh during the lean months, besides providing that country with a useful inland navigation waterway. Even if Bangla Desh is unable to see the benefits from this scheme, India would still need to, and can, build up the network of interconnected waterways, of course, the costlier way.

Desilting the heavily silted rivers and minimizing the rate of future siltation are, however, formidable problems. While the latter can be solved by afforestation and soil binding, the former will require *excavation of thousands of miles of raised river beds*. This will have to be done mainly by mobilization of manpower, wherever dredging operation proves impossible, as has been done in China. The report of the Central Water and Power Commission team that visited China in 1955 described the the Chinese mobilization for such works in the following words: "One of the most important and largest irrigation canals constructed in China is the Main Irrigation *Canal in North Kiangsu. The bed width of the canal is* large, being 420 ft: 106 miles of this canal were dug in the course of 80 days involving earthwork of 247 crores cu. ft, that is, every day 3 crores cu. ft were done. There was



no machinery and the entire earthwork including excavation, transport and tamping was done by human labour amounting to 13 lakhs of men. The finished work is neat and the canal is functioning efficiently."

Since in our country, we face a unique problem from the highly erodable Himalayas and since further delay will mean disaster, we will have to mobilize our people on a much greater scale to save our rivers and our irrigation, drainage, and navigation systems, and to prevent our arable lands from turning into swamps. This is a battle for our very survival. Here human energy will have to be the main input, to retain the rain and snow waters and divert their energies away from destructive to creative channels.

Exploiting the energy potential of livestock

According to the 1966 cattle census, India's cattle population consisted of 230 million animals including 51 million buffaloes. According to one recent estimate, it was 247 million in 1970-71. In other words, India's cattle population is appreciable which we can turn to our advantage.

The usefulness of cattle dung as source of fuel and manure and the importance of cattle in various operations like ploughing, lifting of water, threshing of grains, and transport of produce are well-known. Even the[illegible] [illegible]rent meal is a rich fertilizer of soil. It is to these in[illegible] advantages of our cattle wealth that we should give more attention and veer away from the lure of tractors and other forms of mechanization. That bullock-driven ploughs of better designs coupled with intensive care can yield more produce than mechanized farming has been demonstrated in umpteen farms in India. What is needed is an improvement in the design of bullock-powered farm machinery and of the bullock-cart to suit rural roads.

To sum up, our basic strategy should be the utilization of our human and animal resources to the fullest advantage. This is needed even for the security and stability of the society, for if the hands of men are not fully employed in creative pursuits, these will be used for destructive purposes. We must tap nature's processes of renewal as known to us, add to them the recycling of our own wastes and those of animals and plants, and renew our own and the livestock's muscle power through their proper use. Alongside, we have to continue to seek bounties from the prime source of all energy on this planet—the Sun.

Biogas plants: prospects and limitations

What are the problems involved in the production and utilization of biogas? And what is being done to tackle these problems in order to make the biogas technology a potent instrument for rural development ?

DR. T.D. BISWAS
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Indian Agricultural Research Institute, New Delhi

Since the hike of petrol price and the consequent energy crisis, the biogas plant has become the topic of the day. In fact, there is a frantic national effort to explore alternative sources of energy. And the biogas plant is one such possible source.

What is biogas? When an easily decomposable cellulosic material is fermented with methane-forming organisms under anaerobic conditions, a mixture of gases containing methane, carbon dioxide, hydrogen, nitrogen [illegible] oxygen is formed. This mixture of gases is known as [illegible] because it is produced from biological materials. The [illegible]esence of methane in biogas makes it burn with a blue sm[illegible]keless flame.

The b[illegible]ogas technology has its own promises and limitations, [illegible]dvantages and disadvantages. A critical appraisal of t[illegible]e technology of biogas production, bringing out, as far a[illegible] possible, the technical problems involved and the prospec[illegible] for new innovations to overcome them, will, I am su[illegible]e, go a long way in putting this important subject in i[illegible] proper perspective.

History of development

The process of methan[illegible] formation through anaerobic fermentation was known sin[illegible]e long to the Sewage Technologists who fermented the ac[illegible]tivated sludge for production of methane. In India, the[illegible]ogas plant and the Dadar Sewage Plant in Bombay have had a similar b[illegible]

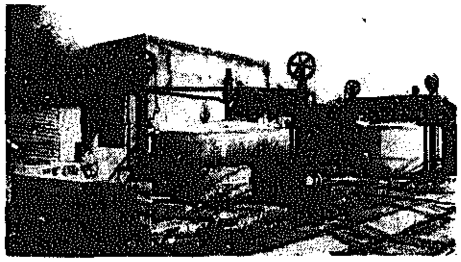


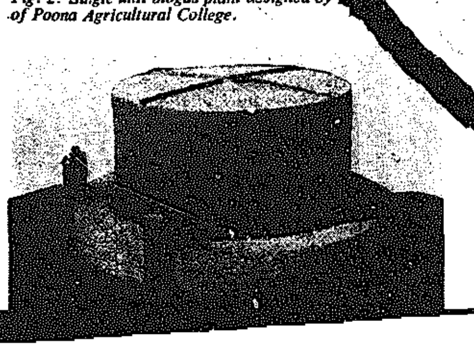
Fig. 1. Plant for large scale production of biogas.

gas had been used for certain domestic and industrial purposes. In 1939, Dr. S.V. Desai of the Indian Agricultural Research Institute (IARI) visited the Dadar plant and, being a microbiologist, realized the possibility of utilizing waste cellulosic materials other than night soil for production of biogas. India being predominantly an agricultural country, he could foresee the immense potentiality of biogas production.

In 1945, Dr. S.V. Desai and late Shri S.C. Biswas of the IARI demonstrated for the first time on a pilot plant scale that cattle dung (particularly bullock and cow dung) could be fermented under certain specific conditions to produce biogas. Thus began the history of cow-dung gas plant in India.

Dr. Desai and Shri Biswas later developed the cow-dung gas plant for large scale production of biogas. Their design basically consisted of two components : a dung digester and a gas holder for collection of the gases produced (Fig. 1). Subsequently, Shri J.J. Patel of the Poona Agricultural College made a significant improve[illegible]ment in this design by combining the digester and the [illegible] holder as a single unit. In this design (Fig. 2) the gas [illegible]der is inverted over the fermenting liquid in the gas ho[illegible]

Fig. 2. Single unit biogas plant designed by [illegible] Shri J.J. Patel of Poona Agricultural College.



digester tank, which reduced the cost of the gas plant considerably. The Khadi & Village Industries Commission (KVIC), Bombay and Shri Ram Bux Singh of the Gobar Gas Research Station in Ajitmal, Etawah *(U.P.) had carried out a series of investigations on* the biogas plant and had [illegible]cated and suggested a number of designs.

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Mechanism of methane formation

The production of combustible gases from organic wastes in marshes and swamps (marsh gas) is well known. Methane is formed from cellulosic materials through the agency of a group of organisms belonging to the family *Methanobacteriaceae,* which are strict anaerobes and proliferate only in the absence of oxygen at a slightly alkaline pH.

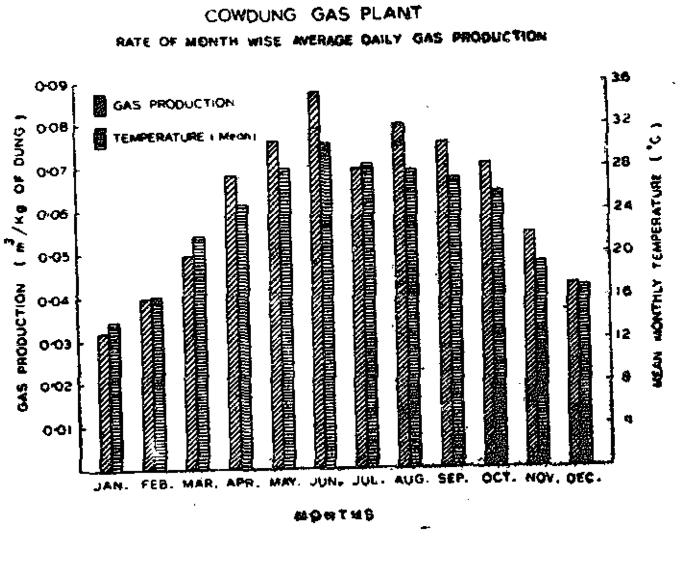
In the initial stages of decomposition of organic *matter, both anaerobic and aerobic organisms produce* a variety of products and at the same time bring down the partial pressure of oxygen, enriching the atmosphere with carbon dioxide. This process energizes anaerobic *organisms and leads to the formation of short-chain* fatty acids and alcohols besides carbon dioxide. Once the environment is rich in carbon dioxide, the secondary flora comprising the bacteria belonging to the family *Methanobacteriaceae* start operating. Methane may be *produced by decomposition of acids or by reduction of* carbon dioxide, the later being the most common mechanism for methane production. The formation of organic acids as intermediates prior to the formation of methane *has been observed in our laboratory at the IARI.*

Parameters of methane production

Temperature and pH are the two important parameters which influence the production of methane under anaerobic conditions. The microorganisms which take part in methane formation have the optimum activity at 35°-40°C. The production of biogas is fastest during summer and it decreases at lower temperatures during winter. The production data under conditions prevailing in Delhi are represented in Fig. 3.

It has been observed that physical protection of the gas holder by alkathene screen arrests the lowering of the ambient temperature and thus helps increase the rate of gas production during winter months. Addition of simple energy materials like urea, sugar, poultry excreta, and cattle urine is also helpful. Ram Bux Singh of Ajitmal has used certain insulating materials around the fermentation well to check the lowering of temperature of the fermenting slurry. Use of solar energy to heat the water for making the dung slurry prior to introduction into the fermentation tank has also been suggested. Yet another proposition is to circulate preheated gas or water through *the slurry in the fermentation tank through* a spiral tube; but this adds to the cost of production.

The methane formers thrive best at neutral to slightly alkaline media and become inactive below pH 6. Under *anaerobic conditions, the dung suspension becomes* alkaline, probably due to formation of ammonia. The fermentation proceeds through at least two stages: (i) development of acidity due to formation of a number of small chain fatty acids; and (ii) evolution of methane



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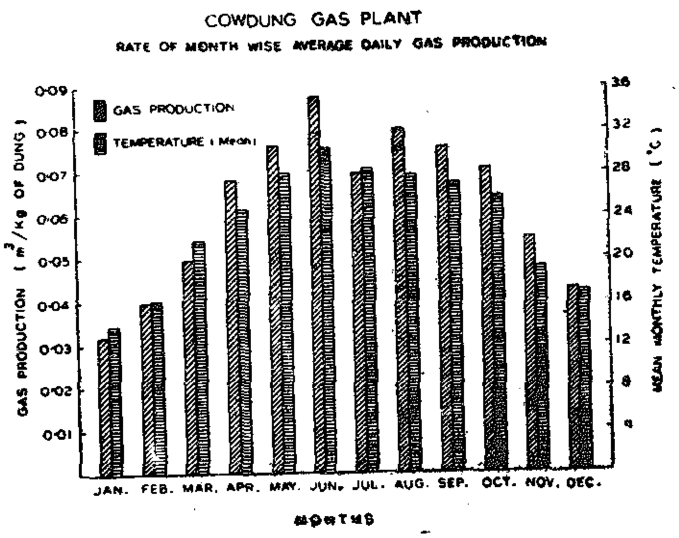

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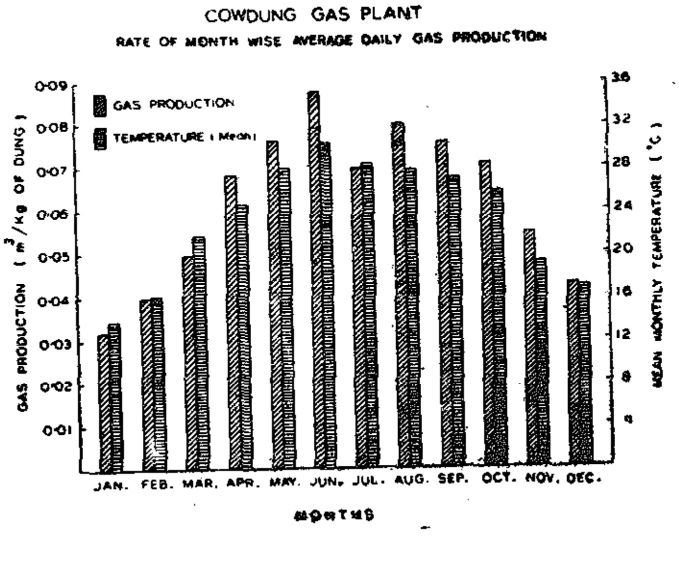

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Gobar gas holder made of ferrocement

The increasing popularity of gobar gas plants in the country has led the researchers and designers to develop low cost gas-holders to bring them within reach of more and more people. One such effort has been made by the Ferrocement Craft Research Project, Madras in making an easily fabricable, corrosionless and longer lasting gas-holder of low capital cost, using ferrocement as the building material.

Ferrocement is homogeneous, strong and impact resisting, does not corrode, requires very little maintenance, and can be easily repaired. It is a thin-shelled structure made of closely knit small diameter steel rods sandwiched between layers of chicken or welded mesh embedded in rich cement-sand mortar. It can be made by unskilled labour without using a formwork or shuttering.

An average size ferrocement gas-holder of 4.25 m^3 has been fabricated with slight modification on the mild-steel plate gas-holder design *of the Khadi & Village Industries Board, Madras,* at whose request the project was taken up. The reinforcement cage has a bottom ring (1.83 m dia.) and four horizontal braces made of mild-steel angle iron (19 x 19 x 3 mm). The horizontal braces hold in position a central pipe of galvanized iron (6.3 cm internal dia.) which supports four vertical braces, four roof braces and a roof ring, all made of mild steel rod (6 mm dia.) The vertical and roof braces are generally taken in one length. A welded mesh (No. 10 gauge) rolled into a 0.91 m high cylinder is welded to the vertical side braces, the roof ring and the bottom ring. A similar circularly cut mesh covering the roof is welded at outer sides to the roof ring and the braces and at centre to the central pipe. The gas outlet is formed by cutting a galvanized iron coupling (2.5 cm internal dia.) into two halves and welding one half to the roof mesh at a distance of 0.76 m from the central pipe. To ensure proper churning of cow-dung slurry, four mild-steel flats (2.5 x 0.6 cm) are welded to the roof and the bottom horizontal braces. Two layers of chicken mesh (No. 19 or 22 gauge) are tightly fitted on the inside and outside of the framework.

When the reinforcement cage is properly shaped, mortar is applied using an elevated jig to avoid shaking of the gas-holder and a separate scaffolding built around the jig to facilitate plastering work. Mortar is pushed from inside to outside by hand so as to completely penetrate the mesh. The layer should be normally 3 mm thick. The surface is then smoothened by trowelling and, after hardening, rubbed with sandpaper and washed.

The gas-holder is then covered with wet gunny bags and allowed to remain so undisturbed for three weeks, after which it is allowed to be completely dried. Its surface is then rubbed smooth and painted black with epoxy paint, which ensures better fermentation by absorbing heat.

To test for leaks. the gas outlet is temporarily sealed and the gas-holder held over a water column and pulled down. This creates pressure inside the gas-holder. Now, if a solution of soap is poured over it, the leaks will show up where the soap solution bubbles out; the spot is located and then repaired.

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spent slurry will overflow into the outlet chamber from where it can be led either directly into the compost pit or into a shallow chamber where it may be sun-dried.

Under the conditions prevailing in Delhi, the rate of gas production from daily addition of fresh dung varies from 0.087 m^3/kg during summer to 0.032 m^3/kg during winter.

Designs of biogas plant

There are two types of processes—continuous and batch—for this anaerobic fermentation. The continuous process is suitable for free flowing suspended materials while the batch process is applicable to light materials. Most of the biogas plants in our country today are based on the continuous process. The process is continuous in the sense that, as the material to be fermented is charged into the fermentation tank, the same volume of the fermented material overflows out of it. The village model gas plant described above is an example of the continuous process. The size and design of the plant will depend on the following factors:

1. Raw materials available for digestion
2. Quantity of gas required
3. Capital available for investment
4. Climatic conditions
5. Soil conditions and water table

The gas plants have three main parts: a digester, a gas holder and gas mains with distribution system. Depending on the amount of raw material to be handled, the digester may be of either single-chamber or double-chamber type. The village model gas plant uses a single-chamber digester. Shri Ram Bux Singh of Ajitmal suggests a double-chamber digester for larger volumes of raw material.

The size of the gas holder should be such as to accommodate the volume of the gas to be consumed during the day with sufficient margin for use the next day. The gas holder is made of 14 or 16 S.G. mild steel. Since the first introduction of the cow-dung gas plant, several designs of the gas holder have been put forward, mainly by the Khadi & Village Industries Commission and the Gobar Gas Research Station at Ajitmal. However, there is further scope for improvement of these designs depending on the requirement—single family level, village level, and community level.

Other materials suitable for biogas production

So far the emphasis has been mainly on production of biogas from animal excreta, particularly bullock and cow dung. The excreta from other animals—horses, pigs, poultry, etc—can also be used for this purpose. In fact pig-dung produces the highest quantity of methane per unit quantity of the material. In South Africa, it has been possible to run engines on a large scale with gas obtained from pig-dung from a pig farm. Other cellulosic materials like wheat straw, fallen tree leaves, and sugarcane beggasse can also be suitably fermented to produce methane.

Another potential source of biogas is the night soil. In cities the night soil is led into sewage plants and turned into activated sludge, which is used as manure while the sewage water is used in irrigated farming. But this activated sludge can be suitably fermented to produce biogas and the residue equally profitably used as manure. The National Environmental Engineering Research Institute of Nagpur has designed a plant for production of biogas directly from night soil. One such plant is located in the Central Jail, Nagpur. The gas thus produced is being used as fuel in the prison and the residual slurry, an excellent manure, is being used to raise a number of vegetables for the prisoners. However, certain precautions are necessary from public health point of view while utilizing night soil for biogas production.

Utilization of biogas

The approximate composition (by volume) of the biogas produced is as follows: methane 50-60%; carbon dioxide 30-40%; hydrogen 5-10%; nitrogen 4-6%; oxygen 1-2%; and hydrogen sulphide in traces. The gas burns with a hot, blue and smokeless flame. Methane and hydrogen when burnt with oxygen give energy in the form of heat.

$CH_4 + 2O_2 = 2H_2O + CO_2 + 233.8$ k. cal

$2H_2 + O_2 = 2H_2O + 2 \times 68.4$ k.cal

The carbon dioxide in the biogas does not contribute to the heat energy; indeed it is unfavourable to any burning process.

The amount of heat energy generated is 8,714 k.cal/m^3 for methane and 2,798 k.cal/m^3 for hydrogen. On the assumption that cow-dung gas contains 60% methane and 10% hydrogen, the heat value of the gas can be calculated as follows:

$8{,}714 \times 0.6 + 2{,}798 \times 0.1 = 5{,}508$ k.cal/m^3

Cooking: Biogas can be utilized for various cooking

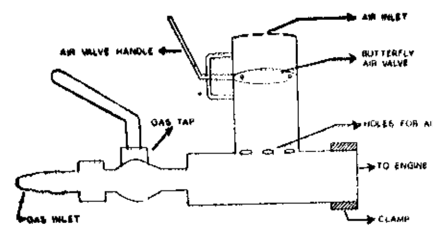

Fig. 6. Cross-sectional diagram of the adaptor for petrol engines to be run on biogas.

purposes. The required valume of oxygen for total combustion of methane and hydrogen is supplied from the air. Therefore, to get the maximum heat energy, the biogas burner should have a proper gas/air mixture, otherwise a part of methane and hydrogen would pass unused. Conventional gas burners available in the market are not suitable for this purpose. Burners for specific use with biogas, designed by the KVIC, Bombay and Bengal Scientific & Technical Workers (P) Ltd, Calcutta, are commercially available. Burners for cooking and an oven for *tandoor* making have been designed in the Division of Soil Science & Agricultural Chemistry of IARI, New Delhi, and preliminary trials have shown promise of better efficiency. Since there are varied requirements for burners, there is wide scope for improvement in their designs.

Lighting: It has been observed that biogas serves well for lighting purposes also when used in a pressure type petroleum lantern, like the petromax: here, the need to convert the kerosene oil into the vapour form is done away with since the cow-dung gas itself is in gaseous form and can be directly fed to the mantles of these lamps, with a proper ratio of supporting gas (air). Special lamps for biogas are being manufactured in our country. To get optimum light intensity, the gas should be at a pressure of about 10 cm of water. There is ample scope for better designed biogas lamps and mantles.

Kerosene and petrol engines: Successful attempts have been made to operate petrol engines and petrol-cum-kerosene oil engines on cow-dung gas. The main difficulty encountered is in regard to starting of the engine, as is the case with kerosene oil. When kerosene oil is to be used as fuel, the engine has to be first warmed up by running it on petrol before it is switched over to kerosene oil; so with biogas: the engine is first warmed up by ignition under petrol vapours before it is switched over to run on biogas. This can be achieved by providing a suitable adapter for introduction of gas into the engine inlet. One method is to feed the gas in the carburetter and control the gas-air mixture, which can be done by attaching a tube of suitable diameter with a gas tap in the inlet manifold. Another simple arrangement is to by-pass the carburetter and modify the air filter inlet by incorporating a butterfly valve to control the flow of air and a gas-cock to control the gas supply (Fig. 6). This adapter, designed by Shri M.C. Jain of IARI's Division of Soil Science & Agricultural Chemistry, can be fitted by means of a collar in place of the air filter which can be shifted to a position just before the air supply inlet. In both these cases, the engine is first started on petrol. After a warm up period of a few minutes, the petrol supply is cut off, the gas tap opened slightly, and the air valve closed gradually till the engine achieves the normal running condition. Once the engine is warmed up, it can directly start on gas also.

Diesel engines: It is possible to run diesel engines also on cow-dung gas, but, unlike the petrol engine, a part of the diesel oil will have to be continuously supplied even after starting and switching over to gas. The engine is first started on diesel oil and after warm up, a mixture of about 80% gas and 20% diesel is fed for continued running of the engine.

Both kerosene/petrol engines and diesel engines run on biogas can be used by farmers for such operations as water pumping and chaff cutting. However, the efficiency of these engines is reduced due to presence of carbon dioxide in the biogas. Scrubbing of the gas to remove carbon dioxide will certainly enhance the engine efficiency

Some useful data regarding average consumption of cow-dung gas are quoted below:

For cooking:	0.34-0.42 m^3/person/day
For gas engine:	0.45 m^3/hp/hr
For gas lamps:	0.07 m^3/mantle/hr (or 0.03 m^3/40 candle-power lamp/hr)
For gas stove:	0.42 m^3/hr
1 litre petrol	= 1.4 m^3 biogas
1 litre diesel oil	= 1.56 m^3 biogas
1 litre kerosene oil	= 2.5 m^3 biogas
1 kwh electricity	= 0.56 m^3 biogas

Utilization of residual slurry

During the fermentation of dung, about 30% of solid material is decomposed and about 15% of total nitrogen is converted into ammonia. On drying, therefore, the residual slurry becomes richer in nitrogen and other nutrients than the original material. The residual slurry flowing out of the digester can be spread in a shallow bed, allowed to dry, and used as manure. Alternatively, it can be led into a pit and made into a compost along with the other waste materials. The ranges of nitrogen (N), phosphorus (P) and potassium (K) content in the cow-dung slurry (on oven-dry basis) are as follows: N: 1.6-1.8%; P_2O_5: 1.1-2.0%; and K_2O: 0.8-1.2%.

One sample from the IARI dairy was analyzed as follows: N 1.8%; P_2O_5 1.7%; K_2O 0.96%; Zn 220 ppm; Cu 20 ppm; Mn 200 ppm; Fe 2800 ppm; Ca 0.47%; Mg 0.67%. It may be mentioned here that the animals in the IARI dairy are fed on rich feeds and fodders. The nutrient content depends on several factors, like type, age, breed and health of the animal and the nature of food consumed.

Promises of biogas technology

The animal dung has been used traditionally as either fuel or manure. The biogas technology has made it possible to utilize the dung for *both* fuel and manure. Besides dung, other organic wastes can also be used for biogas production, either alone or with dung. The biogas technology thus helps in utilizing organic wastes, controlling environmental pollution, providing means for residue management, and recycling of nutrients.

In a village, soil-plant-animal-man is a complex of ecological community and environmental functioning as a whole. At the individual level, the village model gas plant can work on dung from four or five mature heads of cattle. The biogas thus produced is sufficient to meet the cooking requirements of the family. The quantity of of dung (on the assumption that 10 kg fresh dung is produced per animal per day) obtained in a year can produce approximately 1,132 m^3 of biogas along with residual slurry containing 50 kg N, 50 kg P_2O_5 and 25 kg K_2O.

The residual slurry, composted with farmyard refuses, unused vegetable matter, fallen tree leaves and weeds, will make an excellent manure and will reduce the expenditure of the farmers on chemical fertilizers. It is thus obvious that biogas technology can help a great deal in rural development and prosperity.

According to the estimates of the National Council of Applied Economic Research, 1,335 million tonnes of wet cow-dung is produced annually in India. If the entire quantity of the dung is mobilized, it could produce 8495x10^7 m^3 of biogas along with residual slurry containing 2.65 million tonnes N, 1.33 million tonnes P_2O_5 and 2.0 million tonnes K_2O, besides a number of essential trace elements. Even if we assume that one-fourth of the nutrients is mobilized for crop growth, this will mean a lot in terms of saving in expenditure on fertilizers; the residual slurry can certainly supplement and substitute a part of the present consumption of chemical fertilizers, which are so expensive. Moreover, organic manures are considered essential for improving and maintaining proper physical condition and productivity of soil.

In villages, many farmers do not have adequate number of animals that will produce enough dung to run a biogas plant. In such cases, four or five families can join to install a biogas plant on a collective basis. A community type biogas plant for a large number of families is another proposition. However, the details of working conditions for such collective or community gas plants in respect of input and use pattern of fuel and manure need thorough investigation.

In an enterprize or organization where the number of cattle heads is sizable, it is in the national interest to utilize the excreta of the animals together with other vegetable waste materials for production of biogas, which will cut down the fuel bill of the organization and also save some energy. Cellulosic waste materials of certain bigger industries and enterprizes should also be utilized for production of biogas to meet part of the fuel consumption and prevent pollution.

According to the scientists of the National Environmental Engineering Research Institute, Nagpur, night soil can be used along with dung in suitable proportion for biogas production. Provided the social structure permits, it is possible to connect public latrines to the cow-dung gas plant for this purpose. Of course, social and public health aspects need to be thoroughly investigated.

Problems to be tackled

In spite of so many advantages, biogas plants have not been as popular as they should have been. So far, only a few thousand biogas plants have been installed in different parts of the country, mainly through the efforts of the Khadi & Village Industries Commission. A certain percentage of Government subsidy and loans from the nationalized banks are also available for setting up biogas plants. The Central and State Governments have initiated ambitious plans and are carrying out systematic compaigns for installation of cow-dung gas plants as a measure for rural development and prosperity. However, there are certain problems that remain to be solved in order to make biogas technology easily acceptable to rural communities in the country. Some of these pro-problems are discussed here.

The economics of the biogas plant has been a burning topic as this is the main bottleneck in its popularization. Because of the slow rate of return on the investment in the biogas plant, the farmer is slow to react to the proposal. Reduction in the cost of its fabrication and installation is, therefore, an essential step toward the popularization of this technology.

The gas holder, which is made of mild steel, is one of the expensive components in the biogas plant. Efforts are being made by several organizations to substitute mild steel with a less expensive material. It is also possible to reduce the cost considerably by utilizing lime and *surkhi* in place of cement in the construction of the fermentation well. The gas holder and other components, except bricks, cement and mortar, are not easily available in the remote villages. There is thus a great need of agencies for fabrication and distribution of such components.

Very often, complaints are received about non-functioning of gas plants due to certain minor defects, which could be easily rectified by an experienced hand. Since such technical help is not easily available at present, there is an urgent need of a net-work of decentralized agencies, comprising suitably trained personnel, to impart technical knowhow to the users of the biogas plant, help them in its installation and operation, and train them to attend to minor working problems. The setting up of such decentralized agencies at each block level under the control of the Block Development Officer of the Agricultural Department appears to be the only solution to the problem of popularization of biogas plants in rural areas.

Because of the low pressure at which biogas is produced and stored, special designs of burners have to be developed. The efficiency of the existing burners also is not very satisfactory. Any research aimed at reduction in cost and increase in efficiency of these burners will be very much welcomed. Because of low pressure, the distribution of the gas to distant sites also poses problems.

Another important problem to be tackled is the slow rate of gas production at low temperatures during winter. This problem is particularly acute in regions where the winter temperature falls steeply. Although some measures to counteract this problem have been suggested, there is a great need of further investigation in this line. In some centres, work is in progress to isolate the microbial cultures so as to evolve enriched cultures of methane formers which will be active even at lower temperatures. To keep the temperature of the fermented slurry at a higher level, it is possible to harness solar energy for heating the water used for making the slurry out of fresh dung.

It would be economical to have a bigger size gas plant which could be jointly installed on a cooperative basis. This no doubt reduces the cost of gas production, but poses a serious problem of how to rationalize the input of dung and other wastes from each family and the *modus operandi* of utilizing the gas and manure by them. However, the distributory system of pipelines and the gas meters add to the cost. Handling, storage and utilization of the residual slurry also pose problems. A systematic study of all these aspects is necessary to ensure that the biogas is economically utilized as fuel and the residual slurry is profitably employed for crop production.

As mentioned earlier, a wide variety of materials can be used for biogas production. The technology of fermentation for each such material has to be worked out in detail and a suitable design developed. It is possible to reduce the fermentation period by pre-digestion of the material followed by anaerobic fermentation. Depending on the kinetics of gas production, the depth of the well can be suitably reduced.

The carbon dioxide in the biogas presents certain difficulties like dilution, reduction in calorific value, and corroding of engine parts. Removal of carbon dioxide from biogas will increase its fuel efficiency for both cooking and running engines, besides reducing the size of the gas holder.

Though certain innovations are now available for utilizing biogas for lighting and running engines, there is still plenty of scope for their further refinement (eg, improvement of gas mantles and adjustment of the engines). Other uses of biogas also need to be explored.

The supernatant liquid from the residual slurry, which contains about 90% water, can be used for growing algae and fish. The algae thus raised can be dried and used as a source material for biogas production.

Summing up

Though a good deal of work on biogas has been done in this country, much more still remains to be done. Only the economics of biogas production and utilization should not stand in the way of its popularization. What is needed is an integrated approach. Besides being a potential source of fuel and manure, the biogas *technology should also be considered as a means of* controlling environmental pollution, residue management, and recycling of nutrients, which are so essential to rural economy development and uplift.

In his welcome address at the 13th Convocation of the Indian Agricultural Research Institute, Dr. A.B. Joshi, Director of the Institute, made a pointed reference to biogas technology as a means of meeting the national needs in respect of domestic fuel at both rural and urban levels. It was mainly through his initiative that the *National Committee on Science & Technology (NCST)* was convinced that the approach to biogas production and utilization should be multi-disciplinary in which Soil Scientists, Agricultural Chemists, Microbiologists, Engineers, Sociologists and Extension workers should participate.

Recently, an All India Coordinated Project for Biogas Technology and Utilization was approved by the Department of Science & Technology of the Government of India. Following institutions and organizations *are cooperating in this project:*

1. Khadi & Village Industries Commission, Bombay
2. Indian Agricultural Research Institute, New Delhi
3. Planning Research & Action Division, Lucknow
4. National Enviromental Engineering Research Institute, Nagpur
5. National Sugar Institute, Kanpur
6. Structural Engineering Research Centre, Roorkee
7. Indian Institute of Management, Ahmedabad

Under this project, all aspects of the technology and *utilization of biogas are being investigated.* It is hoped that this project will go a long way in making this vital technology an important instrument of rural change.

From horse manure to rich 'soil' in a week

■ A new high-speed composting system which can transform horse and other manure into odourless 'soil' and fertilizer in only 7-9 days has been developed by the Swedish firm Inventor Invest AB, Ostersund. Launched under the trade name 'Mullbank 50', it is a combination of mechanical, chemical, and biological techniques.

The composting process occurs inside a large, 12-sided cylinder with a capacity of 50 cubic metres of manure per cycle. The manure is chopped, freed of foreign particles, like horseshoe nails, *and placed inside the cylinder. The vessel begins* to rotate and the temperature within it gradually rises to 80°C. The manure is pasteurized and eventually transformed into a substance which is said to smell, feel, and function like soil. When the process is complete, the end product can be packed in sacks.

Manure from 175 horses at an Ostersund pilot plant yields an annual volume of some 2 million litres of soil-fertilizer. A complete Mull-*bank plant capable of composting 40 cubic metres* of manure from 1,000 horses daily is to be installed at the Solvall-race-course near Stockholm, it is stated. Calculations indicate that a loss caused by handling costs can be transformed into a substantial profit through the sale of the soil.

Inventor Invest had launched a waterless composting toilet for weekend cottages based on similar principles some years ago.

Energy plantation and silvi-pastoral systems for rural areas

With increasing pressure of human settlements diminishing the country's firewood resources, the rural landscape is being stripped bare of its tree cover, leading to serious ecological and other consequences. The process can be checked by systematic plantation of trees, shrubs, grasses and legumes on hilly terrains, ravines and wastelands—with a multiplicity of gains in terms of soil and water conservation, better land utilization, increased crop and fodder production, easy availability of firewood, and improved environments.

DR. B.D. PATIL
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The world energy demand doubles every 13 years or so. In the last century, nearly 4 Q of energy was consumed while the requirement of the next century is of the order of 100 Q. But the total non-renewable energy resource of the entire world is not more than 50 Q, which is likely to be exhausted in the next 50 to 100 years[1]. In view of this scarcity of non-renewable sources of energy, the scientists have diverted their attention toward renewable sources of energy. Even though many substitutes (atomic, solar, tidal, wind power etc) are being developed, for more than a third of the world's population perhaps the most pressing energy crisis in the coming years would be the famine of firewood. About 90% of the populations in developing countries depend only on firewood for cooking; at least half of the timber cut in the world today is used as fuel.

According to Eckholm[2], the firewood prices in Nepal have risen faster than that of kerosene. In the west-African Sahel region, wood is the major living expense and takes up one-fourth of the family's income. "The firewood crisis goes unnoticed", says Eckholm, "because it lacks the photogenic visibility of famine, but it is a portent of dust bowel future."

The developing and fast multiplying rural population strips the nearer forests, avenue plantations and farm lands of trees, leaving the landscape bare. Today, as a result, people in most of the South Asian countries are forced to use cowdung as fuel. During the dry periods, all the cowdung is dried and piled up in heaps, which dot the rural landscape like little pyramids. The dried dung is sold even in the surrounding urban areas for use as fuel. In India alone, an estimated 60-80 million tonnes of dried dung, representing 300-400 million tonnes of wet, freshly collected manure, are burnt as fuel. The plant nutrients and organic matter thus wasted equal more than a third of India's chemical fertilizer use[2].

The only source of firewood are our forests which are fast shrinking due to enchroachment by new agricultural settlements and industrial complexes. The fast growing population is also increasing the pressure on our forests for fuel : in hilly areas during very cold winters, tonnes of firewood are burnt by single families to keep the houses warm.

Forests : a renewable resource

The Government has now accelerated the introduction of gobar gas or biogas plants, which break down organic wastes into methane gas for cooking and leave a rich compost for the farms. Promotion of this system will certainly go a long way in reducing the energy crisis, yet substantial proportion of energy for cooking will still have to come from firewood.

For the rural population, firewood will always be a high demand commodity, the availability of which will decrease very fast because firewood consumption and population growth are directly related. The firewood resources, therefore, must be augmented with the growth in population to cope with the demands.

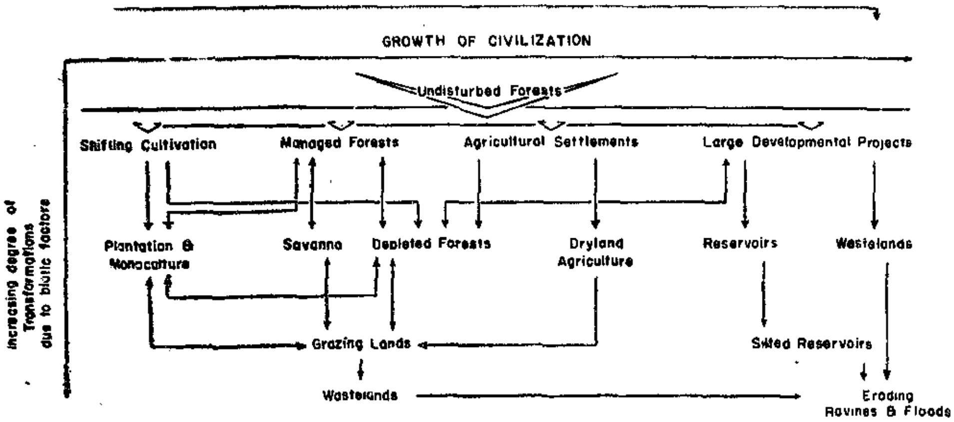


Fig. 1: Possible sequences of changes brought about by the continued misuse of Natural Forest Ecosystems (Based on MAB Regional Meeting 1975, Varanasi)

Trees are the cheapest source of energy because they fix the readily available solar energy without any extra inputs. Solar energy can be trapped efficiently only by certain plants put under proper management as a form of direct renewable energy resource. Our forest wealth — covering only 22.7% of the total land area — is to be protected and managed to yield most suitable economic and industrial wood. The National forest policy is to increase the area under forests to at least 33% of total land area.

With increasing researches in wood products most of the small wood from fellings in the forests is now being used as raw material for industries. The proportion of industrial use of wood has thus increased more than its use as fuel. This is yet another reason why our forest wealth should be treated as a renewable resource.

Trees and Nature's balance

The Indian sub-continent has experienced severe changes in its climate and landscape due to increasing human interference with its natural forest cover. The accelerated degradation of forests caused by shifting cultivation, agricultural and developmental projects, nomadic grazing, lopping etc has reduced the productivity of our land itself due to soil erosion, flooding, creeping deserts, declining soil fertility, and increased pest infestation. The possible changes brought about by the continued misuse of the natural ecosystem are shown in Fig. 1. The double pointed arrows in this figure indicate the possibility of their reverting back under proper protection and management.

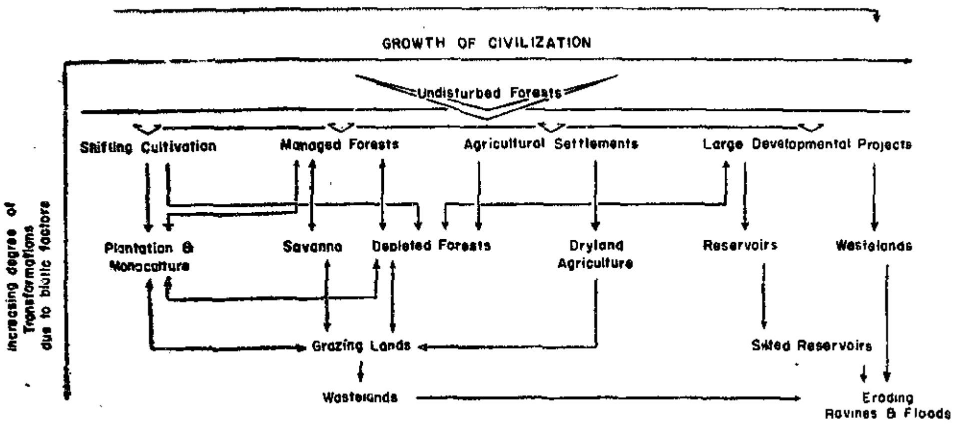
The results of such a transformation of the ecosystem are scarcity of food, fodder, fuel, and timber, and increase in pest infestation and pollution.

Energy situation in rural India

Of all the problems mentioned above, fuel and fodder scarcities affect the rural areas most. Our country had a real breakthrough in agricultural production over the past 5-10 years because of introduction of improved crop varieties and superior management techniques. But when we compare the availability of solar energy with the crop production averages at 2.5% efficiency of its utilization, the yield per hectare of land is only one-third that of several countries of the world receiving even lower quantums of solar energy[3]. Thus there is a need to improve the energy capture efficiency in our country through application of various management techniques and removal of factors limiting production.

Our forests are less productive compared to the world average — India: 0.5 m^3/hectare/yr; world: 2.1 m^3/hectare/yr. During recent past, while wood production has shown a marginal increase with a constant growth rate of 2%, its utilization for industrial purposes has doubled and the per capita production has remained constant. The total consumption of fuel-wood in India was 203 millions m^3 in 1970, of which 13 millions m^3 was obtained from recorded sources; the requirement is likely to increase to 300 millions m^3 by 1990 (NCA, 1973). Thus, the gap in demand and supply of fuel-wood by 1990 would be of the order of 100 million m^3. To bridge this gap we need to raise the fuel-wood plantation of quick growing, short rotation species (average production rate 5 m^3/hectare/yr) to about 20 million hectares.

Our country has a vast animal wealth, accounting for world's 16% cattle and 45% buffalo population, 69 million goats, and 43 million sheep. This huge animal stock has to depend for its food on forests, waste lands, community grazing lands, crop residues, and



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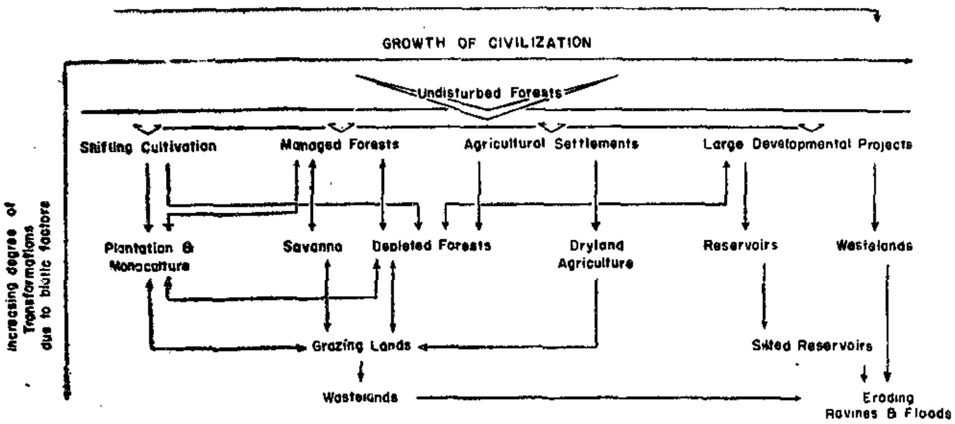

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Silvi-pasture with **Acacia tortilis** *and grasses as a two tier system.*

plantation. Based on similar principles are the ideas of *horti-pasture, agri-forestry and farm-forestry. Agri-forestry*, commonly known as Taungya system, has been practiced as part of Indian forestry in which crops are grown in the interspaces between trees. Horti-pasture is being given a new shape by our researchers because most of the orchards in the hilly regions are bare at the ground and do not produce anything except the fruits. Growing suitable legume-grass combinations not only stabilizes the soil structure and fertility but also provides extra production of nutritious forage for the livestock. In central India, a crop of lucerne is being taken up from banana plantations very successfully at the early stages without any extra inputs, with additional benefits to the plantation crop by way of provision of extra nutrients and freedom from weeds.

The new theme : improved energy output

Based on the above experiences, the Indian Grassland & Fodder Research Institute (IGFRI) has recently launched a program of synthesizing multi-storeyed plant population models with diverse flora of complimentary, not competitive, nature for better solar energy utilization and maximum yield. This process is accelerated by increasing the soil moisture regime by application of rain water harvesting and protective irrigation techniques.

Depending on the plants' canopy structure, energy *fixation efficiency and light requirements, different* combinations of trees, shrubs, bushy and trailing legumes, and tussock grasses are now being grown in such a way that the solar energy does not reach the soil level, being intercepted by the plant leaves. This system increases the efficiency of energy synthesis many-fold. The following examples of different types of plants may give an idea of such a system :

Trees : Albizzia amara; Hardwickia binata (in 5 m lines).

Shrubs : Sesbania sesban; Leucaena latisiliqua; Desmanthus virgatus etc.

Bushy and trailing legumes : Macroptelium atropurpureum; *Atylosia scarabaeoides*; *Dolichos lablab*; Clitoria terneata; Desmodium diffusum; Desmodium uncinatum etc.

Grasses : Setaria *anceps*; *Cenchrus ciliaris*; Sehima nervosum; Paspalum dilatatum; C. setigerus; Chrysopogon fulvus.

The grasses and legumes are planted/sown in 3:1 ratio while the shrubs are grown as two rows (central) of hedges. The legumes trail on the shrubs/trees so that no bare stems are left. The trailing surface allows the legumes to proliferate, thus increasing the per unit dry matter production. Besides, the quality of the harvested material is also improved due to the presence of legumes

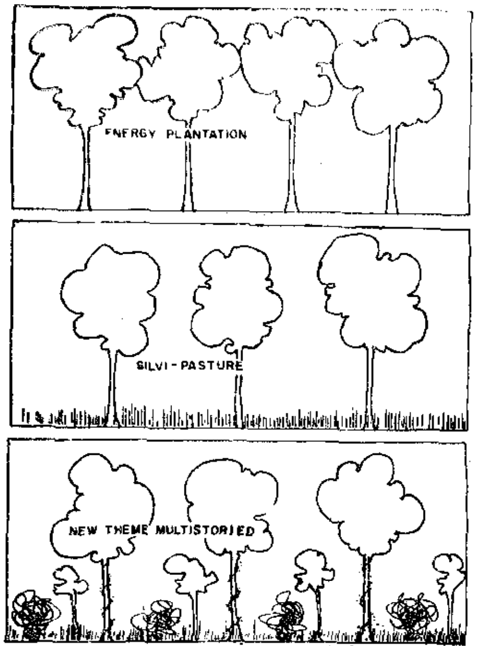


Fig.2 SCHEMATIC DIAGRAM SHOWING PROFILES OF DIFFERENT SYSTEMS

and fodder bushes. Since the rain drops do not get in direct touch with the ground, soil loss due to splash erosion is avoided. The grazing animals get balanced feed due to second tier browsing on more nutritious leaves of the bushes. The trees are lopped only during scarcity periods (or to provide the light canopy) thus increasing fuel-wood production.

A schematic diagram of all the plant growth models described above is shown in Fig. 2. Trees, shrubs, grasses and legumes suitable for various agro-climatic conditions *are given in Appendix II.*

The above types of population manipulation are being carried out at IGFRI in order to improve the energy output and to provide additional advantages for a better rural life. The whole theme is illustrated in Fig. 3 from the point of view of possible benefits to the rural environment.

A comparison of soil and water conservation by different vegetation systems shows that grasslands (protected) conserve the most (Table 2). But a combination of trees, grasses and shrubs increases the conservation manifold. The grass-legume-tree combinations have been found to improve not only the soil structure but the fertility status, too : in a natural grassland subjected to annual harvests, the fertility level is maintained even after 8 years, while with fodder crops it deteriorates in spite of fertilizers and other inputs. Soil amelioration through leguminous nitrogen fixation is illustrated in Table 3. This has a greater significance to rural agriculture in view of the shortage and high price of inorganic fertilizers and a limited soil moisture status in general.

This system also ameliorates the general environment.

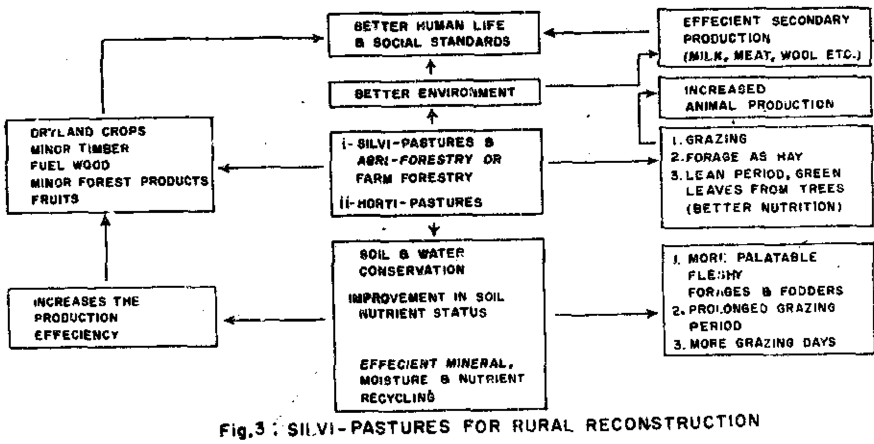
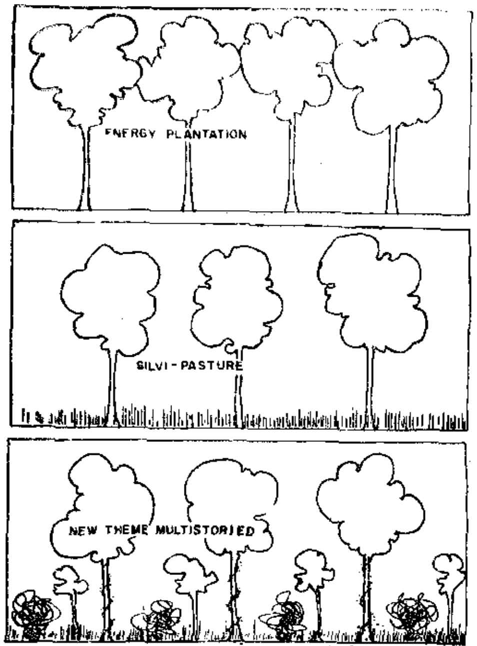


Fig.3 : SILVI-PASTURES FOR RURAL RECONSTRUCTION



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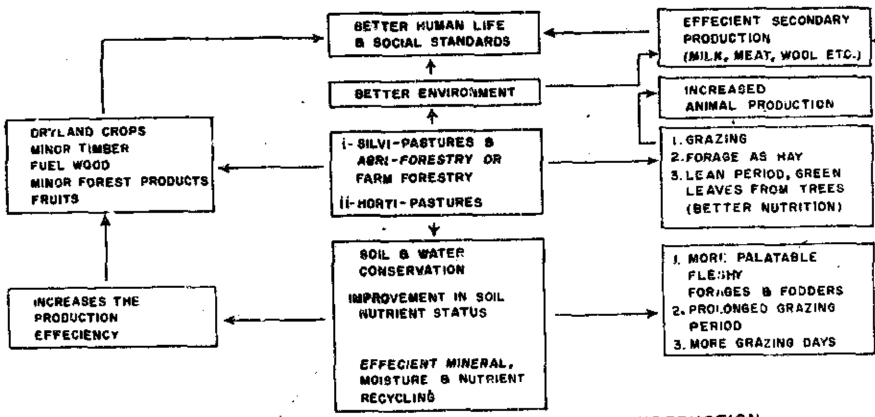


Fig.3 : SILVI-PASTURES FOR RURAL RECONSTRUCTION

2. *Humid Bengal-Assam region:* Azadirachta indica; Dalbergia sissoo; Emblica officinalis; Peltophorum pterocarpum; Pithecellobium dulce; Pongamia pinnata; Albizzia lebbek; A. stipulata; Artocarpus heterophyllus; Bauhinia sp.; Leucaena latisiliqua; Moringa oleifera; Morus alba; Syzygium cumini; Tamarindus indica; Ecalyptus sp.

3. *Humid eastern Himalayan region and Islands:* Eucalyptus globulus; Pongamia pinnata; Quercus semicarpifolia; Salix tetrasperma; Albizzia chinensis; Artocarpus heterophyllus; Bauhinia sp.; Moringa oleifera; Morus serrata; Syzygium aqueum; Pongamia pinnata; Mesua ferrea; Populus ciliata.

4. *Sub-humid Sutlej-Ganga alluvial plains:* Acacia nilotica; A. tortilis; Anogeissus latifolia; A. pendula; Azadiracuta indica; Dalbergia sissoo; Kydia calycina; Morus alba; Pithecellobium dulce; Pongamia pinnata; Zizyphus mauritiana; Ailanthus excelsa; Albizzia lebbek; A. procera; A. amara; Bauhinia variegata; Cordia dichotoma; Hardwickia binata; Leucaena latisiliqua; Cordia dichotoma; Moringa oleifera; Adina cordifolia; Bridelia retusa; Schleichera trifuga; Gmelina arborea.

5. *Sub-humid/humid eastern and south eastern upland regions:* Acacia nilotica; Anogeissus latifolia; Azadirachta indica; Cordia dichotoma; Dalbergia sissoo; Delonix elata; Emblica officinalis Grevillea robusta; Hardwickia binata; Kydia calycina; Pithecellobium dulce; Pongamia pinnata; Zizyphus mauritiana; Ailanthus excelsa; Albizzia chinensis; A. lebbek; A. amara; Artocarpus heterophyllus; Bauhinia purpurea; B. variegata; Moringa oleifera; Morus alba; Leucaena latisiliqua; Mimusops hexandra; Glyricida maculata.

6. *Arid western plains:* Acacia tortilis; Azadirachta indica; Cordia rothi; Hardwickia binata; Morus alba; Parkinsonia aculeata; Pithecellobium dulce; P. seman; Salvadora oleoides; Tamarix sp.; Zizyphus mauritiana; Ailanthus excelsa; Albizzia lebbek; Hardwickia binata; Moringa oleifera; Tecomella undulata; Eucalyptus sp.; Prosopis cineraria; P. juliflora.

7. *Semi-arid/lava plateaux and central highlands:* Acacia auriculiformis; A. nilotica; Casuarina equisetifolia; Cordia rothi; Emblica officinalis; Kydia calycina; Morus alba; Pithecellobium dulce; Pongamia pinnata; Tamarindus indica; Tamarix sp.; Zizyphus mauritiana; Ailanthus excelsa; Albizzia amara; A. lebbek; Bauhinia variegata; Hardwickia binata; Leucaena latisiliqua; Moringa oleifera; Tecomella undulata; Eucalyptus sp.; Glyricida maculata; Thespesia populnea.

8. *Humid and semi-arid western Ghats:* Acacia auriculiformis; A. melanoxylon; A. nilotica; Aplanifrous; Albizzia amara; A. procera; Anageissus latifolia; Cassia auriculata; Casuarina equisetifolia; Eucalyptus sp.; Grevillea robusta; Kydia calycina; Morus alba; Peltophorum pterocarpum; Pithecellobium dulce; Pongamia pinnata; Zizyphus mauritiana; Aegle marmelos; Ailanthus excelsa; Cordia dichotoma; Hardwickia binata; Leucaena latisiliqua; Moringa oleifera; Tamarindus indica; Glyricida maculata; Mesua ferrea; Thespesia populnea.

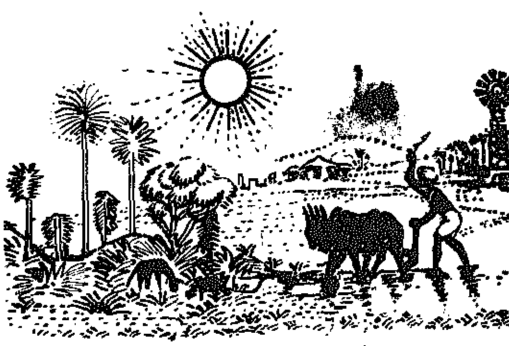
Appendix II

Species suitable for the proposed three-tier and silvi-pasture systems of production in different ecolcgical zones
(Tree species as listed in Appendix-I for every region)

1. Temperate and humid western Himalayan region
Shrubs: Grewia oppositifolia; Leucaena latisiliqua; Dichrostachys nutens; Banhinia sp.; Sesbania sesban.
Grasses & legumes: Themeda anathera; Chrysopogon fulvus; Arundinella nepalensis; Heteropogon contortus; Cenchrus ciliaris; Setaria anaps; Phaseolus atropurpureus; Stylosanthes hamata; Phleum pratens; Muhlenbergia duthieana; Poa pratensis; Dactylis glomerata; Medicago sp.; Trifolium subterraneum.

2. Humid Bengal-Assam region
Shrubs: Leucaena latisiliqua; Sesbania grandiflora; S. sesban; S. microcarpa; Banhinia. sp.; Desmanthes virgatus; Desmodium uncinatum; Morus alba; Moringa oleifera.
Grasses & legumes: Setaria anceps; Pennisetum pedicellatum; Panicum antidotale; Chrysopogon aciculatus; Marenga porphyrocoma; Panicum notatum; Arundinella bengalensis; Atylosia scaraboides; Desmodium uncinatum; Pureria thunbergiana; Clitoria terneata; Vicia sp.; Glycine javanica; stylosanthes hamata.

3. Humid eastern Himalayan region and Islands
Shrubs: Desmodium cephalotus; Leucaena latisiliqua; Sesbania grandiflora; S. sesban; Moringa oleifera; Morus alba; Desmanthes virgatus.
Grasses & legumes: Setaria anceps.



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6. *Arid western plains:* Acacia tortilis; Azadirachta indica; Cordia rothi; Hardwickia binata; Morus alba; Parkinsonia aculeata; Pithecellobium dulce; P. seman; Salvadora oleoides; Tamarix sp.; Zizyphus mauritiana; Ailanthus excelsa; Albizzia lebbek; Hardwickia binata; Moringa oleifera; Tecomella undulata; Eucalyptus sp.; Prosopis cineraria; P. juliflora.

7. *Semi-arid/lava plateaux and central highlands:* Acacia auriculiformis; A. nilotica; Casuarina equisetifolia; Cordia rothi; Emblica officinalis; Kydia calycina; Morus alba; Pithecellobium dulce; Pongamia pinnata; Tamarindus indica; Tamarix sp.; Zizyphus mauritiana; Ailanthus excelsa; Albizzia amara; A. lebbek; Bauhinia variegata; Hardwickia binata; Leucaena latisiliqua; Moringa oleifera; Tecomella undulata; Eucalyptus sp.; Glyricida maculata; Thespesia populnea.

8. *Humid and semi-arid western Ghats:* Acacia auriculiformis; A, melanoxylon; A. nilotica; Aplanifrous; Albizzia amara; A. procera; Anageissus latifolia; Cassia auriculata; Casuarina equisetifolia; Eucalyptus sp.; Grevillea robusta; Kydia calycina; Morus alba; Peltophorum pterocarpum; Pithecellobium dulce; Pongamia pinnata; Zizyphus mauritiana; Aegle marmelos; Ailanthus excelsa; Cordia dichotoma; Hardwickia binata; Leucaena latisiliqua; Moringa oleifera; Tamarindus indica; Glyricida maculata; Mesua ferrea; Thespesia populnea.

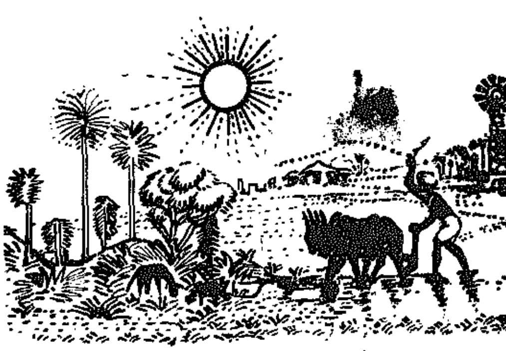
Appendix II

Species suitable for the proposed three-tier and silvipasture systems of production in different ecolcgical zones
(Tree species as listed in Appendix-I for every region)

1. Temperate and humid western Himalayan region
Shrubs: Grewia oppositifolia; Leucaena latisiliqua; Dichrostachys nutens; Banhinia sp.; Sesbania sesban.
Grasses & legumes: Themeda anathera; Chrysopogon fulvus; Arundinella nepalensis; Heteropogon contortus; Cenchrus ciliaris; Setaria anaps; Phaseolus atropurpureus; Stylosanthes hamata; Phleum pratens; Muhlenbergia duthieana; Poa pratensis; Dactylis glomerata; Medicago sp.; Trifolium subterraneum.

2. Humid Bengal-Assam region
Shrubs: Leucaena latisiliqua; Sesbania grandiflora; S. sesban; S. microcarpa; Banhinia. sp.; Desmanthes virgatus; Desmodium uncinatum; Morus alba; Moringa oleifera.
Grasses & legumes: Setaria anceps; Pennisetum pedicellatum; Panicum antidotale; Chrysopogon aciculatus; Marenga porphyrocoma; Panicum notatum; Arundinella bengalensis; Atylosia scaraboides; Desmodium uncinatum; Pureria thunbergiana; Clitoria terneata; Vicia sp.; Glycine javanica; stylosanthes hamata.

3. Humid eastern Himalayan region and Islands
Shrubs: Desmodium cephalotus; Leucaena latisiliqua; Sesbania grandiflora; S. sesban; Moringa oleifera; Morus alba; Desmanthes virgatus.
Grasses & legumes: Setaria anceps.



Solar energy for rural development

Solar energy could be a boon for Indian villages, particularly the ones situated away from industrial centres. Pumping irrigation water, drying and processing agricultural products, producing potable water from brackish water, cooking, lighting, and entertainment are some of the important fields of solar energy application for rural areas, which need to be given priority in our developmental efforts.

DR. H.P. GARG
Head, Solar Energy Studies Section, Central Arid Zone Research Institute, Jodhpur

The enormousness of the world's present rate of energy consumption can be gauged from the fact that, in the USA, for one food calorie available at the table for human consumption, about 10 calories of industrial energy are consumed in production, processing and distribution. Thus, at the present alarming rate of energy consumption, it may be safe to predict that all the stored energy of the Earth will last for only a few decades.

India is essentially an agricultural country, with 80% of the population living in villages and 50% of the gross national product coming from the agricultural sector. In our villages, both commercial fuels like coal, oil and electricity and non-commercial fuels like dried dung, firewood and agricultural waste are being used; besides these, human and animal power is also used for various applications. However, for most of the operations, the energy from human and animal power and from non-commercial energy sources is derived in a most inefficient way. Moreover, increasing use of firewood results in deforestation leading to soil and water erosion and a disturbed ecosystem; and cowdung and agricultural waste, if used as manure, can bring about a tremendous increase in our agricultural production.

There are about 4,51,500 villages in the country with a population less than 1,000. In these villages, where the energy requirement is low and which are thinly populated and away from the industrial centres, solar energy could be an attractive alternative. It can meet small localized needs and can be put to a number of applications in rural areas.

Availability of solar energy

Because of its comparatively small size and large distance (149 million km) from the Sun, the Earth receives only 0.000000005th part of solar energy output. Outside the Earth's atmosphere, the average solar radiation intensity is 1.36 kw/m^2 or 1.94 cal./cm^2/min. on a surface normal to the direction of radiation. This radiation is further rarefied by the atmosphere due to reflection, scattering and absorption and also by geometrical factors, so that the Earth receives direct and diffuse solar radiation which is variable and intermittent with a maximum value of 1.2 kw/m^2.

There is at present a network of 30 stations (Fig. 1) in the country for recording total solar radiation on horizontal surface, under the control of India Meteorological Department. The monthly means of daily total solar radiation in respect of 20 of these stations are

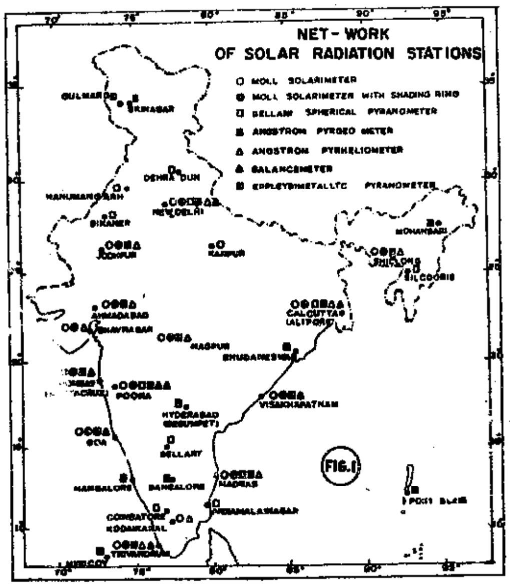


Table 1—Monthly means of total solar radiation (cal./cm^2/day) on horizontal surface at 20 Indian cities

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1. Minicoy	470	488	508	499	423	376	378	412	431	412	420	402	435
2. Trivandrum	503	538	563	530	470	449	416	458	499	448	425	442	478
3. Kodaikanal	508	562	555	535	550	445	374	397	421	383	405	453	462
4. Port Blair	403	486	515	492	307	306	300	247	361	346	342	374	373
5. Mangalore	455	518	551	541	503	359	293	353	413	421	411	431	427
6. Bangalore	472	493	596	587	556	443	354	366	405	412	388	417	466
7. Madras	441	539	584	581	559	498	449	474	482	425	367	376	481
8. Goa	484	541	579	599	588	434	329	436	467	490	467	453	490
9. Hyderabad	409	505	521	533	579	461	334	352	339	392	347	394	431
10. Visakhapatnam	451	521	553	567	576	425	395	444	438	445	441	427	473
11. Poona	445	524	578	611	620	514	388	392	448	487	435	409	487
12. Nagpur	420	500	543	583	598	505	379	367	433	488	442	390	471
13. Bhavnagar	431	502	588	614	655	547	389	369	505	515	446	394	496
14. Calcutta	357	417	480	528	542	413	394	392	367	381	386	350	417
15. Ahmedabad	410	493	563	623	650	565	413	405	480	496	420	387	492
16. Shillong	316	449	437	467	493	363	327	351	293	351	343	333	377
17. Jodhpur	399	467	557	627	651	619	513	485	520	497	421	375	511
18. New Delhi	341	430	518	584	627	569	443	432	474	454	386	323	465
19. Gulmarg	265	303	346	425	411	491	406	337	365	293	291	223	346
20. Srinagar	175	247	386	493	593	628	583	506	427	322	278	172	401

shown in Table 1. This represents the available potential for installation of solar energy appliances utilizing total solar radiations. It can be seen that the maximum radiation (annual mean) is received at Jodhpur (511 cal./cm^2/day), an arid region, followed by Bhavnagar, Ahmedabad, Bangalore, Hyderabad, New Delhi and Poona, which come under semi-arid regions of the country. Further, the maximum solar radiation is received in May at most of the north Indian stations (400-651 cal./cm^2/day) and in March or April at most of the peninsular stations (500-600 cal./cm^2/day). Minimum radiation is received during the winter season or in the monsoon season. These figures clearly indicate the enormous potentiality of solar energy utilization in our country.

Solar cooking

According to a recent report of the United Nations Environment Program (UNEP) published on the eve of the World Environmental Day, the real energy crisis is shortage of firewood for one-third of the world population, and it has urged 'mass tree planting schemes' and development of alternative cooking devices like solar and biogas cookers. This crisis is so severe that, at many places, the task of collecting wood which used to take an hour or two now takes a whole day.

In rural India cooking is done mainly by firewood, dung cake and vegetable waste, which together account for 94.6% of the total fuel consumption; and out of this, firewood provides the major share—58.6% (Table 2).

The amount of energy obtained from non-commercial sources in India in terms of coal equivalent over the last 20 years is shown in Table 3. It shows that in 1971-72, 191.3 million tonnes (coal equivalent) of non-commercial fuels (20.0 million tonnes of dung, 138.2 million tonnes of firewood, and 33.1 million tonnes of agricultural waste) were burnt in India for cooking purposes, and this constituted about 50% of the total energy need of the country. These fuels, when used directly as fuel, are of least economic value, and the villagers have to spend little money for procuring them. However, the agriculture sector can benefit immensely if cow-dung and agriculture waste are used as organic manure rather than

Table 2—Pattern of fuel consumption in rural India

Fuel	Percentage share
A. *Commercial*	
Soft cake	1.6
Kerosene	3.8
Electricity, gas etc	nil
B. *Non-commercial*	
Firewood	58.6
Dung cake	21.0
Vegetable wastes	15.0
Total	100.0

burnt at a low efficiency of only 10%. In view of this enormous indirect economic cost to the country, the National Commission on Agriculture has recently declared the use of cow-dung as fuel virtually a crime. In this context, solar energy offers a ready alternative to domestic fuel if harnessed economically through cheap solar cookers.

Though the technology of solar cookers is simple, their advantages could be significant if used extensively. Generally, solar cookers are made up of a single or multiple plane reflector with a hot box arrangement and/or of spherical parabolic reflector of average precision. The materials used in their construction are wood, aluminium and iron sheets and tubes, plastics, glass, mirrors etc.

The paraboloidal type cooker was first developed in India in 1950 and was then modified in other countries like USA and Burma. The plane mirror type cooker was first developed in USA and was later modified in India. A more stable and dependable cooker comprising a number of highly polished concave glass mirrors has been developed in Israel. A solar steam cooker comprising a flat-plate collector and an insulated box at the top for boiling food has been developed in Canada.

Recently a systematic techno-economic study on the development and field use of solar cookers was undertaken at Central Arid Zone Research Institute (CAZRI) Jodhpur, and as a part of this study, five different types of solar cookers/ovens were designed, fabricated and tested in the laboratory by the author. Out of these five solar cookers, the solar oven shown in Fig. 2 was found to be the best. It comprises four square and four triangular plane glass reflectors and a well insulated semi-cylindrical box at the back made of sheet aluminium and wood on an angle iron stand designed for adjusting the equipment towards the sun. A cradle-like cooking platform made in the oven helps in keeping the vessel containing the food horizontal irrespective of the inclination of the oven. The suitability of glass reflector, chromium plated reflector, anodized aluminium reflector and aluminium reflector was also studied. It was observed that the maximum temperature in the solar oven with a looking glass reflector reached 350°C in summer and 250°C in winter.

Practically all types of food can be cooked with this solar oven. Some of the cooking tests conducted on this oven are given in Table 4. The Table shows that practically all types of dish can be prepared with this oven within 30-45 minutes. Its other advantages are: (i) its performance is not affected by wind; (ii) there are no chances of dust falling in the cooking pot; (iii) the food

Table 3—Consumption of non-commercial fuels in India in terms of million tonnes of coal replacement

Year	Dung	Firewood	Waste	Total	Total energy need (%)
1953-54	18.6	82.2	25.1	125.9	68
1955-56	19.6	84.4	26.3	130.3	67
1960-61	21·6	95.3	29.2	146.1	60
1962-63	22.0	96.8	29.6	148.3	55
1965-66	17.6	120.1	31.1	168.8	53
1968-69	19.7	135.1	32.6	187.4	52
1971-72	20.0	138.2	33.1	191.3	50
1978-79 (expected)	20.0	144.0	44.0	208.0	30

Table 4—Cooking trials on a new solar oven developed at CAZRI, Jodhpur

Type of food	Cooking time (minutes)
1. *Cooking*	
(a) Rice (1 kg in water)	45
(b) Potatoes (1 kg in water)	50
(c) Arhar dal (1 kg in water)	75
(d) Other vegetables (1 kg in water)	60
2. *Roasting*	
(a) Potatoes (1 kg)	60
(b) Chicken (1.5 kg)	60
(c) Fish (1 kg)	20
3. *Baking*	
(a) Cake (1 kg)	50
4. *Boiling*	
(a) Tea (4 cups)	25
(b) Milk (1 litre)	45
(c) Water (1 litre)	45

Fig. 2. Solar oven with octagonal silvered glass reflector, developed at CAZRI, Jodhpur.

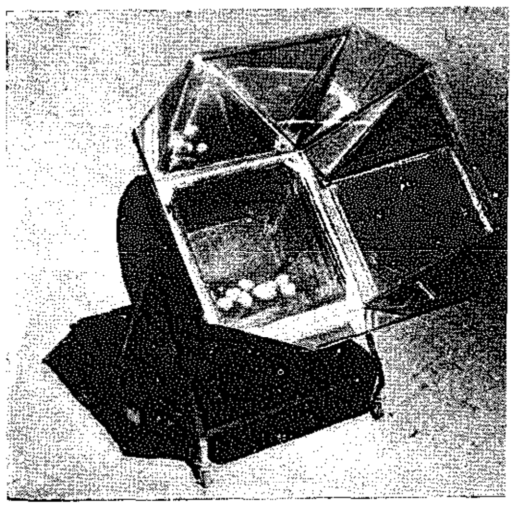


Table 5—Distribution of villages according to population (1971) and number/percentage of villages electrified

Population	Total	Electrified	Percent
Less than 500	318611	35047	11
500 to 999	132873	35876	27
1000 to 1999	81909	34402	42
2000 to 4999	35992	24834	69
5000 to 9999	4975	3980	80
10000 and above	1358	1249	92
Total	575718	135388	24

Table 6—Estimated energy availability for pumping water (million kwh)

Year	Human/animal power	Diesel engines	Electric motors	Total
1968-69	2746.6	1000.5	1543.9	5295.0
1973-74	2365.8	1813.2	3973.1	8152.1
1978-79	2178.0	1905.2	6778.4	10861.6
1983-84	1932.2	3264.5	7573.4	12770.1
1988-89	1642.9	2627.4	10234.2	14504.5
1993-94	1294.4	3107.4	12153.5	16555.3
1998-99	893.1	3620.9	14207.9	18721.9

remains warm for hours if kept inside the oven even after sunset; and (iv) it does not require frequent adjustment towards the sun.

Solar pumping

To increase agricultural production and per capita income it is essential to increase the energy input in the rural India. To achieve the production level of 2,000 kg/hectare to meet the requirement of 3,000 food calories day per person in India, at least 0.75 hp/hectare of energy input is required as against 0.35 hp/hectare available now.

The major ingredients of an agricultural system are soil, sunlight, water, plants and animals. We are rich in respect of all these ingredients, but ours is one of the least productive farming system because of inadequate availability of energy in rural areas. There is a vast scope for multiple and relay cropping provided more power is available for lifting water from wells and other sources, which are at present under-utilized.

The total number of villages in India categorized according to ranges of population with number and percentage of those which are electrified is shown in Table 5. Only 3,061 out of 5.76 lakh villages were electrified before the beginning of the first Five Year Plan; up to March 1971, 24% or over 1.35 lakh of these villages had been electrified; and by 31 March 1974, 27.3% or 1.55 lakh villages had come under the electrification scheme. The remaining villages are so widely dispersed, thinly populated, and with low energy demands that their electrification would be highly uneconomical—indeed, even the interest on the total investment would not be recovered. Thus, for a long period, these villages will remain without electricity and, hence, without electrically operated pumping sets.

There are about 4.51 lakh villages in India with a population less than 1,000 (Table 5). The daily energy requirement of these villages is estimated at 500-600 kwh (cooking 200 kwh; irrigation 250 kwh; lighting & entertainment 100 kwh). Until now, this energy has been obtained from non-commercial energy sources and human/animal power. The pattern of energy availability from different sources — human, animal, diesel and electricity — for pumping water over the period 1968 to 1999 is shown in Table 6. It can be seen that by 2000 AD the consumption of diesel fuels and electrical energy would increase by about 200% and 300%, respectively, over the 1973-74 level.

The development of a small solar pump of 2-5 kw capacity for irrigation purposes can result in an agricultural revolution. In most of the arid areas and in some parts of semi-arid areas, the major portion of our agricultural land is rainfed, and if some portion of this land is brought under irrigation then crop production could be substantially increased. As the power requirement for this purpose is localized and scattered in small pockets, a small self-sustained energy unit would be very useful. Since the requirement of water and solar radiation availability are quite in phase, its utilization would be more stable than electrical and diesel engine pumps which are adversely affected by periodic power breakdowns and shortage of conventional fuels.

Solar pumps can be energized by converting solar energy into either electricity (by solar cells) or mechanical power. Solar pumps based on direct conversion of solar energy into electricity using solar cells are at present highly uneconomical, while those based on conversion of solar energy into mechanical energy are not only feasible but have been successfully tried in France, USA, USSR and Israel.

A low temperature solar engine (LTS engine) developed in France for lift irrigation is shown in Fig. 3. The operating principle of this pump is the opposite that of a refrigerator. It uses a large number of flat-plate collectors to heat water up to 70°C by thermo-syphon action in a heat exchanger, where the heat is taken up by a low boiling liquid (like methyl chloride or butane) which evaporates and produces a high pressure, actuating a reciprocating engine. This engine runs a hydraulic press which operates a pump immersed in water in the well. Having done the mechanical work, the vapours at low pressure reach the condensor which is cooled by the pumped water, and the condensed liquid is pumped back for the next cycle by a small re-injetion pump coupled to the engine.

This solar pump was fabricated by the French research organization SOFRETES. It uses a number of heat exchangers and operates four water pumps and, therefore, its overall efficiency is very low: only 1%; besides, a 3 kw pump costs about Rs 1 lakh. The cost can be brought down by a factor of 2 if these pumps are mass produced and the collectors, which account for a major portion of the cost, are integrated into the roofs of buildings.

It is obvious that, because of their very high capital cost and high maintenance and running expenses, these solar pumps cannot be used as such in our rural areas. Perhaps a simple, efficient and low pressure vapour engine or turbine could be developed for converting solar energy into mechanical energy so that water could be pumped by using centrifugal or reciprocating type pumps. But here again some maintenance and running expenses would be involved and the capital cost would still be higher than conventional pumps.

A novel idea being tried by the author at CAZRI, Jodhpur for solar energy does not involve much capital and running costs. In this pump, a number of 'Bonduct' type flat-plate collectors made out of aluminium sheets (developed for the first time in India by a Poona firm) are used. The efficiency of these collectors is much higher than of those used in other solar pumps. A low boiling point organic liquid (like ether) passing through these collectors evaporates to give a very high pressure. The condensation and vapourization of the liquid makes the diaphragm of a diaphragm pump move back and fourth, which causes pumping of water.

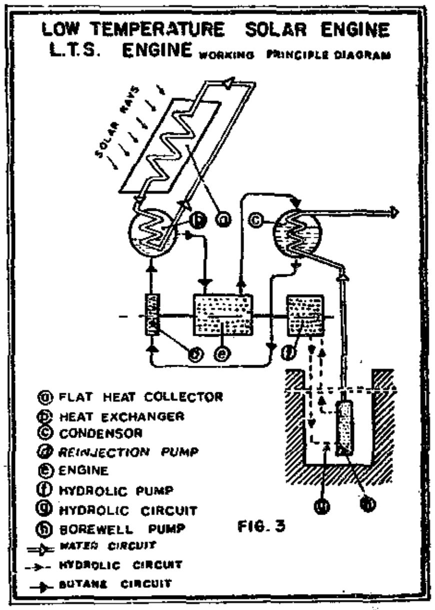


FIG. 3

This solar pump is suitable for pumping water even against high heads. It is free from vibrations and it needs little maintenance. Flat-plate collectors and a diaphragm pump which can operate at a low pressure have already been fabricated and their performance tested by the author. This pump has no moving parts and has a lesser number of heat exchangers, and hence its overall efficiency would be higher and capital cost and running expenses lower than other types of solar pumps.

Rural lighting and entertainment

In India 80% of the people live in villages and out of a total 5,75,718 villages only 1,35,388 are so far electrified. The remaining 4,40,330 villages are without electricity due to low population, low energy demand, or distant location from central electricity grid systems. In these villages, either kerosene or mustared oil lamps are used for lighting purposes. And there is almost no communication system. For such villages, the sun could be an ideal source of energy for lighting and entertainment through radio and television.

Direct conversion of solar energy into electricity by means of semiconductor photovoltaic cells (solar cells) is receiving worldwide attention. During the last two decades, solar cells have been widely used in space applications to power satellite systems. Until 1972, over 600 US satellites and about 400 USSR satellites have used solar cells as primary sources of electrical power. These solar cells are of extremely high quality and. therefore, they cost at the rate of about Rs 1,000/watt. Such high quality cells are not required for terrestrial applications, but for their widespread use on earth the cost per watt must be reduced by at least 100 times, and they have to be made resistant to wind, dust, precipitation, humidity etc.

The standard solar cell available today employs the same material as was used a decade ago. These cells are n-on-p type silicon p-n junctions, with a contact grid structure on the negative electrode side. These are fabricated by diffusing an n-type impurity (generally phosphorus) in a p-type single crystal silicon wafer. The base material could be of an n-type wafer which will require diffusion of a p-type impurity to achieve a junction. Though the theoretical efficiency of the silicon solar cell is about 22%, the actual efficiency of the cells made so far is 15.5%.

The first solar cell was developed in USA in 1954, and since then considerable improvement in performance has been achieved. Solar cells are now made in a number of countries, like USA, USSR, France, and Japan. In India, work on solar cells was started at the Indian

Institute of Technology, New Delhi in 1965 and the Solid State Physics Laboratory, New Delhi in 1966. Both these institutions have developed solar cells with up to 10% efficiency. But these cells are very costly and require further research and development to improve their efficiency and life.

Recently, the Department of Science & Technology, Government of India, has established an institution named Central Electonics Limited (CEL) to carry out R & D work on solar cells and also to co-ordinate research effort in this field. According to CEL, by 1985, three million rural families in India will be able to generate their own electricity for lighting purposes and for operating radios, using solar cells.

In this direction, preliminary experiments carried out in some villages in Pakistan by the Atomic Energy Commission (Pakistan) are encouraging. They have developed with imported solar cells two solar lighting kits, one each of 2-watt and 5-watt ratings, providing 13 and 25 candle-power light, respectively, which is about 5 times more than the light produced by kerosene or mustered oil lamp. Each kit contains a panel of solar cells along with Ni-Cd storage batteries.

These kits can not only provide light for a small house but also power to run radio, fan and TV. However, at the present stage of technology, the cost of these solar kits is very high and, therefore, a major technological effort is imperative on the development of suitable materials, techniques and processes for large scale, low cost production of solar cells. The attention of scientists all over the world is focussed on this goal, and it is not unlikely that by the turn of the present decade we may have solar cell power stations on the Earth.

Solar desalination

Solar distillation is a simple technology but is full of promise for areas where potable water is not available for drinking purposes, such as some arid regions of Rajasthan, Haryana and Gujarat and some Coastal areas. Distilled water is also required by laboratories, petrol pumps, health centres etc. Moreover, solar stills can be very useful in isolated places like light-housses and salt farms.

In some thinly populated villages the underground water is unfit for drinking because of high salinity, which may vary from 5,000 ppm to 10,000 ppm. The only source of drinking water in these villages is the rain water collected in *tankas*. So acute is the scarcity of drinking water in some of these villages that one to two family members are constantly busy going miles away in search of fresh water.

Solar energy, available in abundance and at the site, can be conveniently used for converting brackish/saline water into distilled water. Nature is a very efficient and automatic solar distiller : water evaporated from oceans, lakes, rivers etc due to heating by solar radiation, and carried away by the wind, gets precipitated in the form of rain at comparatively cooler places. The same phenomenon occurs on a small scale in a solar still. The entire process of evaporation, condensation and collection in a solar still, with various uses of distilled water, is shown in Fig. 4.

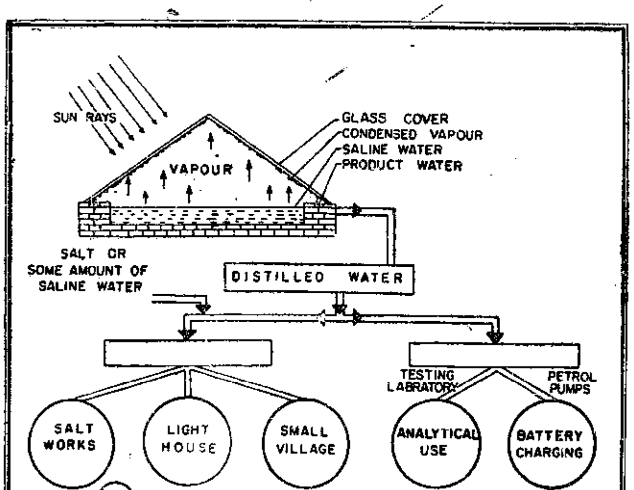


FIG.4 SOLAR STILL PROCESS AND SOME OF THE USES OF DISTILLED WATER

The first solar still in the world was set up by Carlos Wilson in 1872 at Las Salinas in the province of Antofagasta, Chile, with a built-in area of 4,700 m^2 and a capacity of about 20 m^3 of distilled water per day during summer. It worked until 1910. The interest in the solar still was revived in 1954 when a number of countries (USA, Australia, USSR, Greece, Chile, Canada, India etc) started work on it. Table 7 lists 12 of the largest basin-type solar stills that are now working around the world. The size refers to the evaporating area and the capacity to daily yield on year round basis. The capacity to area ratios in respect of all these stills are different which may be because of different climatic and design parameters. All these stills are built on ground with no insulation at the base.

In India work on solar still was started in 1950 at the

the vapours at low pressure reach the condensor which is cooled by the pumped water, and the condensed liquid is pumped back for the next cycle by a small re-injetion pump coupled to the engine.

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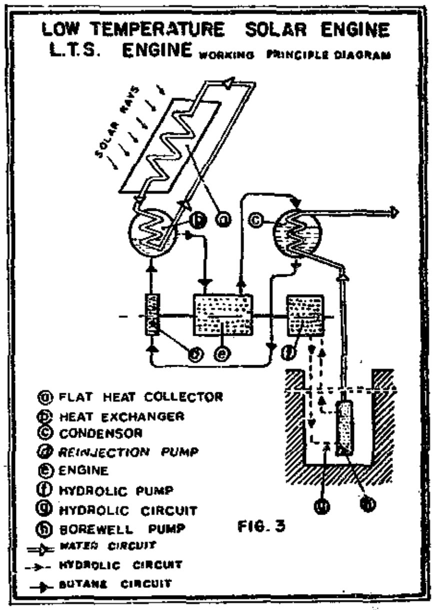

FIG. 3

This solar pump is suitable for pumping water even against high heads. It is free from vibrations and it needs little maintenance. Flat-plate collectors and a diaphragm pump which can operate at a low pressure have already been fabricated and their performance tested by the author. This pump has no moving parts and has a lesser number of heat exchangers, and hence its overall efficiency would be higher and capital cost and running expenses lower than other types of solar pumps.

Rural lighting and entertainment

In India 80% of the people live in villages and out of a total 5,75,718 villages only 1,35,388 are so far electrified. The remaining 4,40,330 villages are without electricity due to low population, low energy demand, or distant location from central electricity grid systems. In these villages, either kerosene or mustared oil lamps are used for lighting purposes. And there is almost no communication system. For such villages, the sun could be an ideal source of energy for lighting and entertainment through radio and television.

Direct conversion of solar energy into electricity by means of semiconductor photovoltaic cells (solar cells) is receiving worldwide attention. During the last two decades, solar cells have been widely used in space applications to power satellite systems. Until 1972, over 600 US satellites and about 400 USSR satellites have used solar cells as primary sources of electrical power. These solar cells are of extremely high quality and. therefore, they cost at the rate of about Rs 1,000/watt. Such high quality cells are not required for terrestrial applications, but for their widespread use on earth the cost per watt must be reduced by at least 100 times, and they have to be made resistant to wind, dust, precipitation, humidity etc.

The standard solar cell available today employs the same material as was used a decade ago. These cells are n-on-p type silicon p-n junctions, with a contact grid structure on the negative electrode side. These are fabricated by diffusing an n-type impurity (generally phosphorus) in a p-type single crystal silicon wafer. The base material could be of an n-type wafer which will require diffusion of a p-type impurity to achieve a junction. Though the theoretical efficiency of the silicon solar cell is about 22%, the actual efficiency of the cells made so far is 15.5%.

The first solar cell was developed in USA in 1954, and since then considerable improvement in performance has been achieved. Solar cells are now made in a number of countries, like USA, USSR, France, and Japan. In India, work on solar cells was started at the Indian

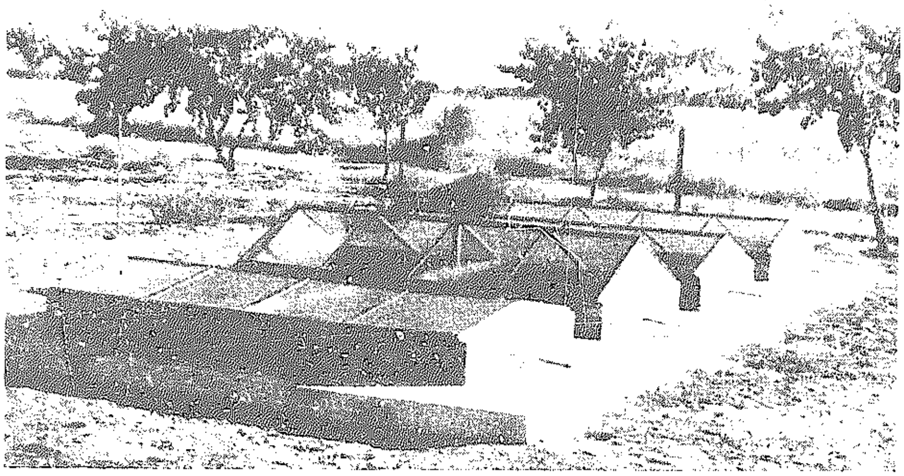

Fig. 5 Experimental solar stills at CAZRI, Jodhpur.

Table 7 -Major solar stills of the world

No	Place	Country	Size (m^2)	Year of instal-lation	Capacity (litres/day)
1.	Coober Pedy	Australia	3158	Nov. 1966	7630
2.	Griffith	Australia	413	Aug. 1967	1090
3.	Quillagua	Chile	100	1968	480
4.	Aegina	Greece	1490	Oct. 1965	5090
5.	Patmos	Greece	8640	July 1967	31320
6.	Kimolos	Greece	2508	1968	9080
7.	Bhavnagar	India	377	Oct. 1965	1090
8.	Las Marinas	Spain	870	Mar. 1966	3090
9.	Chakmou	Tunisia	440	1967	640
10.	Bakharden	USSR	600	Apr. 1969	1950
11.	Petit St. Vincent	West Indies	1710	Feb. 1967	5900
12.	Haiti	West Indies	223	June 1969	910

National Physical Laboratory, New Delhi where experiments were conducted on concentrator type and flat-basin type stills. Unfortunately, this work was discontinued after a few years. The Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar started work on solar stills in 1964, first with a small laboratory model (basin area 0.316 m^2) and subsequently with a pilot plant solar still (basin area 377 m^2; capacity 1,090 litres/day). The CSMCRI has studied the effect of different design variables, like depth and cover angles, on distilled water output, and also the use of indigenous building materials for solar still construction. The designs developed at CSMCRI are available in the published literature or can be obtained from the National Research Development Corporation of India.

The author started work on solar distillation in 1973 at the CAZRI, Jodhpur with the specific aim of optimizing the size of domestic solar stills under Indian arid zone conditions. A number of single-sloped and double-sloped solar stills, both on ground (with and without ground insulation) and raised plateform, were fabricated and hourly data of the distilled water output were collected over a period of two-and-a-half years. A photograph of four experimental solar stills is shown in Fig. 5. The effect on distilled water output of a number of climatic parameters (solar radiation, ambient air temperature, outside wind speed, outside air humidity etc), design parameters (base insulation, cover glass inclination, orientation of still, single-sloped and double-sloped etc), and operational parameters (depth of water in basin, preheating, colouring etc) were experimentally studied. Efforts are now being made to optimize the size of the solar still for both domestic and laboratory use.

Solar drying

Solar energy has been used since times immemorial for open air drying of a number of agricultural products, like hay, cereals, fruits, vegetables, timber, and fish, and non-agricultural products like bricks, salt from sea water, rubber sheets, and paper. In such natural sun-drying

Table 8—Summary of recommendations for drying grains with natural air and heated air

Recommendations	Ear corn	Shelled corn	Wheat	Oat	Barley	Grain sorghum	Soya bean	Rice	Peanut
1. Maximum moisture content of crop at harvesting for satisfactory drying									
(a) with natural air (%)	30	25	20	20	20	20	20	25	45-50
(b) with heated air (%)	35	35	25	25	25	25	25	25	45-50
2. Maximum moisture content of crop for safe storage in a tight structure (%)	11	11	11	11	11	10	9	10	11
3. Maximum relative humidity of air which will dry the crop down to safe storage level, when natural air is used for drying (%)	60	60	60	60	60	60	65	60	75
4. Maximum safe temperature of heated air for drying when the crop is to be:									
(a) used for seed (°C)	45	45	45	45	40	45	45	45	35
(b) sold for commercial use (°C)	55	55	60	60	40	60	50	45	35
(c) used as animal feed (°C)	80	80	80	80	80	80	—	—	—

processes, usually high labour cost, inferior product quality (due to contamination by dirt and insects), product degradation, wastages etc are frequently tolerated. In India, only 0.5% of the 32 million tonnes of fruits and vegetables produced every year are processed and preserved in industries while about 25% of the total production gets spoiled before it reaches the consumers. Similarly, a considerable amount of grains like wheat and paddy is spoiled because of high moisture content at the time of storage. In view of this type of wastages, modern controlled methods like mechanical drying with heated air or steam have become important in recent times, because these methods are independent of weather conditions and give good quality products. However, because of exhorbitant cost of fuels and electricity required for operating mechanical dryers, these have been used only in industries thereby making the final products costlier.

By applying a little technology solar drying may be made more efficient with improved product quality and reduced spoilage. Though this would add a little to the product cost, savings in fuels and electricity can be substantial. Research on solar drying is being carried out in USA, Canada, England, USSR, Australia, France, India, Pakistan, Ethiopia, Portugal, Turkey and Middle East countries.

Solar dryers are basically of two types. In direct drying solar dryers, the material is directly exposed to solar radiation in a hot box-like arrangement so that, due to solar heating and air circulation, the moisture gets vapourized and goes into the atmosphere; these

Table 9—Optimum temperatures for dehydration of fruits and vegetables

Vegetables	*Optimum temperature(°C)*	*Fruits*	*Optimum temperature(°C)*
1. Bitter Gourd (Kerala)	65-70	1. Apples	60-65
2. Brinjal	50-55	2. Apricots	55-60
3. Cabbage	60-65	3. Bananas	50-55
4. Carrot	65-70	4. Grapes	65-85
5. Cauliflower	60-65	5. Peaches	60-70
6. Garlic	55-60	6. Pears	60-65
7. Knol-Khol	50-60	7. Dates	60-80
8. Okra (Lady's finger)	65-70	8. Bers	60-80
9. Onions	60-65	9. Pomegranates	50-60
10. Peas	60-65	10. Figs	50-60
11. Potatoes	60-65		
12. Pumpkin	65-70		
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15. Turnip	50-55		

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Table 1—Economics of a windmill costing Rs 10,000 operating in areas covered by the curves in Fig. 1

Curve no.	Average annual wind velocity (km/hr)	Annual windmill output at 75% duty cycle (kwh)	Recurring annual cost (Rs)	Cost/unit (kwh) energy produced (Rs)
1	12.2	2,227	1,950	0.88
2	9.7	1,059	1,950	1.84
3	6.3	329	1,950	5.93
Hypothetical	20.0	9,702	1,950	0.20

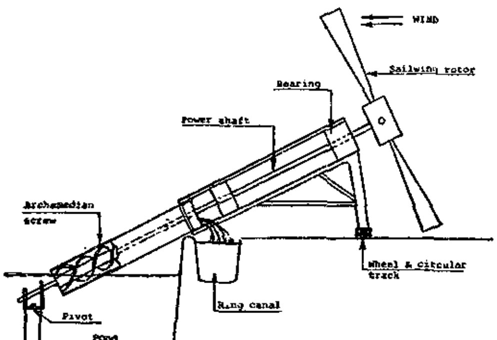


FIGURE 2 - DUTCH SCREW WINDPUMP

on the availability of adequate wind velocity over a period of time sufficient to justify the investment in and maintenance of the energy conversion device. To illustrate, consider a windmill costing Rs 10,000 on which the recurring annual expenditure in terms of interest on capital invested (12%), depreciation (5%) and maintenance (2.5%) is Rs 1,950. The economics of this windmill operating in areas covered by the curves in Fig. 1 can be broadly summarized as shown in Table 1.

The table indicates that the economics of the windmill are favourable for such areas of the country as are indicated in curves 1 and 2, if the cost per unit energy produced by the windmill is compared with the cost of commercial energy, which is about Rs 1.18 per unit (obtained by averaging the relative costs of agricultural electric power, kerosene and diesel oil).

Windmills and their uses

Windmills had been widely used in Persia, China, Europe and the USA for pumping water and grinding grains. Efficient wind electric generators were later developed in the USA, thousands of which produced electricity for farms and homesteads before the advent of rural electrification.

A windmill converts the energy of a moving mass of air into mechanical motion that can be used to either work a machine directly or to turn a generator to produce electricity. The mechanical type windmill and the wind electric generator (aerogenerator) are compared in Table 2.

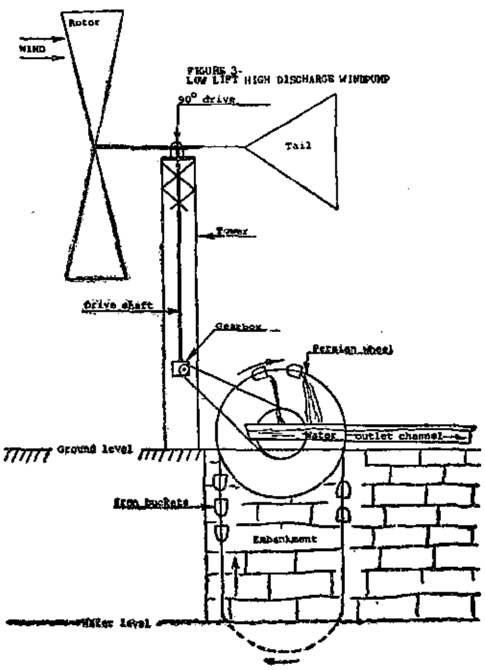


FIGURE 3- LOW LIFT HIGH DISCHARGE WINDPUMP

Windpumps

The windpump is the simplest type of windmill to manufacture and maintain, and is therefore the most relevant to rural India.

Windpumps can be classified into low-lift high-discharge and high-lift low-discharge types. The first type, illustrated in Fig. 2 & 3, can be coupled to Archemedian screw pumps, low speed centrifugal pumps with wooden or metal paddles, pallet pumps, chain washer pumps, double acting reciprocating pumps or Persian wheels similar to the "Halt" used by farmers in Punjab, Haryana and around Udaipur. Such devices can discharge up to 40 litres per second (500 gallons/minute) in a 15 km/hour wind. They can be constructed with local expertize and materials. They have potential for lift irrigation from canals, rivers lakes, tanks and open wells where the water table is 3 metres or less, and for pumping sea water for the manufacture of salt.

The high-lift low-discharge windpump is widely used in the USA, Europe, South America and Australia to pump water from deep wells when the water table is between 12 and 90 metres. The water yielded by tube-wells is biologically pure and can normally be safely used for drinking purposes.

Table 2—Comparison between mechanical type windmill and wind electric generator (aerogenerator)

Sr. No.	Factors determining choice of windmill type	Mechanical type windmill	Aerogenerator
1.	Applications :	*Limited to water pumping and some* mechanical functions like grinding of grains, oil expelling, fodder chop*ping, and operation of simple machi*nery when operating frequency and rpm are not critical.	*Very wide, particularly if stored* power is converted to 220 volts 50 hz ac before distribution.
2.	*Cost of construction :*	Low to moderate, depending on design and choice of materials, ranging between Rs 3,500 and Rs 15,000.	High, usually exceeding Rs 22,000 (excluding electrical storage and distribution systems) according to rated output.
3.	Maintenance :	Simple sailwing windmills need regular attention because of crude construction and choice of materials; commercially manufactured windmills, if properly installed, can work unattended for a year or more.	Limited mechanical maintenance is required, but a technician is needed to regularly attend to the electrical storage and distribution system.
4.	Level of construction technology :	Low : it is possible to construct simple windmills using facilities available at district and *tehsil* towns.	High : efficient aerogenerators operate at high speed and require sophisticated techniques for manufacturing wind rotors, mechanical transmission and generating equipment.
5.	Wind velocity required :	Relatively low : specially designed mills can pump water at a wind velocity of 4 km/hr.	High : aerogenerators operate efficiently at wind velocities of 20 km/hr and higher.
6.	Energy conversion efficiency :	Generally low : efficiency falls and transmission losses increase with increasing wind velocity.	High at optimum windspeed, often approaching 70% of the theoretical maximum conversion efficiency of 59.26%.
7.	Possibility of energy storage for use during calm spells :	Limited : the only feasible method of storage at present is pumping water into overhead tanks; future possibilities are use of large flywheels and operation of compressors *for storage of compressed air.*	Electrical energy is easily stored in accumulators; another possibility is *production and storage of hydrogen* and oxygen by electrolysis of water.
8.	Spatial distribution of energy produced :	Scope limited to water pumping windmills (wind-pumps), when *water stored in tanks can be distri*buted through pipelines and channels.	Distribution of electricity over reasonable distances is easily possible through cables and overhead transmission lines.

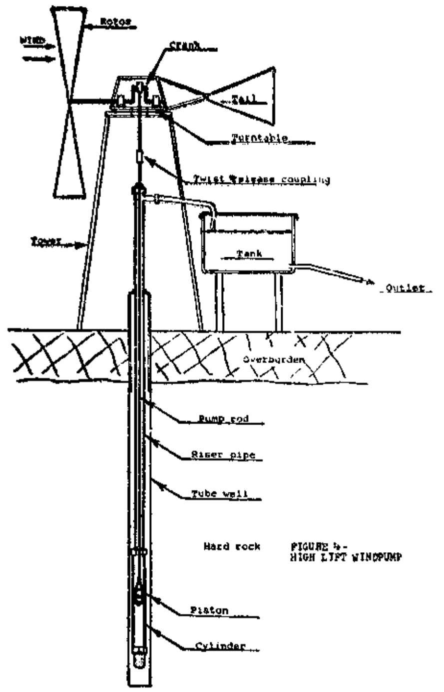


Fig. 6. Deep well windpump built by village artisans, designed by Marcus Sherman.

Fig. 5. Type WP-II deep well windpump developed by the National Aeronautical Laboratory, Bangalore.

Fig. 7. Gearbox and crank mechanism of commercially manufactured deep well windpump.

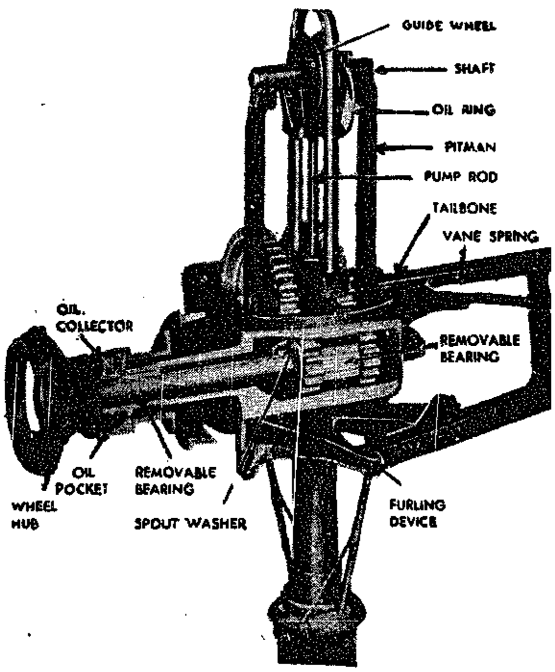


Table 3—Wind velocity and windmill output

Wind velocity (km/hr)	Power output, 5 m dia. rotor (hp)	Pump strokes with 2:1 crank reduction drive (strokes/min.)	Pump discharge (7.5 cm cylinder, 15 cm stroke) (litres/hr)	Power for pump (hp)	Excess power available (hp)
10	0.07	30	1,250	0.07	—
15	0.22	45	1,875	0.105	0.115
20	0.53	60	2,450	0.14	0.39
25	1.00	75	3,125	0.175	0.825

Reciprocating piston pumps with an operating stroke of 12.5 to 25 to cm lend themselves well to windmill operation. Pumps of this type are commercially available in India and are extensively used as deep well handpumps in village water supply schemes.

In the windpump, reciprocating motion is transferred from a crank attached to the rotor shaft via a plunger rod which goes down the water riser pipe, through the top of the pump cylinder located near the bottom of the tubewell, and thence to the piston yoke and bucket-washer assembly. Valves located in the piston yoke and the foot of the cylinder assure positive lift to the column of water at each upward stroke of the plunger. A high-lift windpump system is schematically illustrated in Fig. 4.

Deep well reciprocating pumps have an efficiency of up to 80% and can operate at any stroke frequency up to 50 strokes per minute.

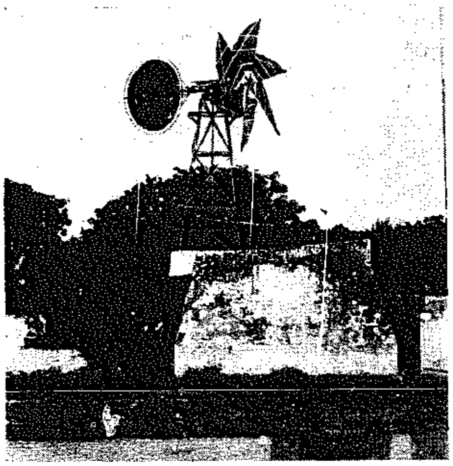
Deep well windpumps have been developed at the National Aeronautical Laboratory, Bangalore, and a number of these along with some imported units are operating in various places in India for supply of protected drinking water to rural communities (Fig. 5, 6 & 7).

Multi-purpose windmills

As wind velocity increases, an increasing amount of power can be extracted from it. At windspeeds above 10 km/hour, more power can be produced than is actually needed for the operation of a deep well pump. Since the windmill output is roughly proportional to the cube of the wind velocity, whereas the shaft horsepower of the pump increases linearly with the pump discharge. The Table 3 enumerates this characteristic.

The wind velocity often exceeds 10 km/hour in many parts of the country (see Fig. 1), particularly between March and September. In such cases, windmills with rotary rather than reciprocating outputs may prove to be more cost effective since they could pump water and, during the windy season, simultaneously operate a variety of agricultural machines and implements used for community services, such as grain grinders, fodder choppers, and oil expellers. A multipurpose windmill of this type, developed by the author, is shown in Fig. 8.

Fig. 8. Multi-purpose windmill to pump water and operate agricultural implements, located at the S.W.R.C., Tilonia, Rajasthan.



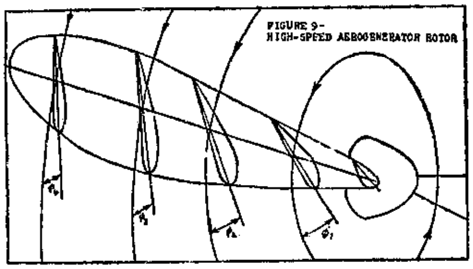


FIGURE 9-
HIGH-SPEED AEROGENERATOR ROTOR

Aerogenerators

Aerogenerators are designed to operate at high rotor-speeds and utilize propeller type rotors shaped to follow conventional aerofoil designs of known aerodynamic characteristics.

In high-speed aerogenerator-rotors (Fig. 9) the aerodynamic lift force, for a given relative wind speed, increases with the angle of attack (ϕ) until it reaches the stalling value of about 15°, after which the lift decreases. For high efficiency, the blade sections must be shaped to have the greatest possible lift and the smallest possible drag. To extract maximum power at each succeeding section along the blade, it is necessary that both its shape and the blade angle, which its principal axis makes with

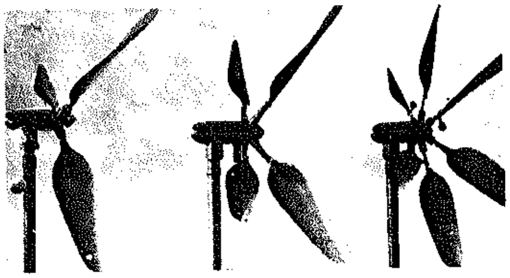


Fig. 10. Aerogenerators with automatic centrifugal rotor pitch control (Rotor blades are made of fibreglass reinforced plastic).

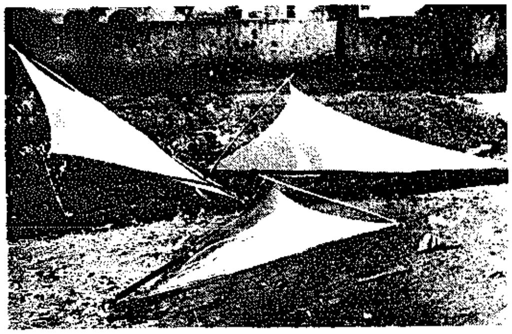


Fig. 11. Bullock-cart wheel, canvas and bamboo windpump rotor.

Fig. 12. Sailwing rotor of multi-purpose windmill.

the plane of rotation, vary to suit the changing magnitude and direction of the relative wind. The smaller the peripheral speed (2π rN) the greater the angle which, for any given wind speed, the relative wind will make with the plane of rotation.

It follows, therefore, that to maintain the best angle of attack, the blade angle should vary continuously along the blade and should be greatest at the root and least at the tip.

$$\phi = \tan^{-1}\left[\frac{R \tan A}{r}\right]$$

where A is the tip angle of attack, R the tip radius, and ϕ the angle of attack for radius r.

The development of the propeller for aircraft in the 1920s, and the commercial availability of storage batteries, catalyzed the development of 'low solidity' windmills for generation of electric power (solidity = ratio of total blade chord to circumference of swept circle at any given radius). Low solidity rotors are not restricted by the actual wind velocity, and can exceed it by 6-10 times.

Either dc generators or ac alternators can be used : dc generators can charge a bank of storage batteries through a voltage regulator similar to the automobile cutout relay, while ac alternators need to operate at constant speed for a constant output frequency. Some aerogenerators have centrifugally operated automatic rotor pitch control which varies the angle of attack of the blades so as to maintain near constant rotor speed despite variations in wind velocity (Fig. 10).

The power stored in batteries can be used directly if dc machinery is available for the load. Alternatively, rotary dc to ac converters, or electronic inverters, are employed to produce alternating current of 220 volts, 50 hz.

The major disadvantage of aerogenerators is their high relative cost and high cost of storage batteries and electricity distribution network. The estimated cost of wind electricity generation, storage and distribution

systems is over Rs one lakh, which may be considered beyond the means of most Indian villages. On the other hand, there is considerable potential for widespread use of much smaller aerogenerators producing about 0.2 kw, which is sufficient to power a radio or a television set. When developed, such devices could be made available at a price that might be considered reasonable in terms of the cost of television set or radio receiver.

Windmill components

The rotor, also called the windwheel, consists of a number of blades or sails disposed radially around a shaft to which they are attached, and which is oriented prallel to the wind direction so that the blades rotate in a plane approximately normal to this direction. The blades may vary in number from one to eighteen or more, may be tapered or of same chord-width throughout, and may be plane or twisted. Their pitch may be fixed or variable and they may either be rigidly mounted or allowed to 'cone' or 'drag' to relieve the stresses set up by rapidly changing windspeeds.

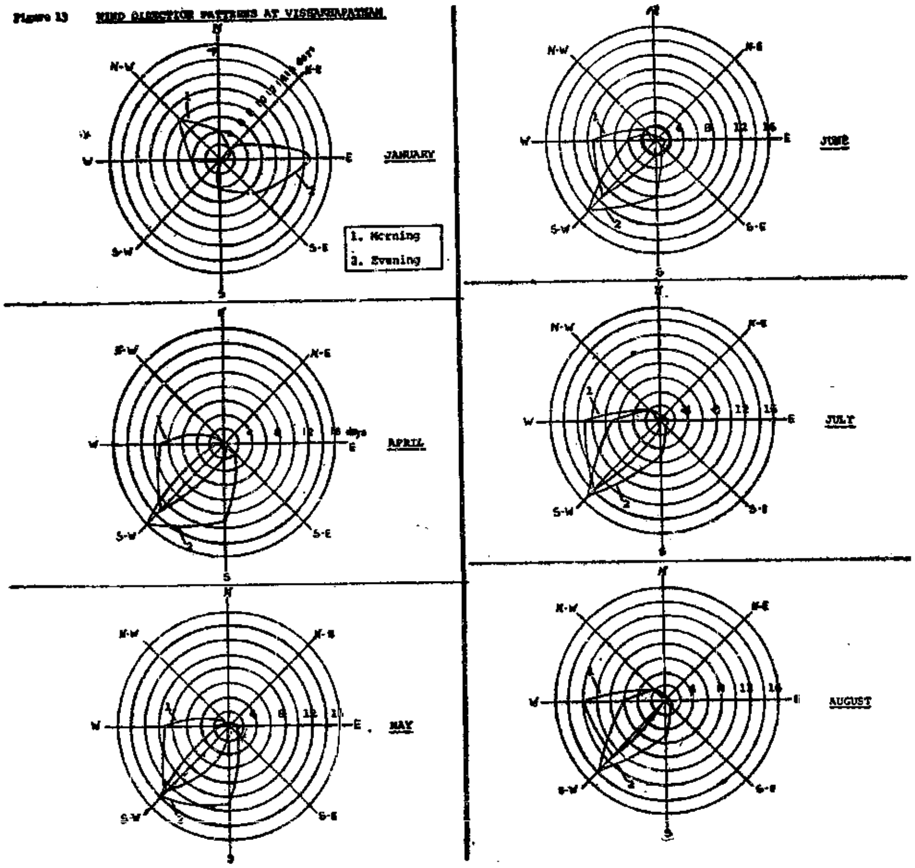
Windpump rotors can be made with strips of sheet steel or aluminium held in position by circular steel frames (Fig.5) or can be fashioned from waterproof cloth stretched between radial poles (Fig. 11 & 12).

Materials for aerogenerator rotors are wood, aluminium or fibreglass reinforced plastics (Fig. 10).

The turntable, usually mounted on a race and resembling a thrust bearing, permits the rotor and power transmission system to 'yaw' or rotate around a central vertical axis to keep the rotor facing up-wind.

It is useful to study the wind direction pattern of a proposed windmill site before the windmill is designed. Locations with marked wind turbulence require windmills fitted with freely-moving turntables, but there are many places in India, particularly along the coastline, where the wind direction does not change more than two or three times a day. Fig. 13 shows the wind direction patterns at Vishakhapatnam during the months of January, April, May, June, July and August. Such uniform patterns indicate that the windmill need not necessarily have provision for automatic 'into-the-wind' orientation,

Figure 13 WIND DIRECTION PATTERNS AT VISHAKHAPATNAM



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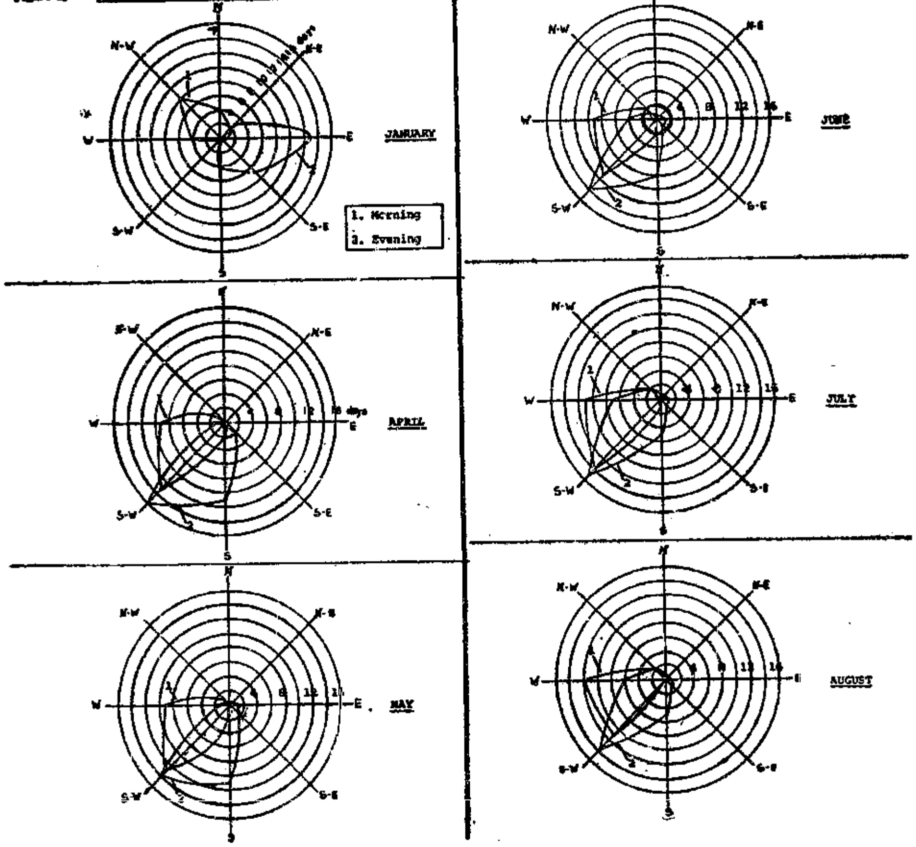


systems is over Rs one lakh, which may be considered beyond the means of most Indian villages. On the other hand, there is considerable potential for widespread use of much smaller aerogenerators producing about 0.2 kw, which is sufficient to power a radio or a television set. When developed, such devices could be made available at a price that might be considered reasonable in terms of the cost of television set or radio receiver.

Windmill components

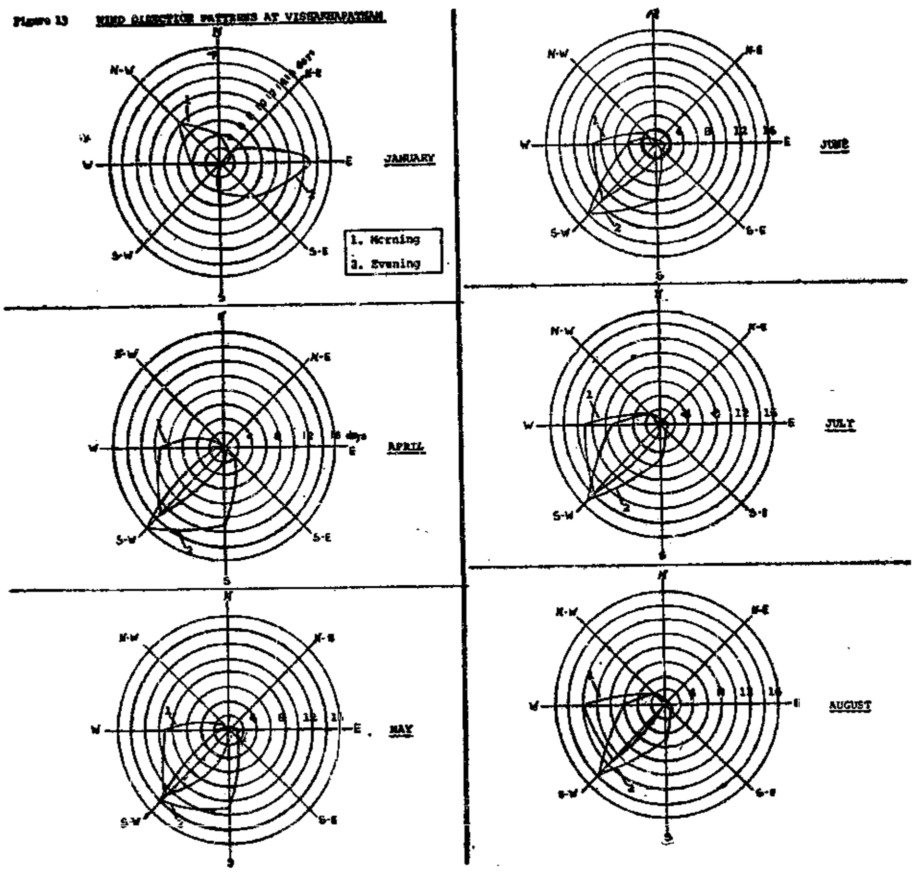
The rotor, also called the windwheel, consists of a number of blades or sails disposed radially around a shaft to which they are attached, and which is oriented prallel to the wind direction so that the blades rotate in a plane approximately normal to this direction. The blades may vary in number from one to eighteen or more, may be tapered or of same chord-width throughout, and may be plane or twisted. Their pitch may be fixed or variable and they may either be rigidly mounted or allowed to 'cone' or 'drag' to relieve the stresses set up by rapidly changing windspeeds.

Windpump rotors can be made with strips of sheet steel or aluminium held in position by circular steel frames (Fig.5) or can be fashioned from waterproof cloth stretched between radial poles (Fig. 11 & 12).

Materials for aerogenerator rotors are wood, aluminium or fibreglass reinforced plastics (Fig. 10).

The turntable, usually mounted on a race and resembling a thrust bearing, permits the rotor and power transmission system to 'yaw' or rotate around a central vertical axis to keep the rotor facing up-wind.

It is useful to study the wind direction pattern of a proposed windmill site before the windmill is designed. Locations with marked wind turbulence require windmills fitted with freely-moving turntables, but there are many places in India, particularly along the coastline, where the wind direction does not change more than two or three times a day. Fig. 13 shows the wind direction patterns at Vishakhapatnam during the months of January, April, May, June, July and August. Such uniform patterns indicate that the windmill need not necessarily have provision for automatic 'into-the-wind' orientation,



Role of aquaculture in rural development

Aquaculture, the farming of aquatic plants and animals, can be as good a source of food as agriculture. Its development will not only generate additional food resources but also create conditions for rural prosperity.

DR. S.Z. QASIM
Director, National Institute of Oceanography, Dona Paula, Goa

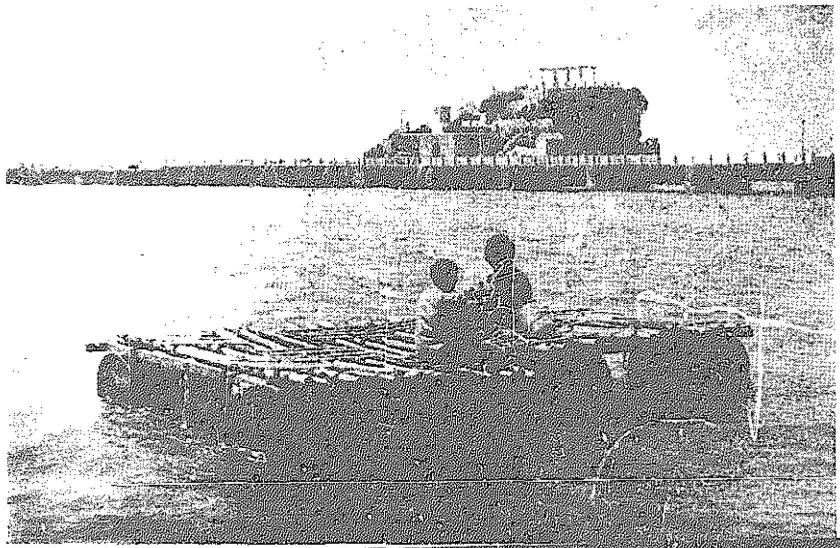
Similar to the utilization of land for multiple cropping, there is a vast scope for using the backwaters and estuaries adjoining the coasts of India for farming of aquatic plants and animals. This type of farming is known as *Aquaculture*, which has recently come up as one of the very useful ways of generating extra food resources.

Aquaculture can be defined as the introduction of certain principles of animal husbandry to gain control over the animals and their environment. It is somewhat similar to agriculture in the sense that it cannot be carried out economically just anywhere. A site for aquaculture, therefore, must have certain prerequisites, like sufficient depth of water, suitable temperature, optimum salinity and fertility of water.

Importance of aquaculture

In agriculture, only the topmost soil, some 30 cm thick, which is subjected to the vagaries of nature, sustains most of the food production. In aquaculture, it is not only the topmost layer but the entire water column, from the surface down to about 100 metres depth, depending upon the clarity of water, that is available for cultivation. This means that the available space for the cultivation of aquatic organisms is many times greater than the available space for agriculture or animal farming on land. Moreover, it is not difficult to grow aquatic animals for food because they are of the same density as the medium in which they live and require only water bodies as their habitat, unlike the sheltering and supporting structures required by the land animals. In fact, in some

A view of the raft used for aquaculture operations at N.I.O., Goa.



View of N.I.O. fish farm at Goa Velha in Goa, where field experiments in prawn and fish cultures are conducted.

parts of the world, aquaculture has surpassed even the efficiency attained in poultry farming by production of over 2,20,000 kg of animal meat per man per year. Another important factor in favour of aquaculture is that most of the crops produced have high quality protein.

Some of the aquatic organisms are known to be better converters of plant food than the land animals. Filter feeding fishes and molluscs subsist on microscopic plankton, which cannot be used directly by human beings. Most of the fishes and other aquatic animals are cold-blooded and hence they do not expend their energy for thermo-regulation. It has been estimated that the accumulation of flesh in some of the fishes—like carps—per unit of assimilated food is 1.5 times as rapid as in pigs or poultry and twice as rapid as in cattle and sheep.

Problems in aquaculture

If aquaculture has such a vast potential, why has its development been so slow? The reason is that, in aquaculture, water rather than air is the environment in which the organisms have to be reared, and because of which the aquatic animals largely remain unseen. In water, the extra food materials and other metabolic products do not degrade as fast as in the air, and hence, the water gets easily polluted. This necessitates either continuous flushing, which requires an over-abundance of water, or rather expensive recycling schemes. Another difficulty is that the young stages of aquatic animals undergo profound transformation from hatching to the adult stage. During this process, they neither resemble their parents nor consume the same food as the parents consume. Thus the rearing of aquatic animals from herbivores to carnivores, or *vice versa*, requires additional labour, skill, and special installations. Furthermore, these practices normally accelerate the ecological cycles which, in turn, lead to faster accumulation of waste materials. These materials have to be eliminated through technological means, which requires more economic inputs. Thus, the product of aquaculture ultimately costs more per kilogram than the naturally occurring fish population obtained by fishing in the sea. Another disadvantage of the aquatic medium lies in the fact that water is a universal solvent, which makes any preventive step against physical and chemical contamination of water very difficult.

Evidently, aquaculture, at least in the near future, is not going to replace fishery, but it would definitely supplement it.

It is clear from some of the facts noted above that, although the total theoretical yield of aquaculture is very high, it is doubtful if this potential can be easily realized in practical terms, unless we use suitable innovations and fairly advanced technology. The future of large-scale aquaculture, therefore, largely depends on a more realistic appraisal of our land and water management.

Economic viability

The economic viability of aquaculture would depend on a large number of interacting factors, which are more often sociological than technological and vary from region to region. The degree of success achieved also

View of N.I.O. fish farm at Goa Velha in Goa, where field experiments in prawn and fish cultures are conducted.

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Frame culture of **Placenta placenta** (*window pane oysters*).

on a commercial scale using indigenous technology.

The culture of seaweeds on coir ropes and wooden frames has also given promising results and many seaweeds of economic importance can now be cultivated on a fairly large scale. Similarly, the culture of several other organisms—sponges, holothurians, turtles etc—can also be attempted in India.

Scope for development in India

India has vast aquatic resources ideally suited for aquaculture. With the technical knowhow and innovations now available and the incentives given by the Government, aquaculture has great potential for development in this country and it can considerably improve our rural economy. If aquaculture is practised on proper lines, the present seafood production of India can increase several times within a few years.

For popularizing aquaculture, nation wide demonstrations are necessary to explain the principles involved and the monetary returns expected from culturing of selected species. Another promising approach could be the utilization of treated sewage for producing fish and the use of wastes from industrial complexes like fertilizer factories for culturing several edible varieties of aquatic animals.

The slow pace of development of aquaculture in rural areas is largely because of shortage of capital, lack of skilled personnel and the use of outmoded techniques. These factors collectively reduce the yield from aquaculture and make the village folk hesitant to adopt aquaculture as their mode of livelihood.

By introducing multiple cropping system and dry land farming, largely due to the untiring efforts of Dr. M.S. Swaminathan, F.R.S., Director-General, Indian Council of Agricultural Research, we have obtained valuable results in agricultural revitalization. Careful selection of seeds, crop rotation, proper use of fertilizers, disease and pest control, and better cultivation techniques have resulted in exceptionally high yields, leading to what is popularly known as the Green Revolution in some parts of the country. The success of the Green Revolution, to a large extent, lies in the planned systems approach that was followed in developing certain high yielding key crops.

In the field of aquaculture, we have yet made only a beginning, and once the new innovations of sea farming reach the rural areas of our long coastline, aquaculture could become as popular as poultry farming. By introducing successful aquaculture we should be able to generate considerable employment potential in our rural areas which would add to our economy substantially.

Dairying as an instrument of rural change

Essentially a by-product of agriculture, dairying until recently has been a source of side-income to the farmer. However, like high yield farming, dairying too can be turned into a high productivity enterprize and allowed to stand on its own in healthy competition with modern agriculture.

DR. D. SUNDARESAN
Director, National Dairy Research Institute (ICAR), Karnal, Haryana

In Indian agriculture, the cattle have always played a leading role by providing working bullocks for cultivation and cows for converting agricultural by-products into milk. Dairying has thus been essentially a by-product of agriculture. Until recently, it has been supplementing the farmer's income, but not competing with agriculture.

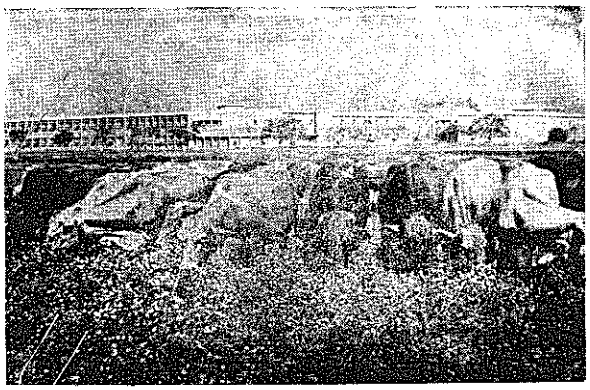
The situation has now radically changed, however. The prosperity brought about by rural economic growth, wherever it is visible in our countryside, is attributable to high input, high production competitive agriculture. High yielding varieties of crops, particularly wheat and rice, have greatly contributed to rural prosperity. Scientific dairying too is capable of competing with such high yield crop farming, and it can play an equally decisive role in ushering in an era of rural prosperity in this country.

Economic benefits of high production dairying

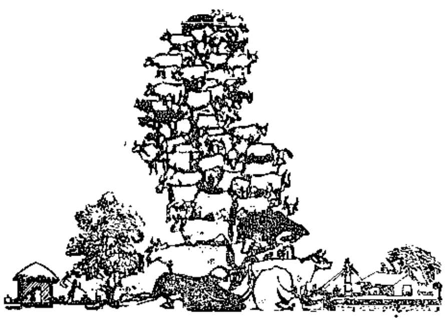
Under the primitive conditions of milk production with low inputs prevailing in India today, the cost of milk production in this country is among the highest in the world. Obviously, the price of milk paid by the consumer is also about the highest in the world. Today an American citizen can buy a litre of milk for 30 cents for which a citizen of Bombay will have to shell out about Rs 3. In terms of labour, an Indian worker has to put in much more effort compared to an American worker to secure a litre of milk, and the cost of milk in India on this scale would be 10-20 fold as high as in the USA.

Data relating to net cost of milk production in India for different breeds of cattle at different production levels, based on a study conducted at the National Dairy Research Institute (NDRI), Karnal, are summarized in Table I. These figures show the fall in production cost per litre as level of production goes up.

This spectacular drop in cost of milk production as the production level per animal increases is also due to inputs of nutrients to the animals through green forages. A kilogram of 'digestible protein' fed through grains costs



High yielding cows (NDRI, Karnal)



twice as much as a kilogram of 'digestible protein' fed through green forage; and in terms of energy, a kilogram, of 'total digestible nutrients' fed through grains costs four times as much a kilogram of 'total digestible nutrients' fed through a combination of high quality green forage and dry fodders.

A project at the NDRI, Karnal has shown that six high yielding cows supported by one hectare of good land under irrigated condition in the northern region of the country, will provide the farmer a net return of Rs 5,000/ hectare/yr for his labour and investment, as against about Rs 3,000/ hectare/yr for intensive crop cultivation with high yielding varieties of cereals.

Employment for rural manpower

Dairying lends itself to small scale enterprize more effectively than other common agricultural enterprizes. Dairying is a very labour intensive enterprize and, when conducted with the help of engaged labour, the effort involved is uniformly distributed throughout the year. Investigations at the NDRI, Karnal have revealed that two full time labourers are required per hectare of land for dairying as against two labourers including seasonal labourers for five hectares of land under crop production. Dairying thus provides an opportunity to the landless and the farmer with insignificant land holding to manage an enterprize with one or two high yielding dairy cows; so also to farmers with large land holdings to manage 10 to 30 dairy cows with engaged labour, thereby providing employment to the unemployed in the rural community.

Role of women in dairy business

A common phenomenon in regions where dairying is an important commercial activity of the rural population, as in Gujarat and Panjab, is that it is the women folk who essentially maintain and manage the dairy cows and buffaloes. In areas where the milk produced is channeled through dairy plants, bringing daily or weekly income to the household, the dairying activity raises the status of women. They often command respect in the community for the direct income brought to the family.

It has also been established that, even though a sizable portion of the milk produced in such areas is drawn by milk plants for urban consumption, the consumption of milk at the farmers' homes in the villages of these areas is more than in the neighbouring villages where milk is not sold to dairy plants. This was clearly brought out in a study of milk consumption in Kaira district, Gujarat, vis-a-vis the milk consumption in the neighbouring districts.

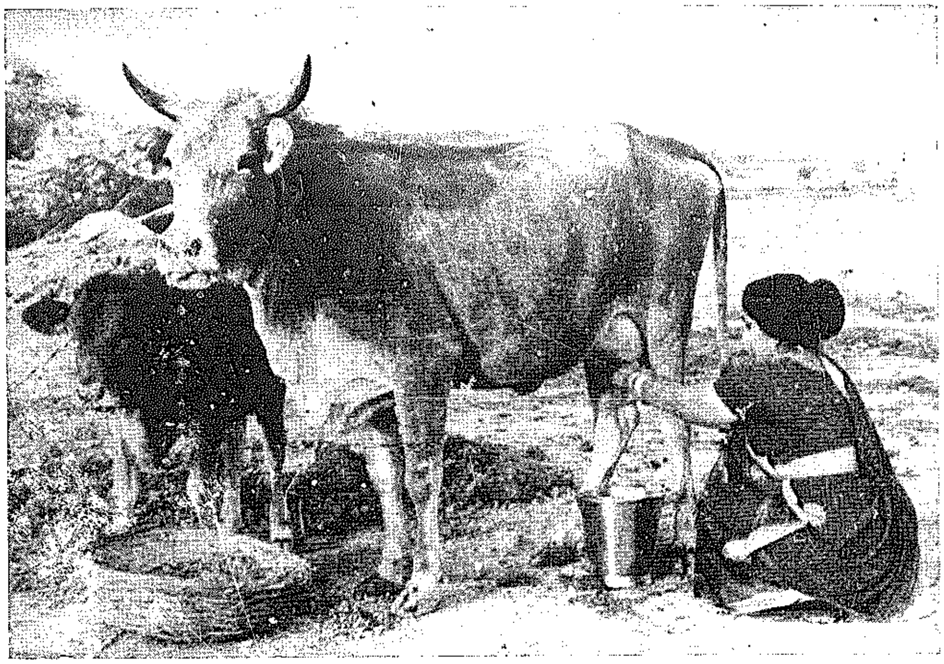
Dairying, soil fertility and energy supply

The concept of cattle fertilizing the fields is innate to our rural economy. However, the potential of dung as a soil fertilizer is minimized due to the facts that under-

Table I—Net cost of milk production for different breeds of cattle at different production levels at NDRI, Karnal (1974-75)

(in Paise/litre)

Production level (litres)	Breed			Pure-bred pooled	Cross-bred
	Tharparkar	Sahiwal	Red Sindhi		
Upto 800	1156.83	—	—	1156.83	684.03
801-1200	292.36	294.90	—	293.21	—
1201-1600	234.96	201.64	254.33	221.53	—
1601-2000	195.84	179.35	198.97	187.94	220.27
2001-2400	149.63	159.08	174.42	156.04	160.82
2401-2800	139.98	148 84	145.08	144.81	144.85
2801-3200	124.45	136.21	137.63	133.66	127.32
3201-3600	127.32	136.70	126.66	132.88	115.60
3601-4000	133.47	157.86	—	145.66	106.92
Above 4000	105.04	123.10	120.66	111.20	91.48
All:	148.16	150.24	150.54	149.34	108.93



A woman milking a cow

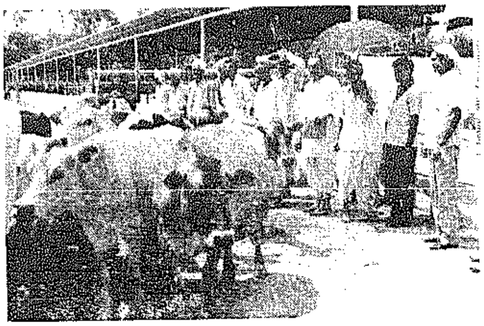
fed cattle provide less nutrients when their dung is added to the soil and that a large amount of dung is traditionally burnt as fuel.

About 60 percent of the nutrients consumed by an animal is digestible, leaving 40 percent as manure. The difference between the nutrient consumption of a low yielding cow and that of a high yielding animal could be as much as 3-4 times. Thus the manure produced by one high yielding cow could be as valuable as that produced by 4-5 low yielding animals, particularly in respect of nitrogen component. The scope of biogas production in rural areas to provide energy for cooking food, running small engines, lifting water, chaffing fodder etc without any loss in the manural value of dung and other wastes has been established. This is another economic benefit to the rural producer of milk.

Dairying for better living

Dairying as a business is tied up with good roads, improved transportation, and easy movement of industrial products to the villages. Since dairying involves handling of a perishable commodity, milk, an agency is necessarily involved for contacting the farmers at least twice a day, which in turn brings the farmer in contact with the outside world; and facilities for prevention of spoilage of milk, provision of compounded feeds for the cattle, artificial insemination of cows and buffaloes, improvement in milk producing capacity through breeding etc

Green forage (NDRI, Karnal)



Farmers visiting NDRI, Karnal

become a part of rural life. Such developments in themselves have implications for promotion of self-improvement of rural communities.

In many parts of the country, the farmers have been associated with the dairying industry through Cooperative Unions for collection of milk. Since a large number of farmers are involved in supplying milk to a large dairy plant, their sense of owning a modern industry has in itself a healthy influence on their lives by intilling in them a spirit of confidence and enterprize.

Conclusion

The magnitude of change that can be brought about in the rural areas through dairying has to be seen to be believed. An outstanding example, which is being copied widely in the country, is the Kaira Cooperative Milk Union in Gujarat which operates a giant dairy plant and markets dairy products all over the country under the trade name *AMUL*. Essentially only one district (Kaira) with about 2 lakh farmers is involved in this huge economic enterprize, having an annual turn-over of Rs 35 crores. These farmers sell to the plant about 4 lakh litres of milk daily, accounting for 30% of the per capita income of the district!

The magnitude of rural change made possible by this enterprize is astonishing. The average milk production per buffalo in Kaira district today is about 4 litres; by just increasing the milk production capacity of this animal to 8 litres, the vast increase in the per capita income and the consequent rural change can well be imagined.

Technology for irrigation and water management

Scientific management of irrigation water offers the best insurance against weather-induced fluctuations in our total food production. Efficient ground water utilization, improved water conveyance and distribution techniques, judicious selection of water application methods, and proper irrigation timing and cropping patterns to ensure high water use efficiency are among the essential elements of our irrigation planning and water management.

DR. A.M. MICHAEL
Project Director, Water Technology Centre, IARI, New Delhi

Irrigation is artificial application of water to soil for the purpose of plant production. Irrigation water is supplied to supplement the water available from rainfall and the soil moisture contributed by the ground water. With more than fifth of the world's irrigated area, India leads the world with the largest irrigation network. During the past 25 years, significant strides were made toward improving our irrigation potential and the irrigated area has increased from 22 million hectares to about 45 million hectares. This increase is mainly accounted for by the increased use of surface water resources through the construction of reservoirs and canal networks, though of late there has been a rapid increase in the number of irrigation wells as well.

Until recently, the attention of our irrigation engineers was confined to the canal outlet, where the water is delivered, while the quantitative aspects of water use on the farm were, by and large, neglected.

In the comprehensive strategy needed for the conservation and development of our water resources, several factors are to be kept in view: the availability of water, its quality, location, distribution and variation in its occurrence, climatic conditions, nature of the soil, competing demands, and socio-economic conditions. In dealing with each of these factors every effort must be made to make the best use of the available water, so as to ensure a high level of continuous production. Our aim today is to increase agricultural production per unit volume of water, per unit area of cropped land per unit time.

Scientific management of irrigation water provides the best insurance against weather-induced fluctuations in total food production, and it is the only way to make our agriculture competitive and profitable. An integrated policy for water resources management, in addition to efficient utilization of the other resources for optimum crop production, should meet the requirements of our growing industry, human and livestock consumption, and also provide for flood control, hydro-electric power generation, recreation and navigation.

Many serious land and water problems now confront our irrigated agriculture. Large quantities of water harvested from watersheds, pumped from ground-water sources, or diverted from streams are lost by seepage and evaporation from tanks, canals, distributories and field channels. Inadequately or improperly designed field irrigation systems and uncontrolled water application methods lead to huge losses of water by way of seepage and deep percolation below the crop root zone. This not only leads to the loss of a valuable resource developed at high cost but also creates serious problems of waterlogging and accumulation of harmful salts.

Efficient water management should, therefore, be an essential feature of our irrigation planning. Integrated development of water resources, efficient methods of conveyance and distribution of water on the farm, judicious methods of water application, proper soil management practices and cropping patterns for high water use efficiency, scientific timing of irrigation to suit crop growth stages, and the removal of excess water are the important aspects of a comprehensive irrigation development program.

Efficient ground water utilization

Efficient and economical utilization of ground water through wells depends on their design that best suits the characteristics of the water bearing formation. The flow of ground water into wells is influenced by the physical charactereristics of the water bearing formation, the extent of this formation, the elements of well design, and the methods used for constructing and developing the wells.

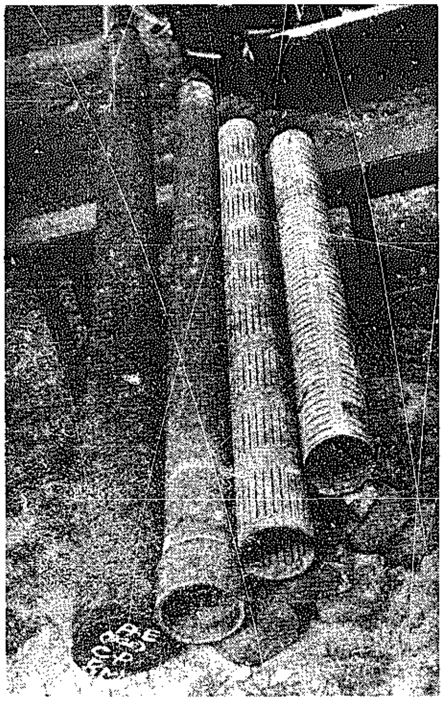


Fig. 1. Different types of well screens: coir strainer, pipe based wire net strainer, and slotted pipes with vertical and horizontal slots.

Tubewells may be deep or shallow; they may be screened wells or cavity wells. Screened wells are often provided with a gravel envelop around them. Fig. 1 shows different types of well screens used—coir strainer, pipe-based wire net strainer, and slotted pipes with vertical and horizontal slots. The choice of one or the other type of well depends on the nature of the underground formation. Faulty design and construction practices lead to failure of the wells and loss of the huge capital invested. For instance, a cavity well constructed where only a screen well is suitable is bound to fail.

Simple tools and techniques are available to enable the farmer to construct low cost shallow and moderately deep tubewells. In many areas, like the hard rocky regions which cover about 70% of the geographical area of the country, tubewells are generally not suitable, and the only way to exploit ground water in such areas is through open wells. In many cases the yield of existing open wells can be increased adequately by driving lateral bores in the rock fissures encountered below the water table or by sinking bore holes from the bottom of the wells. These lateral or vertical borings in open wells can be done with low cost indigenous boring tools consisting of sharp pointed or twisted bits and extension pieces.

Irrigation wells are costly structures which should be used at an optimum level. These wells, in general, are under-utilized at present, with the average annual utilization ranging from 1,200 to 2,500 hours. Low intensity cropping, lack of cooperation among the farmers on sharing water from a common well, and non-availability of electric power and diesel fuel are the principal causes of under-utilization of wells.

Irrigation pumping

Installation of pumps to match the yields and pumping heads of wells deserves much greater attention. This calls for quality control in pump production and availability of a wide range of pumps to meet varying needs. There is a need to introduce pumps of higher efficiency to suit the conditions of high discharge and low to medium pumping heads. Increased emphasis is required on the development of more efficient water lifts operated by human and animal power.

The discharge and efficiency of an irrigation pump depends on its design. Any pump may be used to lift some water. But how much discharge it gives and how much power it consumes are important considerations.

Careful planning of energy sources and their efficient utilization are vital for meeting the water needs of agriculture. Agricultural production in developing countries is seriously hampered due to non-availability of adequate power for lifting water for irrigation from ground and surface water sources.

The energy requirements for irrigation pumping may be broadly grouped into (a) pumping from wells and (b) pumping from rivers and canals. Based on the extent of utilization of different sources of power in river and canal pumping schemes, the possible increase in irrigated area from ground and surface water sources, and the consequent higher demand for power, estimates have been made of energy requirements for the period 1973-74 to 1998-99. According to these estimates, there will be a gradual reduction in human and animal power from 2,366 million kilowatt-hours/yr in 1973-44 to 893 million kilowatt-hours/yr in 1998-99, while diesel power requirement will increase from about 1,813 million kilowatt-hours/yr to 3,621 million kilowatt-hours/yr during the same period, which would necessitate an increase in the total annual requirement of diesel fuel from 559 million litres to 1,116 million litres. The requirement of electrical power will increase from 4,242 million kilowatt-hours in 1973-74 to 14,208 million kilowatt-hours in 1998-99.

The above projections are based on a reasonable level of efficiency in pumping. Due to the present inefficiency in pumping, the actual values of energy consumption are higher than the projected values.

Much greater care is necessary in selecting the correct size of electric motor or pump needed to lift the desired quantity of water to the required height. The capacities of electric motors and engines at present available in the market may not always suit the needs of irrigation pumping; therefore, their production should be tailored to suit the requirements of irrigation.

Improving water conveyance and distribution

One of the areas where a breakthrough can be achieved quickly is water conveyance and distribution. The Second Irrigation Commission (1972) has estimated that in the Indo-Gangetic plains the conveyance losses amount to about 17% in the main canals and branches, 8% in the minors and distributories, and 20% in the water courses. There is a further loss in the field channels which may amount to 10-20%. Thus over 60% of the water diverted at the canal head never reaches the fields.

Farmers in India mainly depend on earth channels for conveying water to irrigate their fields. In permeable soils, like sand and sandy loam, seepage losses in earth channels may be as high as 10-40% of the water delivered to the channel. The loss by seepage is directly proportional to the length of the unlined channel. Rats and other rodents burrow through the banks and bottom of the unlined channel. These holes may lead to a network of holes below the ground surface, resulting in the loss of large quantities of irrigation water. Yet another serious problem in the use of earth channels is that of weeds, which obstruct the flow of water. If the weeds are allowed to grow to maturity, their seeds may spread over the farm through the irrigation water. Earth channels therefore require continuous maintenance to control moss and weed growth and to repair demage by livestock, rodents, or by erosion, the last being a serious problem on steep slopes.

Lining of channels can overcome or minimize seepage loss by preventing erosion or damage by rodents and burrowing animals. It can also help reduce the amount of land occupied by channels and minimize the labour required for channel maintenance.

Concrete and brick or stone masonry are commonly used for lining irrigation channels. Well mixed and well made cement concrete and single layer bricks or stones laid in cement or lime morter provide virtually waterproof channel lining (Fig. 2). Limited use has also been made of bituminous mixtures, soil cement, chemical sealants, polyethylene film, and impervious earth materials. However, most of these materials are susceptible to damage by trampling by livestock, insets, weed growth, and erosion by high velocity flows. Their short life often makes them uneconomical unless special protection is provided.

Water application methods

The quantity of water supply, the type of soil, the topography and the crops to be grown determine the correct method of applying irrigation water. Irrigation water may be applied by controlled surface flooding methods, sprinkler method or drip method. Whatever be the method chosen, the essential requirement in water application is the use of right amount of water for uniform distribution over the field to wet the root zone soil to its storage capacity. Due to injudicious methods of irrigation, considerable amount of irrigation water is lost by percolation below the crop root zone, which also causes loss of plant nutrients due to leaching. The ultimate result is a rise in the water table, making the soil saline or alkaline.

The common methods of surface irrigation are the check basin, the border strip, and the furrow. High water application efficiencies may be obtained by any of these methods, if the system is properly designed.

Recent developments in surface irrigation have made it possible to predict the behaviour of the irrigation stream on the land surface so as to apply precise amounts of water to the crop. Analytical equations developed to predict the advance of water front on the land surface help in designing efficient irrigation systems. The design of any surface irrigation system will require the determination of the optimum size of the irrigation stream, the length and breadth of the irrigation bed, and the slope of the land. The duration of irrigation is so timed as to wet the root zone to the optimum moisture level.

Fig. 3 illustrates the layout of the impounding type border irrigation system and the water front advance.

Sprinkler irrigation has advantages over the surface

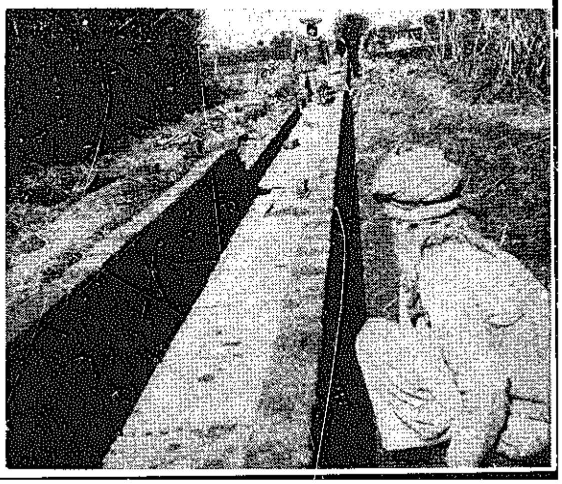


Fig. 2. Lining of a canal water course in progress in district Rohtak, Haryana.

methods mainly on the hills, especially for irrigation of plantations, as it requires little or no land levelling and can be adapted to irrigate standing crops. Under average conditions of soil and topography, the cost of land grading and construction of lined field channels and the cost of laying a sprinkler irrigation system are nearly the same. However, the maintenance and operational costs of the sprinkler :· . are comparatively very high due to the addition..! .y required to force the water through the sprinklers and the depreciation of the component parts of the system. Investigations have revealed that both the sprinkler and the surface methods of irrigation could be used efficiently if designed properly.

The recently developed drip irrigation method offers a very good means of reducing the total water required for irrigation under many field situations. In this method, water is conveyed to the field through flexible pipes and is applied through drip nozzles directly into the soil. The drip method makes it possible to irrigate frequently and apply precise amounts of water to the crop. Water loss by surface evaporation and deep percolation are reduced to the minimum. The method, though costly on a comparative basis, would be most suitable in scarcity areas and is likely to prove economical for irrigating orchards, widely spaced vegetables and cash crops.

Irrigation scheduling

Water requirements of crops are different at different stages of their growth. When water supply is limited, it is necessary to take into account the critical stages of crop growth with respect to moisture. The term 'critical

New deep-well hand-pump for rural areas

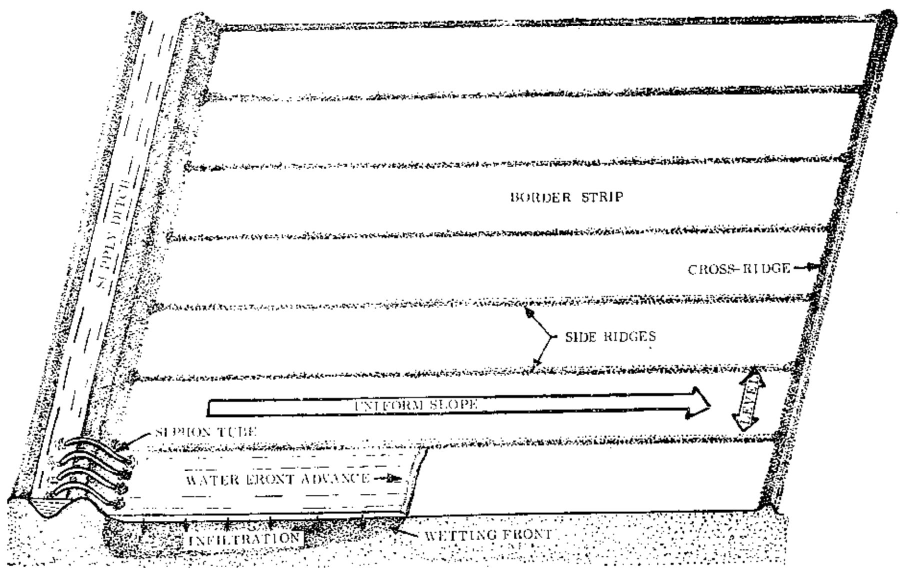
A deep-well hand pump developed by the Mechanical Engineering Research and Development Organization (MERADO), Madras has shown satisfactory performance in accelerated life tests lasting over 1,000 hours at a stretch. Christened 'Bangalore pump', it has been developed in collaboration with the World Health Organization for rural community water supply.

A workshop of engineers and representatives from concerned departments organized to evaluate the design and performance of this pump has unanimously recommended its mass manufacture for extensive field trials in different parts of the country.

The principal features of the 'Bangalore pump' are the use of cheep non-metalic raw materials that minimize damage due to corrosion; standardized components designed for mass manufacture and easy interchangeability; efficiently designed pump head and hand lever mechanism to ensure minimum human effort during pumping; provision of a non-ferrous cylinder for deep well operation; and reduced cost of maintenance.

This sturdy, reliable and efficient hand pump is expected to go a long way in meeting the requirements of such pumps in rural areas.

Fig. 3. Schematic sketch illustrating the layout of the impounding type border irrigation system and the water front advance.



stage' is commonly used to define the stage of growth when plants are most senstive to shortage of water. Each crop has certain critical stages at which shortage of moisture causes drastically reduced yield. In Mexican varieties of wheat, for instance,the crown-root initiation (about three weeks from sowing) is a critical stage. It has been observed that, regardless of the depth of planting, the crown-root develops about 2 cm below the surface of the soil. If the soil zone around the crown-root is dry at the time of its initiation, it does not develop properly and only a few tillers are produced. Irrigation at the crown-root initiation stage stimulates root development and tillering in wheat.

Tiller initiation, pre-flowering, flowering and grain development are normally the critical stages in crop growth. When there is shortage of water, it is better to first take care of the critical stage to obtain increased water use efficiency. There is need to study the critical stages of crop growth in respect of different crops.

Increasing water use efficiency

The water use efficiency (crop yield/evapo-transpiration of crop area) is influenced by crop and soil management practices. The numerator of this formula, namely, crop yield, can be changed appreciably by proper management practices. The evapo-transpiration, or the denominator of the formula, is more difficult to be controlled by man because it is so dependent on the heat of the physical environment and the availability of water. Evidently, the immediate practical way of increasing water use efficiency is to seek ways to increase the yield. Water use efficiency is not closely dependent on the water available if the supply is within the evapo-transpiration limit, even though crop yields depend on the adequacy of water supply. Storage of more water in the soil profile greatly increases the water use efficiency of grain crops grown under conditions of limited water. Likewise, letting an irrigated grain crop like wheat or maize run out of water at the critical phase of its growth may reduce yield and water use efficiency drastically, without appreciably lowering the total seasonal evapo-transpiration.

Table 1—Productivity of cereals per unit of water

Crops (new strains)	Water requirement (cm)	Yield (kg/ha)	Productivity of water (kg/ha/mm)
Rice	120	4,500	3.7
Sorghum	50	4,500	9.0
Pearl millet (*Bajra*)	50	4,000	8.0
Maize	62.5	5,000	8.0
Wheat	40	5,000	12.5

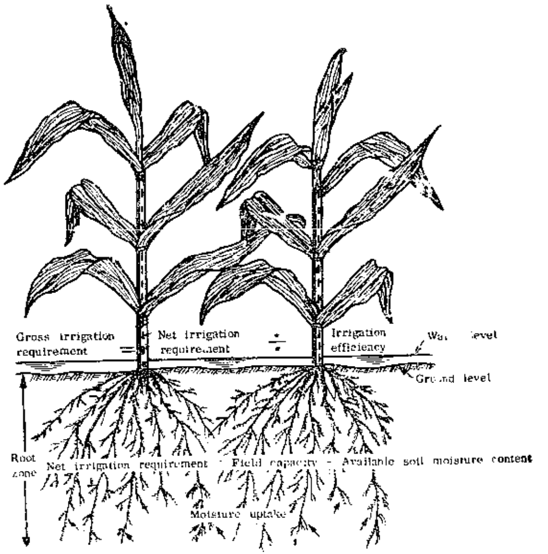


Fig. 4. Schematic sketch illustrating the concept of irrigation requirement and irrigation efficiency.

One of the primary ways of increasing crop yield and water use efficiency in a particular environment is to select plant species adapted to the total amount and distribution of water. Plant species vary greatly in water requirement. Table 1 summarizes sample experimental data obtained on water requirement and water use efficiency of some of the commonly grown cereal crops.

The concept of irrigation requirement and irrigation efficiency is schematically illustrated in Fig. 4.

The plant characteristics that influence water requirements include the length of growing season, extensiveness of the root system, leaf area and angle of inclination, and the number, distribution and size of the stomata. Species selection, plant selection and plant breading have greatly helped in increasing the efficiency of water available in a given area. Plant breeders have made significant contribution to stabilization of crop yields by protecting the plants against insects or diseases through breeding. With the aid of suitable predictions in regard to moisture availability from rainfall, ground water and surface water sources, it is now possible to arrive at suitable cropping patterns to make maximum use of the available water.

Efficient and economic utilization of water resources will involve the integrated efforts of the farmer, the scientist, the engineer, the economist and the policy maker. The available water resource should be tapped and husbanded properly, particularly through intensive efforts to increase the efficiency of water conveyance and water use.

5 Development of roads, future plans and possible progress
6. Overall economics of various modes of transportation

Let us now consider the above six aspects separately to determine possible approaches of tackling them.

Technological solutions

In India, rural transportation today consists of : (i) animal drawn vehicles (ADVs), (ii) low-technology mechanical vehicles like cycles, cycle-rickshaws and wheel-barrows; and (iii) powered vehicles like motorcycles, cars, trucks, buses and trains.

Among the ADVs, the bullock-cart tops the list. The number of ADVs which was estimated at around 8 million in the nineteen-thirties rose to over 13 million in the seventies. The aggregate investment in ADVs including cost of animals is of the order of Rs 40,000 million, which is more than the total investment in Indian Railways (Rs 31,000 million in 1968-69) or in the network of roads (Rs 35,000 million in 1970-71).

The bullock-cart : T. design of the bullock-cart has remained the same over several centuries, without any improvement in spite of the advent of modern science and technology. This was perhaps because of the contempt it evoked in the mind of the modern engineer who always dwelt in the realm of high powered, high speed automobiles, supersonic aircrafts and inter-planetary space vehicles. In spite of the lack of any technological inputs, there has been an increase of 6,22,000 bullock-carts over a small span of five years (1961-66), and the number is ever increasing. The mass produced automobile, on the other hand, is today a victim of the energy crisis due to a sharp increase in the petrol price from a mere 67 Paise a litre to Rs 3.40 a litre. It is worth mention that the nearly 30 million bullocks in India are used only or 30% of their time for agricultural operations, and they are available for transport during the rest of the time. Moreover, unlike automobiles, the ADVs do not need heavy investment in road construction.

It is worthwhile to point out here that the bullock-cart does not cost more per tonne-kilometre than a lorry (for short hauls of farm produce), as is generally made out. In fact, lorries cannot reach most of the farms at all. This is so because, out of the 5,72,834 villages in India, 83.7% do not have metalled roads within one kilometre; and out of the 16.3% that have, 39.1% villages have metalled roads only within 8-15 km and 19.1% beyond 15 km. It is obvious that the use of lorries alone, even for short distance haul in rural areas, is not practicable, as advocated by foreigners.

In 1965-66 an estimated 71 million tonnes of goods were transported by bullock-carts, which might have crossed the 100 million tonnes mark in 1975-76 and might double, if not treble, by nineteen-nineties.

It is evident from the foregoing that the bullock-cart is going to stay. It is indeed a pity that India with its huge technical manpower (ranking third in the world) could not so far improve the design of this versatile vehicle.

Problem areas in bullock-cart design : There are said to be as many as 300 different types (designs) of bullock-carts in use all over the country. But most of them have a few common features, as described below, which must be tackled first during any design exercise.

1. Wheels : Bullock-carts basically use wooden wheels fitted with iron tyres or rings. Majority of the wheels used are spoke type (66%) and the rest arm type (33%). The wheel diameters range from 3 ft to 6 ft (The bullock heights also vary from one State to another). The carrying capacity of the bullock-cart is reduced with reduction in wheel diameter, while the tractive effort is increased.

2. Wheel tyres : The width of the iron-tyres ranges from 1½ to 3½ inches : the greater the tyre width, the higher the cost, but lesser the tractive effort involved. Though pneumatic wheels reduce the tractive effort, lessen the wear and tear of roads, and increase the carrying capacities, the overall economics of operation at present rates and the investment ability of the individuals and the State do not give it a clean chit to be installed on all the existing 13 million ADVs.

3. Wheel hub, bearing and axle : The normal axle is a mild-steel hand-made affair which is not a true circle, and so are the hubs and bearings : they wear out faster, causing wheel-wobble, which increases the tractive effort and is injurious to the bullocks. The lubricant used (castor seed oil) has too little viscosity to provide the desired lubrication for the spot-loads created while driving. The absence of any springs on the axle results in all the instant impact loads, caused by unevenness of the road surface, getting transmitted to the bullocks. The situation is further aggravated by the problem of imperfection of load balance due to the scantlings being either higher or lower than the actual neck of the bullocks, which causes a part of the load to bear directly on to their necks—so that they start carrying such loads instead of dragging them. And no saddle-like fitment is used on a bullock (as on a horse or a tonga) to avoid the load of the cart resting on its neck.

Probable solutions : The efforts made in the past by Mr. B.V. Vagh under the auspices of the Indian Road Congress and the experiments at the Central Road Research Institute, New Delhi to develop a self-aligning wheel that could adjust to the sloping road-camber, and the idea of using two conical roller bearings on each wheel, deserve appreciation. However, more concerted efforts in this direction are required, for unless the ideas developed are put into practice, all research and thinking on bullock-cart design would go waste. To my mind, any attempt at improving the bullock-cart design must take care of the following points :

1. The village carpenter should be able to learn the new techniques easily and continue to manufacture and repair the bullock-carts.

2. As the present bullock-cart is supposed to last for 30 years with occasional repairs, the modified bullock-cart should have a longer or at least the same life.

3. If the bullock-cart of today costs only Rs 1,000-1,500 and lasts for 30 years (ie, an investment of Rs 30-50/ annum or paise 10-12/day), and if bullocks used for other agricultural operations continue to be used to drive them, it would be much better to so redesign it as to make it a multi-purpose vehicle with increased utilization.

4. Other design elements that are going to matter in future are : (i) use of old auto-axles or newly designed steel axles; (ii) introduction of leaf springs on the axles; (iii) use of over 4½" iron tyres, solid rubber tyres (as used in *tongas*) or pneumatic tyres with rims specially designed for up to 8 km/hr speed (as against the present ADV tyres fit for 50 km/hr or more); (iv) elevated or non-horizontal scantlings; (v) leather saddles for the bullocks to reduce direct loads on their necks; (vi) increased vehicle utilization from the present 1,500 km to 10,000 km (as against 1,00,000 km for lorries); and (vii) increased payload from the present 3/4 tonne to 2 tonnes.

5. The conical roller or ball bearings and even axles, manufactured by any agency, should be distributed only through Government or cooperative agencies at regulated prices, with easy availability, so that manufacture of new bullock-carts or repair and modification of existing ones could be speeded up.

6. All bullock-carts should be registered (though not licensed by a tax) and the registrations renewed once in 5 years so that it is easy to regulate supplies of axles, bearings, hubs and wheels from Central Stores or Production Centres.

Bullock-cart of the future : The 2000 AD bullock-cart may have the following design features :

1. A chassis with not more than 18" ground clearance and 24" wheel radius.

2. To increase frictional coefficient, either solid rubber tyres of adequate width or iron tyres of doubly increased width, both preferably with mud and snow type treads.

3. Two ball bearings or preferably conical bearings on each wheel with adequate shim and tightening mechanism to last 30 years of 10,000 km or 3 lakh km driving, respectively.

4. I-section (4" all round) aluminium central scantling, bent to desired shape to accommodate the neck height of bulls, or box-section (4") of 12 guage MS as second preference.

5. Body made up of two longitudinal aluminium extrusion 2" I-sections or 2" MS box-sections; five horizontal supports of aluminium extrusion 1½" I-sections or 1½" MS box-sections; side frames of bamboo or 1/4" iron or aluminium hollow rods (2 ft high) and a canopy, where needed, supported on 3x½" diameter iron rods and covered by a detachable canvas of suitable dimensions.

6. Either 5-ply plywood or 18-gauge sheet aluminium floor for the cart with adequate space to keep grass for the bullocks and a cloth to cover it.

7. Leather saddles for the bullocks round their waist with U-foam lining and double-suspended load-carrying loops on either side.

8. Where needed, an aluminium diagonal mesh for carrying loose seeds, manures etc on the frame or in a detachable container of 4 ft height, 8 ft length, and 6 ft width.

9. A foot-operated double-pedal hand-brake of 4 inch width and 1 ft diameter on either wheel, a mechanical friction foot horn, two oil/carbide lamps with reflectors, a fibreglass driver seat fitted on a spring frame, and leaf springs fitted on the axle with shock absorbers in between.

Implications of the fuel crisis

Since November 1973, the Indian economy has been suffering under the impact of the fuel crisis caused by the spurt in the cost of petroleum fuels sold by the Arab countries. The import value of crude petroleum has risen many times which our economy can ill-afford to withstand. The demand for petroleum products in the country rose from 20.76 million tonnes in 1971 to 29.34 million tonnes in 1974, and is likely to go up to 45.58 million tonnes by 1979 if no fiscal or rationing curbs are employed.

The present position of world reserves of fossil fuels indicates that while proved oil reserves may last only another 30 years or so, the coal reserves may last many centuries. However, the cost of mining and transport will keep on increasing as the mines go deeper and deeper into the Earth's crust. The trend, therefore, is to shift the emphasis from fossil to fissile fuels (Uranium-235) and breeder reactors based on fusion.

The percentage distribution of energy production in India (Table 1) shows that the bulk of it (45.4%) is contributed by farm waste, wood and charcoal, followed by animate effort energy (34.6%) and commercial energy (20.0%) derived from coal, oil and hydro-power. The sector-wise consumption of commercial energy during

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Railways and Roadways to obtain about 5% extra capacity without any extra investment.

Economic capability of possessing/providing transport facility

The higher the GNP of a country the higher the investment on transport and the greater the sophistication of technology used in transport vehicles: America with 1/3rd the population of India has almost five times the Railway route mileage; Russia with less than half the population has more than double the route mileage; even Canada with 1/25th the population has more route mileage than that of India. So is the case in respect of the number of cars and trucks per thousand population or length of roads per thousand population. The technology employed in the design of the rolling stock — for road, rail, air or water — is of a higher order, requiring higher investment and involving greater specific fuel consumption — factors which only rich nations can afford.

For India, with its present rate of industrial and agricultural growth, a greater percentage of low technology transport vehicles is more appropriate. Here the use of animate and human energy in transportation of men and materials is more likely to stay put or even increase. With low availability of petroleum crude, there is greater need for improving the functional efficiency of mopeds and bullocks-carts, to cover longer distances per trip.

In fact there is already an awakening among the Indian automobile manufacturing firms to reduce the brake-horse-power and maximum speed of vehicles, after they are freed from the obligations of foreign licences. In the past one decade the Indian automobile industry has considerably increased the production of two-wheelers and heavy-duty trucks.

Changes in life styles

To keep up with Jones's is a normal human tendency. However, India with its vast ancient cultural heritage has been able to withstand the consumerism of the West and retain its individuality as a nation. Here, urbanization is still only 20% as against 70-80% in the developed world. Keeping such parameters in view one can safely guess that our nation can adopt a speed management policy of not travelling at high speeds. The present socio-cultural situation and the trend of its development surely permits us enough leeway to take a national decision on the type and quantum of our transport needs, appropriate to Indian conditions, rather than going about irrationally copying and adopting foreign standards and designs.

If the above assumption is right, adequate mobility can be planned to meet the total needs of movement of men and materials by animated and low technology vehicles for short distances and economic units of faster and costlier vehicles of higher technology for larger hauls of longer distances.

Development of roads

Road construction is a costly affair. The type of road construction needed mainly depends on the speed of vehicles to ply on them: in general, higher the average speeds, costlier the road construction per kilometer.

Basically, surfaced roads are of cement-concrete, bitumen (black top), or water-bound macadam, and the cost of construction per kilometre length varies considerably depending on the material used. The unsurfaced roads, made up of an admixture of granular material and natural soil, are motorable in fair weather, but sometimes may be unmotorable round the year.

Table 3—Possible fuel (petroleum products) consumption by powered vehicles in India (1976)

Type of vehicle	Approx. no. of vehicles (lakhs)	Assumed possible average annual usage (thousand km)	Fuel used (average)		Possible annual fuel consumption (million tonnes)
			km/litre	ml/km	
1. Trucks	4.5	100	4.0	250	9.00
2. Buses	1.0	75	4.0	250	1.50
3. Cars	6.5	9	8.0	125	0.06
4. Taxis	1.0	40	8.0	125	2.00
5. Jeeps	1.0	20	5.0	200	0.32
6. Scooters & motor cycles	8.0	12	25.0	40	2.59
7. Auto-rickshaws & three-wheelers	1.0	40	20.0	50	0.16
8. Other vehicles including Defence vehicles	7.0	50	5.6	175	4.90
	29.0				16.25

With increase in the speed of vehicles and unit loads to be carried, the quality of the road surface has to be improved leading to increase in the cost of road construction in geometric proportion.

In India, during the period 1951-71, the surfaced roads increased from 157,000 km to 388,000 km and the unsurfaced roads from 400,000 km to 844,000 km. These are in addition to urban roads within municipal limits, which increased from 41,000 km to 94,000 km during the same period. In spite of this impressive increase of over 200% within two decades, India still does not have even a fraction of 1% of road length per thousand population when compared to the developed countries, though the expenditure on road construction per annum increased from Rs 32 million in 1951 to Rs 62 million in 1971.

The above figures do indicate the country's inability to finance construction of adequate road lengths fit for fast travel comparable to those in developed countries. However, they do suggest, once again, that low horse-power, low speed vehicles will be the most important transport systems of the rural scene of tomorrow.

Overall economic considerations

There are three important points that have emerged out of the facts presented in this article :

1. A study of the economics of various modes of transport reveals that speed of travel costs money by way of both capital investment and recurring operational and maintenance expenditure.

2. The adequacy of transport could be measured in tonne-kilometres or passenger-kilometers irrespective of the mode and type of vehicle used and operated with either human/animate energy or fuel energy.

3. Low technology, low speed vehicles subject to less frequent replacements (in USA cars are changed once in three years while Indian bullock-carts last 30 years) will be the future modes of transport in rural India.

In conclusion one can say that our budding inventors and entrepreneurs should focus their attention on the development of improved designs of low technology vehicles like cycles, wheel-barrows, low horse-power semi-motorized transports, and animal-drawn vehicles (ADVs) like bullock-carts.

Technological innovations for housing the rural poor

Scientists at the Central Building Research Institute, Roorkee have developed a number of innovations for rural housing, both to improve traditional methods of construction and to provide more durable and strong structures.

NARENDRA VERMA
Scientist Coordinator, Rural Building Division, Central Building Research Institute, Roorkee

■ The shortage of houses, specially for the poor in rural areas of our country has been increasing over the years, and the backlog piling up. The major reason for this shortage is, no doubt, the population explosion, but a number of houses do collapse and vanish every y - during the rainy season, or due to earthquakes, floods, outbreak of fires etc.

It is estimated[1] that the housing shortage may reach the figure 80 million units by 1979. As against this shortage, the rate of construction has been pitifully small, mainly due to economic reasons and the priorities fixed by both the individual and the Government. Obviously, short term gains are preferred to less productive jobs like housing. Added to this is the rural poverty : about 50 percent households in India earn[2] less than Rs 100 and about 80 percent less than Rs 200. With such meagre economic resources, it is almost impossible for the poor even to think of anything more than food and clothing.

Problems of rural housing

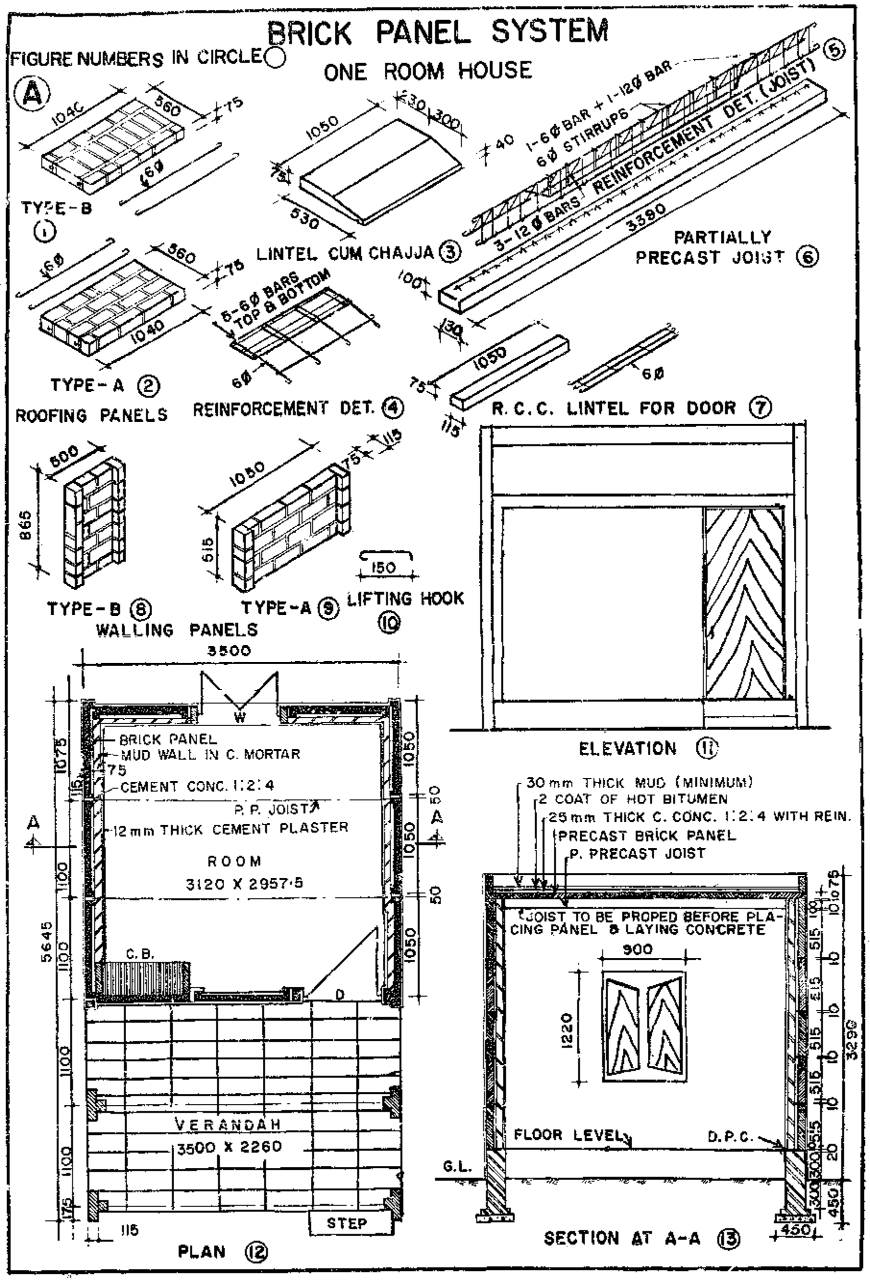
Things are now changing, however, mainly due to welfare policies of the Government and partly due to the marginal economic improvement as a result of the Green Revolution. Various schemes[4], like village housing projects, provision of houses to backward castes, and crash employment programs, are already being implemented. Out of the 110 lakh families eligible for allotment of house-sites under the scheme of provision of house-sites to landless workers, 61.13 lakhs have already been allotted.[3] But this is not sufficient. If we calculate the budgetary requirement for meeting the finances to meet the total demand, the figure will be enormous. Added to this is the shortage of construction materials, like cement, steel, brick and timber; their rates are prohibitively high, especially for the rural poor.

The rural poor are in a dilemma, in so far as their housing problems are concerned. On the one hand they are fed up with maintaining, repairing and rebuilding their houses with perishable traditional materials, on the other hand the permanent materials are beyond their reach. A few villagers, especially in prosperous areas of U.P., Punjab, Haryana and some other States, do construct[6] their houses by using construction techniques based on permanent materials, like reinforced brick, reinforced cement concrete, galvanized iron and asbestos sheet (for roof) and burnt brick (for walls). But in absence of proper technical guidance, and being dependent upon the skill of the local mason having some experience of similar construction techniques in urban areas, they have to reckon with wastage of materials and labour, which ultimately lead to costly construction.

Further, India has a large variety of locally available materials, both permanent and perishable. The burnt bricks may be of good quality and a commonly used material in one area, but in other areas it may be of a very poor quality having unreliable strength. In the later case, the ingredients of concrete and timber may be locally available.

It is only under the constraints of locally available materials, local skills and the economic resources of individuals that technological innovations must be made to provide a solution to the problem of constructing permanent houses with minimum use of permanent materials to reduce cost and maintain simplicity in construction. This may be achieved by employing simple methods of partial pre-fabrication, intensive use of semi-skilled and unskilled labour force, application of simple tools of the local mason, and by making the technique of construction foolproof. It is also essential at the same time to develop innovations to improve upon traditional materials and construction techniques.

The Central Building Research Institute, Roorkee has developed a number of technological innovations in rural housing, both to improve the traditional methods of construction and to meet the crying need for construction of more durable and strong housing structures for the masses. This article primarily deals with such innovations, which are briefly described below.


BRICK PANEL SYSTEM
FIGURE NUMBERS IN CIRCLE
ONE ROOM HOUSE
TYPE-B ①
TYPE-A ②
ROOFING PANELS
LINTEL CUM CHAJJA ③
REINFORCEMENT DET. ④
REINFORCEMENT DET. (JOIST) ⑤
PARTIALLY PRECAST JOIST ⑥
R. C. C. LINTEL FOR DOOR ⑦
TYPE-B ⑧
TYPE-A ⑨
WALLING PANELS
LIFTING HOOK ⑩
ELEVATION ⑪
PLAN ⑫
SECTION AT A-A ⑬
BRICK PANEL
MUD WALL IN C. MORTAR
CEMENT CONC. 1:2:4
P. P. JOIST
12 mm THICK CEMENT PLASTER
ROOM
3120 X 2957·5
VERANDAH
3500 X 2260
STEP
30 mm THICK MUD (MINIMUM)
2 COAT OF HOT BITUMEN
25 mm THICK C. CONC. 1:2:4 WITH REIN.
PRECAST BRICK PANEL
P. PRECAST JOIST
JOIST TO BE PROPED BEFORE PLACING PANEL & LAYING CONCRETE
FLOOR LEVEL
D.P.C.
G.L.

Improvements in traditional techniques

The mud and thatch houses deteriorate fast and collapse due to attack of termites and rodents, rains, floods and fires. Following techniques have been developed to make these materials more durable :

1. Non-erodable mud plaster
2. Soil stabilization by using cement and bitumen
3. Water-proofing treatment for mud walls
4. Fire-proofing treatment for thatch roof

The first two techniques have found very limited application, particularly because of high cost of stabilizers and labour involved in comparison to the advantages achieved. The later two techniques, however, are now being adopted and have good scope of acceptability by the masses.

Water-proofing treatment for mud walls : The conventional mud walls commonly used by the villagers get eroded during the rainy season and many a time collapse. The technique of spraying bitumen solution[5] has been developed to make these walls waterproof. The basic materials required for this purpose are normal asphalt (80/100 grades used for road construction) and kerosene oil. Fifty litres of kerosene oil is taken in an open iron container of 100 litres capacity and 25 kg molten asphalt is added to it in batches with constant stirring, till the asphalt is completely dissolved. This solution is then allowed to cool and transferred to another barrel through a seive.

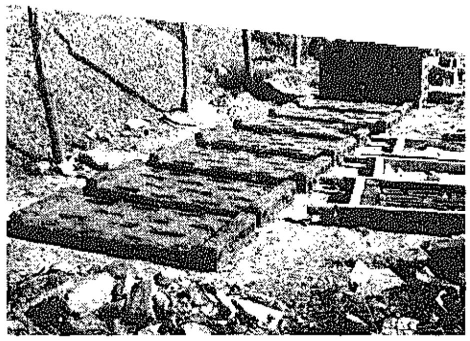
The mud wall to be treated should be repaired to fill up any hollows, cracks and flacked off plasters, and then given a thin coat of mud-gober slurry to seal the fine cracks. The bitumen solution prepared earlier is now sprayed on the dry surface of the repaired mud wall with the help of a pump commonly used for insecticide and pesticide spraying by the villagers. Two coats of this spray are applied at an interval of minimum 4 hours depending upon the porosity of the surface and drying of the first coat. The pump should be cleaned after use and the left over kerosene oil stored for making other batches of solutions.

Two persons can easily spray about 200 m² of wall in one day. The treated wall, which becomes black, can be whitewashed by a solution obtained by adding 70 gm of animal glue (solution in half-litre water) in 1 kg of quick lime solution. The white-wash so prepared adheres well to the sprayed surface.

This technique was applied on the walls of about eight houses in different villages around Roorkee, and it is found to be very satisfactory. The total cost of treatment and white-washing, including animal glue, comes to Rs 1.50/m².

Fire-proofing of thatch roof : The use of combustible materials like thatch, palm leaves and reeds cannot be ruled out altogether in the construction of rural houses. When a fire breaks out in such a house, heavy damage is caused not only to one but a number of houses, and lives are often lost.

The fire-proofing treatment for thatch[6] roof is based on the use of fertilizer grade diammonium phosphate (99.95%) and sodium fluoride (0.05%), the former acting as a fire retardent and the latter as an insecticide and fungicide. A solution of these chemicals is prepared in water (14%) and the dry thatch, rope, palmyrah leaves etc are soaked in it for a period of 10-12 hours. They are then taken out of the solution, drained of the extra chemicals, and kept for drying in the air. The dried material is fire-proof. To avoid leaching out of the chemicals during rains, a paint prepared by mixing zinc oxide (15%), mica powder (15%), talcum powder (15%), chloro-wax (30%), polyvinyl acetate emulsion (25%), and required quantity of spirit, is sprayed on the completed roof.



Photo—1. Precasting of wall-panels (one room house).

The total cost of treatment comes to Rs 5.50/m². The life of the material is increased from 1-2 years to 4-5 years. Large scale tests have been conducted and the demonstrations given to prove the efficacy of the treatment have been very successful. The technique has now been accepted by the Tamil Nadu Government for use in the construction of low income group houses.

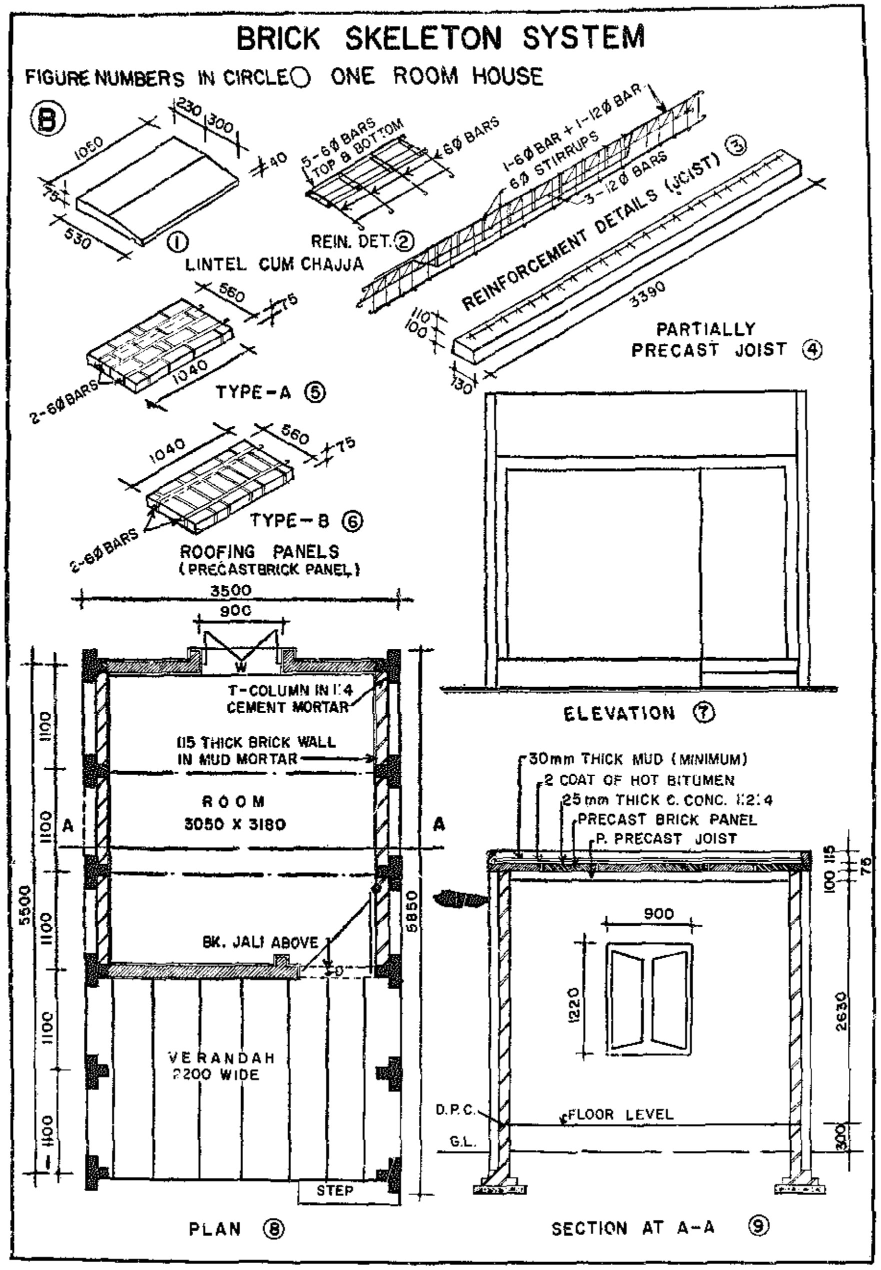
Minimum use of permanent materials

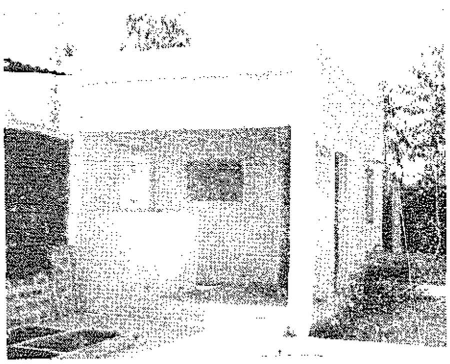
The techniques developed to minimize the use of locally available permanent materials fall under two categories : (i) construction of load bearing walls of minimum thickness sufficient to satisfy structural requirements; and (ii) construction of durable and strong skeletons (roofs and columns) leaving the cladding walls to be done with cheap materials. The salient features of the various systems developed are given below :

Prefab brick panel system : This system[7] (Fig. A) utilizes the potentiality of the good quality brick (50 kg/cm² and above) and the principle of pre-fabrication. Following components of brick and concrete have been pre-fabricated.

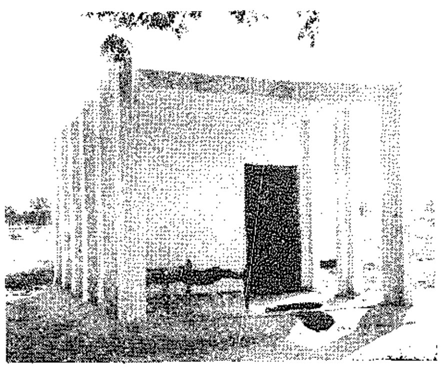
1. Unreinforced wall panel (515 x 1050 mm) made by laying 18 bricks in 1:4 cement/sand mortar and having four lifting hooks of 6 mmϕ (Fig. A-9 & A-10; Photo-1).

2. Reinforced roof panel (560 x 1040 mm) made


BRICK SKELETON SYSTEM
FIGURE NUMBERS IN CIRCLE ONE ROOM HOUSE
B
LINTEL CUM CHAJJA ①
REIN. DET. ②
REINFORCEMENT DETAILS (JOIST) ③
PARTIALLY PRECAST JOIST ④
TYPE-A ⑤
TYPE-B ⑥
ROOFING PANELS
(PRECAST BRICK PANEL)
ELEVATION ⑦
T-COLUMN IN 1:4 CEMENT MORTAR
115 THICK BRICK WALL IN MUD MORTAR
ROOM
3050 X 3180
BK. JALI ABOVE
VERANDAH
2200 WIDE
STEP
30mm THICK MUD (MINIMUM)
2 COAT OF HOT BITUMEN
25mm THICK C. CONC. 1:2:4
PRECAST BRICK PANEL
P. PRECAST JOIST
D.P.C.
FLOOR LEVEL
G.L.
PLAN ⑧
SECTION AT A-A ⑨



Photo—2. Prefab brick panel system (one room house).



Photo—3. Brick skeleton system: Harijan houses constructed in district Varanasi.

of 17 bricks and 1:4 cement coarse-sand mortar (Fig. A-2) or 16 bricks and M-150 concrete (Fig. A-1) reinforced with two bars of 6 mm Φ.

3. Partially precast RCC joist (130 x 100 mm) reinforced as per structural design for a particular span; however, three bars of 12 mm Φ at the bottom and one bar of 6 mm Φ at the top with 6 mm Φ stirrups at 15 cm spacing can be used for a clear span of 3,300 mm (Fig. A-5 & A-6).

4. Precast RCC lintel, slabs and projections 70 mm thick (Fig. A-3, A-4 & A-7).

5. Wall panel (500 x 865 mm) for extra flexibility (Fig. A-8).

The wall panels are laid side by side with a gap of 50 mm (Fig. A-12). This gap is filled with concrete (M-150) to form a brick-cum-concrete column. These columns support the roofing joists, together with part of the adjacent panels. The exposed faces of the panels may be plastered or left exposed, as desired (Photo-2).

The thermal requirements of walls are met by providing non-load bearing sun-dried brick walls 75 or 115 mm thick (Fig. A-12 & A-13) on the inner faces of the external walls with or without a 40 mm cavity.

The roof panels are supported on partially precast joists (Fig. A-12) and joined together with 1:4 cement/sand mortar. For negative reinforcement across the joists, 550 mm long 6 Φ bars are provided, one on each panel. Temperature reinforcement is provided by three 3 mm Φ wires parallel to the joists and one across them on each panel. A 25 mm thick cement concrete (M-150) is laid all over the roof panels to develop T-beam action. Two coats of hot bitumen are applied for water-proofing before lime concrete terracing or mud phuska — the latter provides additional insulation and protection to the bitumen against heat.

Door and window frames are eliminated and a simple device has been developed for fixing the shutters (Fig. A-3 & A-10). The floor is made of 50 mm thick compacted brick aggregate finished with 20 mm thick cement concrete (1:2:4).

The system was adopted by the Rural Engineering Services Department of U.P. for construction of *Harijan* houses each comprising a room and a verandah with a plinth area of 19.75 m² (floor area 17.45 m²); these houses could be provided within the ceiling cost of Rs 2,000 (April 1974). Two prototypes were constructed at CBRI, Roorkee (Photo-2) and two at Ghaziabad by the Ghaziabad Improvement Trust.

Brick skeleton system : This system[7] (Fig. B) utilizes the construction of in-situ T-shaped columns of bricks and precast reinforced brick panels supported on partially precast RCC joists.

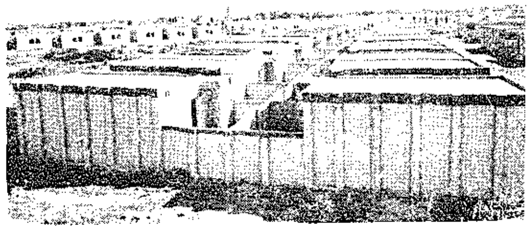
The details of precast components have already been given above. The T-shaped columns are constructed in 1:4 cement/sand mortar. The cladding walls, doors, windows and floors may be made according to one's choice and resources.

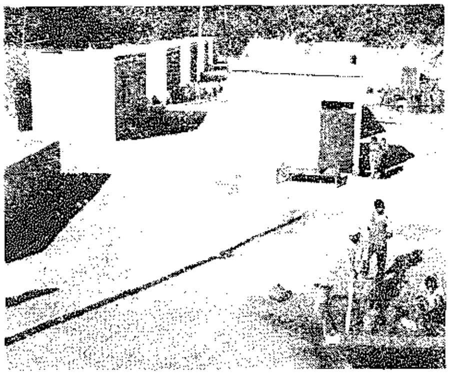
This system was also adopted by the Rural Engineering Services Department of U.P. for construction of *Harijan* houses (Photo-3), each comprising a room and a verandah with a plinth area of 19.75 m²; these houses also could be provided within the ceiling cost of Rs 2,000 (April 1974) in the districts of Bullandshahar, Varanasi and Meerut.

Both the prefab brick panel system and the brick skeleton system have been accepted by the U.P. Government for construction of 11.5 lakh houses for landless workers. By application of these techniques, the anticipated savings in the consumption of scarce materials like cement, brick, steel and timber are 30%, 40%, 48% and 50%, respectively.

Integrated thin-wall and column system : Combining the merits of the two systems described above, this system[8] (Fig. C) involves the use of thin walls (half-brick

Photo—4. A view of houses for economically weaker section at Ghaziabad.





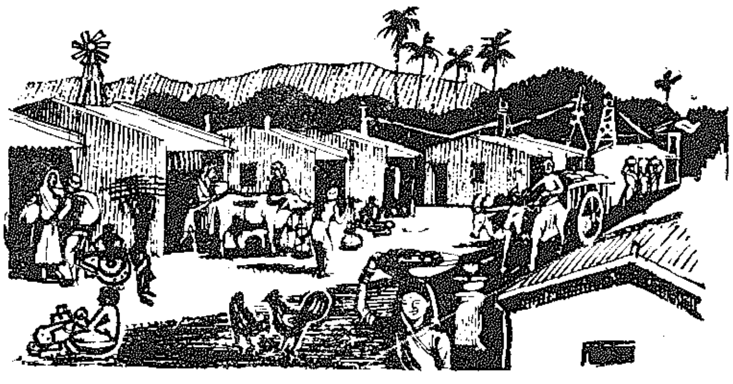
Photo—5. Houses for the landless at village Sunehra near Roorkee.

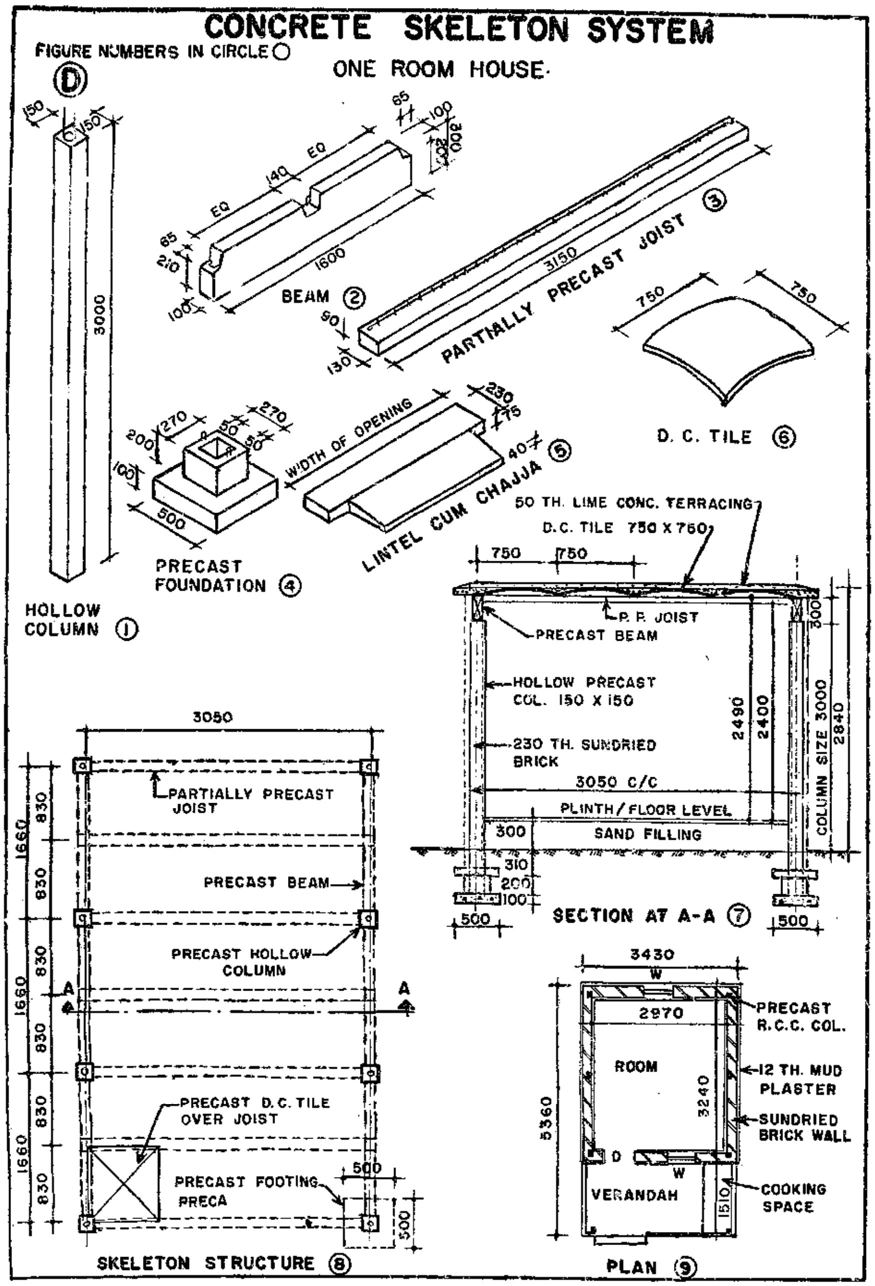
thick or 11.5 cm) made together with 23 x 23 cm thick columns in cement mortar (1:6). The brick columns, spaced 1.10 m apart, support the precast concrete joist taking the load of the roof. The common walls are 23 cm thick to avoid projection of columns and to get more floor space. The partitions in the cupboards are also used to strengthen the 11.5 cm thick end-walls. The method of casting of the brick panels and concrete joists is the same as described earlier.

This system has been adopted for construction of 1,550 houses for the economically weaker section by the Ghaziabad Improvement Trust (Photo-4), and 90% of the houses are already complete; the Trust is now preparing a new scheme for 1,800 houses for the same economic group. This system was also adopted for construction of 19 houses for the landless labourers in the village Sunehra near Roorkee (Photo-5).

This method has made possible an overall economy of about 32% in the cost of construction (1975-76). The savings in consumption of scarce materials like cement, steel, bricks and timber are 20%, 40%, 40% and 50%, respectively.

Concrete skeleton system: This system[9] (Fig. D) is based on the use of concrete (PCC or RCC) for making precast components — pocket footing, hollow columns, doubly curved tiles, beams (short span) and partially precast joists (long span). The spacing of the columns depends upon the maximum size of the DC tiles (maximum possible size 750 x 750 mm) adopted in the design. The joist carries the load of the roof and transfers the same to the columns through the beams. The filler wall may be made of any local material, like bamboo mat, mud, sun-dried brick or low strength brick. The door and window shutters are made of mango or other cheaper





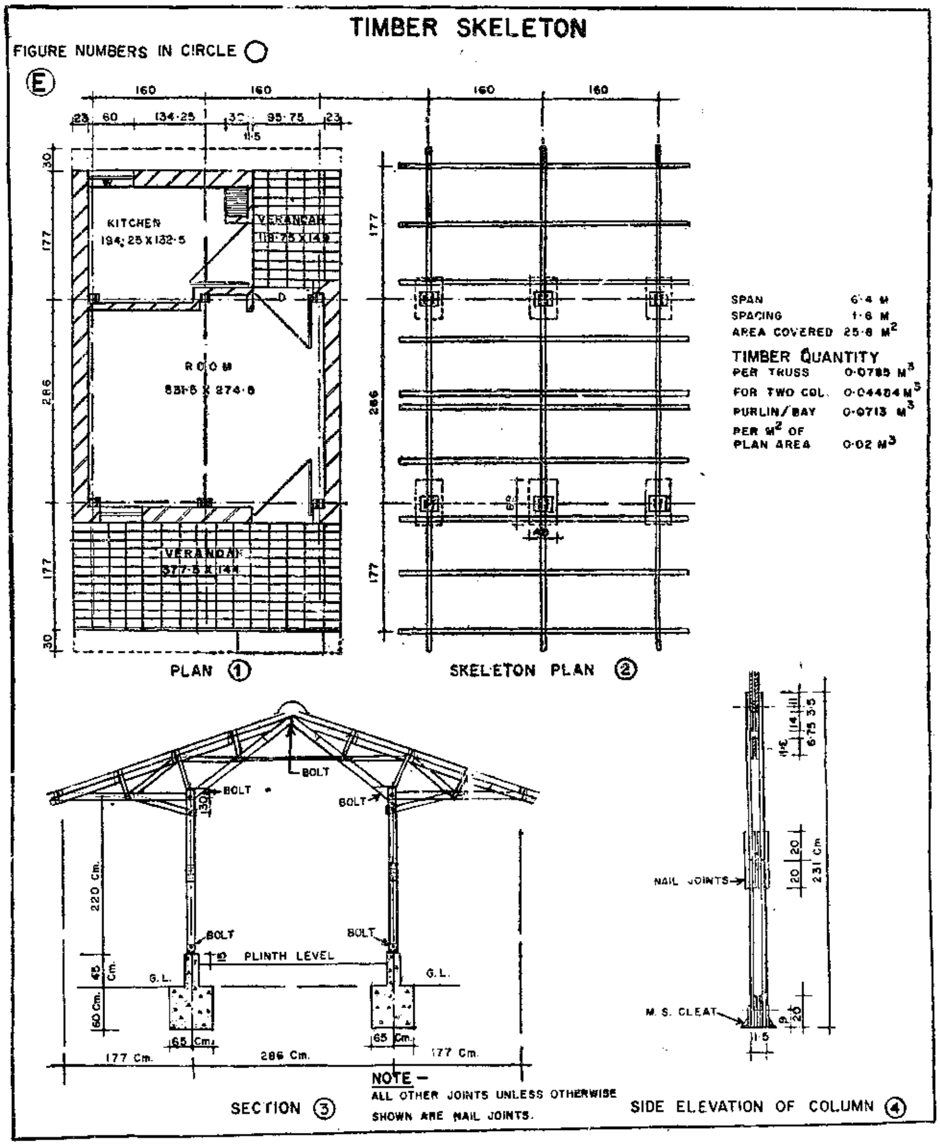
CONCRETE SKELETON SYSTEM
FIGURE NUMBERS IN CIRCLE
D
ONE ROOM HOUSE
HOLLOW COLUMN ①
BEAM ②
PARTIALLY PRECAST JOIST ③
PRECAST FOUNDATION ④
LINTEL CUM CHAJJA ⑤
WIDTH OF OPENING
D. C. TILE ⑥
50 TH. LIME CONC. TERRACING
D.C. TILE 750 X 750
P. P. JOIST
PRECAST BEAM
HOLLOW PRECAST COL. 150 X 150
230 TH. SUNDRIED BRICK
3050 C/C
PLINTH / FLOOR LEVEL
SAND FILLING
COLUMN SIZE 3000
SECTION AT A-A ⑦
PARTIALLY PRECAST JOIST
PRECAST BEAM
PRECAST HOLLOW COLUMN
PRECAST D.C. TILE OVER JOIST
PRECAST FOOTING
SKELETON STRUCTURE ⑧
PRECAST R.C.C. COL.
ROOM
12 TH. MUD PLASTER
SUNDRIED BRICK WALL
VERANDAH
COOKING SPACE
PLAN ⑨

variety wood; these are fixed with specially designed pivot hinges without any kind of door or window frames.

This system was adopted for construction of 42 houses for scheduled castes and tribes at Karimnagar (A.P.), where the cladding walls were made by laying poor quality bricks in mud mortar (Photo-6) followed by plastering with cement mortar on both sides. The flooring was done with plain cement concrete (1:3:6) and finished with neat cement at the top, and the roof provided with lime terracing.

The final cost of a house (Fig. D-9) with one room, kitchen and small verandah (floor area 20 m²) was Rs 2,057 (July 1973).

Timber skeleton system : This system (Fig. E) makes use of locally available secondary species of timbers, like mango wood. Small dimension timbers are pre-



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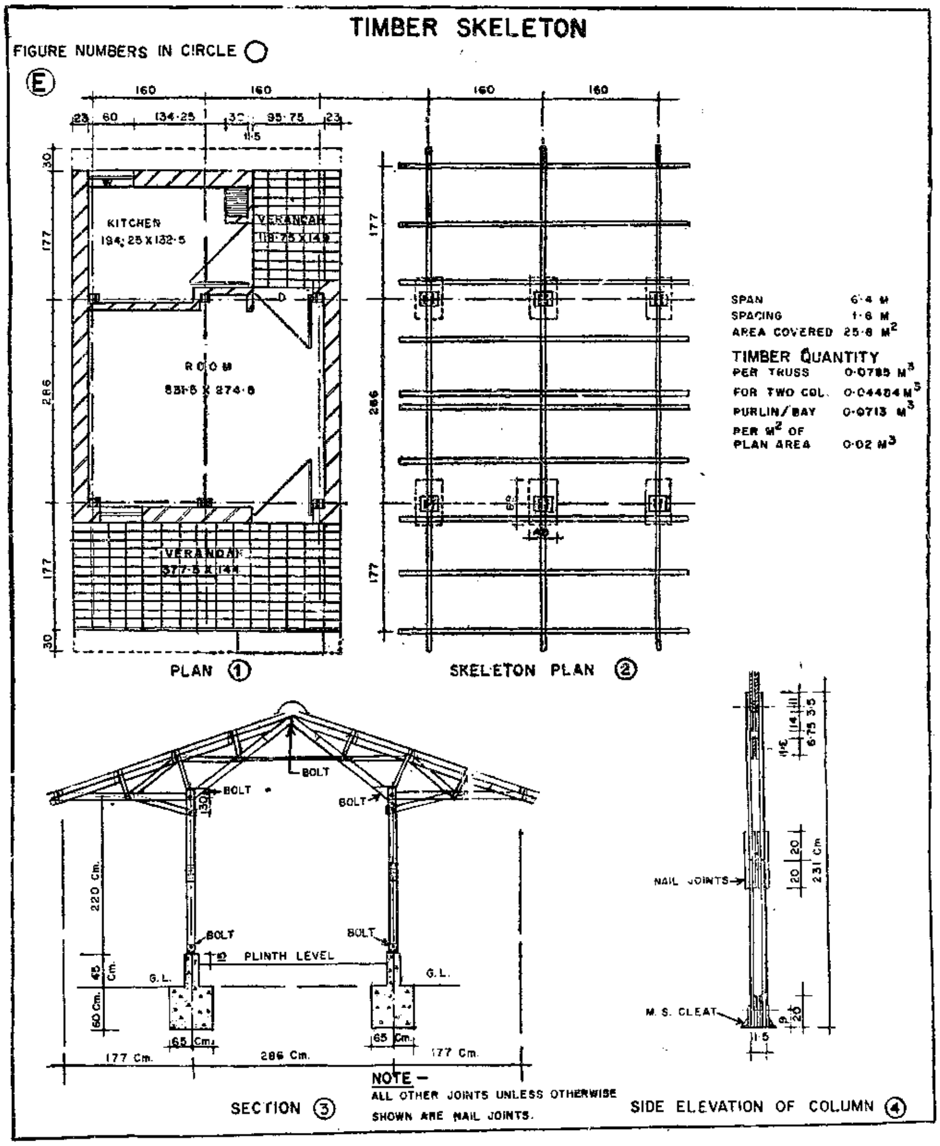

Need for development of new implements and tools

What are the implements and tools that need to be developed to improve the productivity of land and labour? The author has made some valuable suggestions for immediate developmental effort.

DR. K.N. SINGH
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G.B. Pant University of Agriculture & Technology, Pantnagar, Nainital

Improved implements and tools play a very vital role in increasing agricultural production. The importance of machinery inputs is generally not as well recognized as that of other inputs like seeds, fertilizers, and irrigation water. This is mainly due to the fact that, whereas seeds of high yielding varieties, good doses of fertilizers, and enough of irrigation water have very obvious effects on the crop growth and its yield, the effects of improved machinery can be realized only in terms of timeliness of operation, conservation and better utilization of energy, increased productivity of labour, and more precise field operations : all these factors ultimately result in increased productivity of land. The removal of manual drudgery is another important factor in the development of improved implements and tools. Sometimes the factor of timeliness becomes so important that, for lack of proper machinery and tools, a large portion of land is not brought under double cropping, which in fact results in under-utilization of national resources.

There are a variety of machines and implements for various agricultural operations available in the world market. However, they are designed for use under particular socio-economic and agricultural working conditions which are quite different from those obtaining in India. Although some of these machines can be directly adopted under Indian conditions, most of them cannot be taken up as such, mainly for reasons of difference in agro-climatic conditions, unsuitability of production technology, and lack of demand potential.

A number of efficient agricultural implements and tools are also available in the Indian market; however, there still exists lot of scope for development of new machines, implements and tools for various operations.

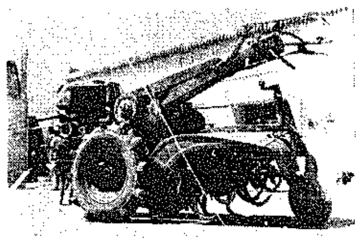
Power on the farm

Indian farms are suffering from huge power shortage. The minimum requirement for a reasonably efficient farming of 140 million hectares of cultivated land in India is about 112 million hp[3]. But we have a total of only 37.86 million hp available on our farms : of this, an estimated 26.04 million hp is supplied by 81.40 million animals, 2.28 million hp by 35.62 million effective labour, 6.34 million hp by 0.211 million effective tractors, and 0.09 million hp by 0.0137 million effective power tillers. It is obvious that the bulk (about 70%) of the power available to Indian farms is supplied by animals.

The above situation necessitates development of suitable harnesses for a single bullock as well as a pair of bullocks so as to increase the availability of power from the draft animals. Some work on this line was started a few years back at the Allahabad Agricultural Institute, and harnesses were developed for both single bullock and a pair of bullocks. Field tests on these harnesses indicated 20% increase in power availability over the local wooden harness — a significant improvement which could have increased the available animal power even at the existing strength of draft animals by 5.21 million hp. However, these harnesses could not become popular due to somewhat sophisticated design and higher cost.

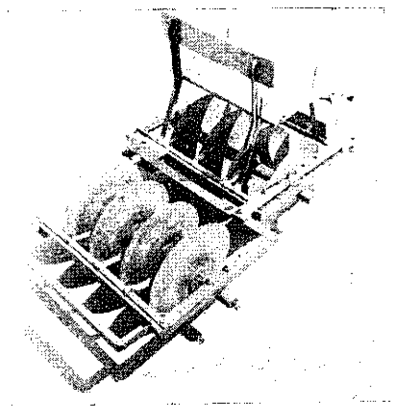
Development work on a simple and efficient bullock harness is very important, especially in the context of overall higher energy cost. Work on a single animal harness is particularly essential in view of the increasing number of small and marginal farmers in the country.

Studies have indicated direct correlation between power availability and production on the farm[1]. For example, the average figures of power availability per hectare of crop land in USA, W. Germany, Japan and India are 1.1, 5.2, 5.0 and 0.27, respectively; while figures for land productivity in terms of cereal yields in tonnes per hectare for these countries are 3.899, 3.817, 5.497 and 1.120, respectively. Even in India, there has been an impressive increase in wheat yield in Punjab from 0.84 tonnes/hectare in 1961 to 1.88 tonnes/hectare in 1973; during this period tractor power per cropped hectare increased from about 0.03 hp to 0.25 hp and area under multiple cropping from about 26% to 44%.



This 7.5 hp power tiller manufactured in India is very suitable as a power source for small farmers, but high cost limits its use to a few rich farmers only.

This bullock-drawn soil turning plough cuts the soil to a depth of 7-8 cm, inverts the furrow slice, and covers the weeds in the furrow.



This bullock-drawn 8-disc harrow, used for secondary tilage operation after ploughing, does the tillage work efficiently and takes about 50% less time in land preparation than a conventional **deshi** *plough.*

To increase the overall agricultural production in the country it is essential to increase the power availability on the farm. Since animal and human power cannot be increased so fast due to biological and social reasons, the only way to supplement the present level of power availability is by augmenting the sources of mechanical power.

A number of 4-wheel tractors are being manufactured and used in India. These are, however, beyond the reach of a large section of the farming community. Low horse-power power tillers of 5-12 hp range are also being manufactured, but due to high cost these, too, are not getting popular. Thus, there is an urgent need for development of a small power unit of 5-7 hp range, which should be simple in design and low in cost. It should be a mobile power unit which could easily replace 2-3 pairs of bullocks, and should cost about as much as three pairs of bullocks. This power unit can be used for various operations starting from tilling and cultivating to pumping of water, driving of thresher, and carrying out of other stationary jobs.

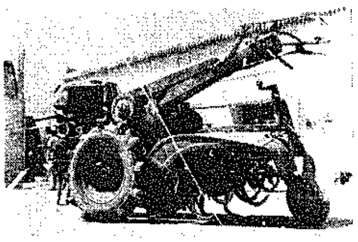
Tillage implements and tools

Ploughing and harrowing are major operations for seed-bed preparation and consume about 40% of the total energy needed for growing a crop. Bullock drawn steel ploughs of mould-board and chisel types are available and being used in some areas. Similarly, disc harrows are also being used in some regions. These implements are quite efficient for seed-bed preparation compared to wooden *deshi* ploughs, and there is a saving of about 50% in energy consumption with the improved tools. However, use of these implements is restricted to certain regions due to the fact that bullocks of one region differ from those of the other regions in size and draft capacity. Development work on modification of steel ploughs and harrows to suit the draft capacity of local animals is, therefore, desirable.

For puddling wet land, a number of puddlers have been introduced in different regions of the country. However, most of these puddlers require heavy draft and hence, many farmers feel better with the *deshi* plough. There is a need for standardizing the designs of puddlers best suited for particular soil conditions after testing the existing designs, and also modifying them to match the power of regional draft animals.

Seeding and fertilizing equipment

Various field demonstrations have shown that, by using a ferti-seed-drill, crop yields increased by 5-10% over conventional method of seed dropping behind the plough. Quite a few ferti-seed-drills operated by



This 7.5 hp power tiller manufactured in India is very suitable as a power source for small farmers, but high cost limits its use to a few rich farmers only.

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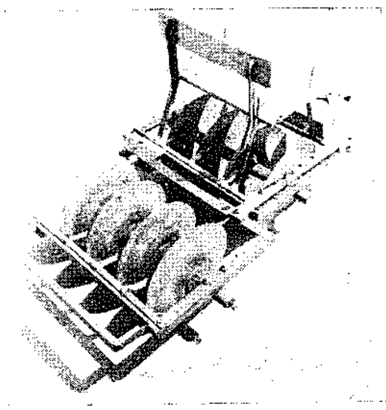

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Tillage implements and tools

Ploughing and harrowing are major operations for seed-bed preparation and consume about 40% of the total energy needed for growing a crop. Bullock drawn steel ploughs of mould-board and chisel types are available and being used in some areas. Similarly, disc harrows are also being used in some regions. These implements are quite efficient for seed-bed preparation compared to wooden *deshi* ploughs, and there is a saving of about 50% in energy consumption with the improved tools. However, use of these implements is restricted to certain regions due to the fact that bullocks of one region differ from those of the other regions in size and draft capacity. Development work on modification of steel ploughs and harrows to suit the draft capacity of local animals is, therefore, desirable.

For puddling wet land, a number of puddlers have been introduced in different regions of the country. However, most of these puddlers require heavy draft and hence, many farmers feel better with the *deshi* plough. There is a need for standardizing the designs of puddlers best suited for particular soil conditions after testing the existing designs, and also modifying them to match the power of regional draft animals.

Seeding and fertilizing equipment

Various field demonstrations have shown that, by using a ferti-seed-drill, crop yields increased by 5-10% over conventional method of seed dropping behind the plough. Quite a few ferti-seed-drills operated by

In India, the sickle is still the main harvesting tool. It is available in various designs, but the productivity of labour with this tool is very low. There is considerable scope of improvement in the performance of the sickle by making suitable changes in its design, metallurgy and production technique. At the same time, some additional tools should be developed to increase the holding capacity of one hand so that a bigger size bunch is cut each time, which would greatly improve the productivity of labour.

Work has been done at the Punjab Agricultural University, Ludhiana and the Indian Agricultural Research Institute, New Delhi to develop a bullock operated reaper. Similar work has been done on the development of engine operated, tractor mounted, and power tiller mounted reapers at the Punjab Agricultural University, Ludhiana, Tamilnadu Agricultural University, Coimbatore, Agricultural University, Udaipur and some other institutions[2]; however, except for the limited success of the tractor front mounted reaper, none of these reapers has achieved commercial success. An acceptable design of a small reaper or reaper binder has good scope in this country.

A large number of wheat threshers is available all over the wheat growing regions. Some high capacity paddy threshers have also recently come up in the market. However, a large number of farmers still uses the age old method of bullock-treading for threshing of wheat as well as paddy. A deep thinking is needed on the development of some simple device which could supplement the bullock power and greatly reduce the time of threshing by the bullock treading method. Perhaps a suitably designed shoe for the bullocks may help reduce the threshing time considerably.

Land levelling and clod breaking

In heavy soils, clod breaking is a big problem in some regions after paddy harvest and before seeding of *Rabi* crops. The available clod crushers and patelas are not successful in these areas. Although this is only a regional problem, it does need attention of farm machinery designers.

For land levelling, quite a few tractor operated and bullock operated levellers are available. More extension work is needed to popularize these implements.

Root crop machinery

Potato is one of the main root crops in this country. Some semi-automatic tractor drawn potato planters are being manufactured by one or two firms. There still exists a need of an animal operated potato planter designed to save time and to bring more area under this crop.

Harvesting of potatoes is another time consuming and laborious process. Some potato diggers have been developed at the Pantnagar and Ludhiana Agricultural Universities. However, the picking of the dug potatoes has still to be done manually, which takes more time than digging. Therefore, a need has been felt of a tray or some other collecting device attached behind these diggers to collect potatoes automatically. Similar problems exist in case of the groundnut crop.

The above mentioned are some of the important areas where development work should be taken up immediately. However, there are still other areas that remain to be explored with a view to improve the productivity of land and labour through the development of new implements and tools.

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Safety at the farm shop

What are the possible accidents that one might meet with at the farm shop? And what are the precautionary measures to ward them off ?

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Department of Mechanical Engineering, College of Agricultural Engineering
Punjab Agricultural University, Ludhiana

Every one wants to be safe. Safety is a multifaceted concept. One wants to live in a safe home, for instance. The safety of the atmosphere is desirable: it should be free from pollution by harmful gases. The ultimate aim of all such safety measures is to safeguard against accidents. Both minor and major injuries may constitute an accident. To avoid accidents, it is very important to know their causes, as only then can one find the ways and means to prevent them.

There could be a number of accidents at the farm shop. What are the precautionary measures that one must observe to ensure that these accidents do not occur?

Safety precautions

Accidents at the farm shop could be due to a fall (on a slippery floor), use of wrong tools for the jobs undertaken, careless handling of tools, ignorance of the proper use of tools, and neglect of the safety rules laid down for different types of jobs.The most important precaution is to use the right tool for the right job. A file, for example, should be used for doing a filing job and not for striking a workpiece or driving a nail. Similarily a spanner should not be used as a hammer, a plier as a spanner for loosening or tightening nuts and bolts (Fig. 1), a screw driver as a cold chisel, a punch as a prying bar, and so on.

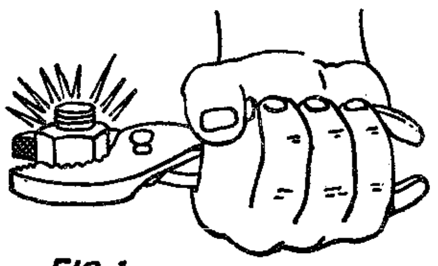


FIG. 1
DON'T USE PLIERS ON NUTS

Many accidents result from the simple fault of not knowing how to do a particular job.For example, many of us do not know how to hold a nail when driving it. If we hold it very near its point our thumb and finger will be smashed, if it slips when struck (Fig. 2a); if we hold it near its head our thumb and finger may be knocked out of the way (Fig. 2b). Even while using the correct tool and following the correct method, the following guidelines and suggestions should be observed to avoid accidents.

1. Don't force light duty tools to do the job of heavy duty tools.

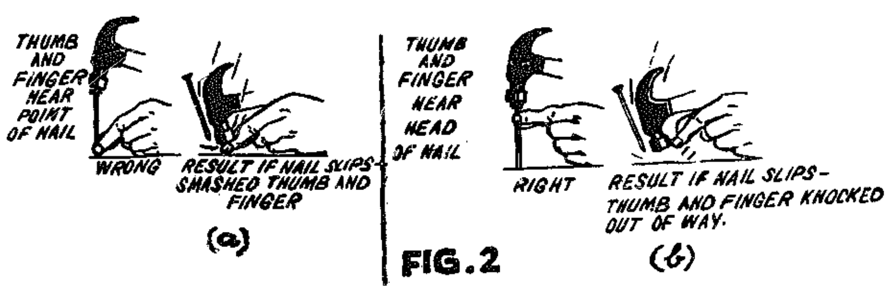


FIG. 2

2. Keep all the tools sharp and well adjusted to avoid sticking and slipping.

3. *Be sure handles are securely fastened: replace* split and loose handles in hammers and before using a file equip it with a tight fitting handle to avoid the danger of injuring the hand due to separation of the handle from the file.

4. While sawing, *start the work slowly and carefully* with a light cut, deep enough to prevent a sideways slip. Also make use of a bench or saw-horse and knee to support the workpiece. When using a hacksaw, anchor the workpiece solidly.

5. Keep wrenches clean and free from oil, otherwise they may slip and cause injury. A pull on a wrench s always safer than a push. If a push is necessary, use the base of the palm and hold the hand open; this will save the hand from being hurt if it strikes against something.

6. Wood chisels are dangerous tools if used incorrectly. Always secure the workpiece in a vice—don't hold it in the hand, otherwise the chisel may slip and cut the hand or the wrist.

7. The head of a cold chisel spreads out or a mushroom is formed after excessive use (Fig. 3a). This spreading is rough and will injure the inside of the hand if the chisel should slip. Besides, while hammering, its pieces may break away from the overhead with enough force to cause injury. For safety purposes, dress the head of the cold chisel well in time (Fig. 3b).

8. Screw drivers with broken blades or loose handles are likely to cause accidents. Don't hold the workpiece in one hand and the screw driver in the other. The screw driver might slip and hurt the hand.

9. *One should be very careful* when working with power tools. When operating a grinder, wear goggles and be sure that the grinding wheel has a protective hood. Use only the face of the wheel; the side should be used only if the wheel is specially designed for grinding on the side, otherwise side pressure may cause it to break. Avoid blows or excessive pressure on the wheel and hold the tool being ground firmly. Stand in such a way that your face is not in line with the grinding wheel, so that flying sparks, grit and bits of metal don't pose a danger by hitting you direct in the face or eyes.

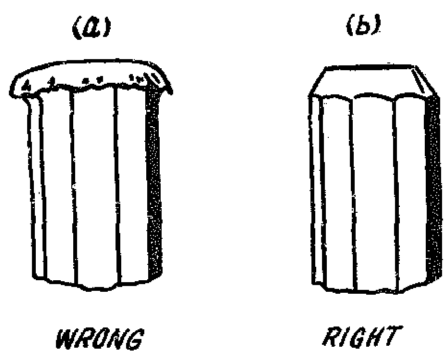


FIG. 3
CHISEL HEADS

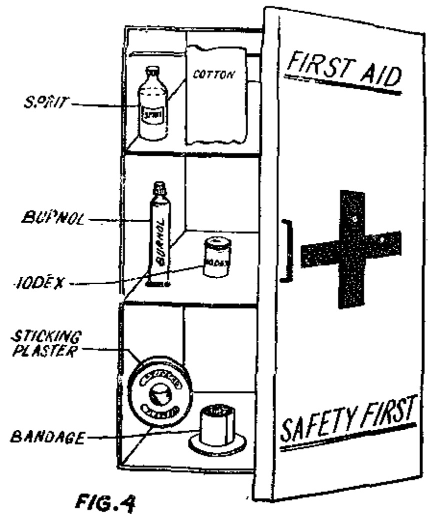


FIG. 4

10. *When using a power drill the workpiece should* be clamped or firmly held on the drill table, otherwise the drill may stick in the job and rotate it on the table, possibly breaking the drill or injuring the operator. When the drill sticks in the workpiece, stop the motor and release the drill by hand. *For drilling small* parts, always use a drill-press-vice. Don't wear gloves when operating a drill-press. Your clothing should not be loose fitting as it might get caught in the moving parts, leading to an accident.

Farm shop maintenance

The farm shop should be kept neat and tidy. Hand tools, scrap materials, broken glass, nails etc should not litter the farm shop, to avoid accidents. Hand tools should be stored in their proper place, preferably on a board fitted on a wall, when not in use. Children should not be allowed in the farm shop. The farm shop floor should be kept clean and free of oil and grease to avoid slipping on it. If at all oil falls on the floor it should be covered with saw dust or sand till it is cleaned.

The work-bench area should be well lit and ventilation should be adequate. The work-bench should not be cluttered with tools not in use. A work-bench crowded with tools is a potential place of accidents.

Thorough grounding of the electrical system and also that of all power tools must be ensured. Power tools should be disconnected and the plugs removed when not in use. Ensure proper insulation, size and type of wire, and there should be enough circuits to avoid over loading of wires. When handling electrical equipment stand on a dry wooden platform or rubber mat and keep the hands dry. Before repairing any electrical connection, disconnect the main switch, remove the fuses, and stand on a dry rubber mat or a wooden board. The new fuse should be installed after the source of trouble has been corrected. Keep a periodic check for loose wires, fittings and worn-out insulation. Repair work should not be temporary. Coins and other metal objects should not be kept in the fuse box.

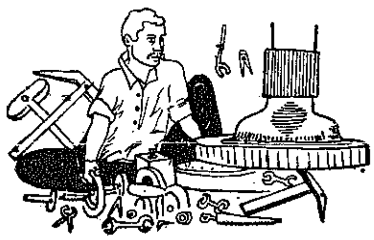
First-aid

Safety comes first and a little caution and systematic work goes a long way in avoiding accidents at the farm shop. One thing is certain: accidents (minor or major) are bound to happen, however hard we may try to avoid them. For this reason we should always be ready to provide first-aid to the accident victim, and a first-aid kit is essential for this purpose.

A first-aid box (Fig. 4) is a must at the farm shop. Its medicines should be replaced as soon as they are used up, so that it is always ready for use. A first aid kit should consist of at least the following items:

1. Cotton .. One packet (medium size)
2. Bandages .. Six (medium size)
3. Scissors .. One (10 cm)
4. Sticking plaster .. One (2.5 cm × 5 m)
5. Burnol .. One tube (medium size)
6. Iodex .. One bottle
7. Tincture Iodine .. Quarter litre bottle
8. Spirit .. Half litre bottle
9. Eye drops .. One bottle
10. Pain relieving tablets (Analgin/Novelgin/ Aspro etc.) .. Ten

The information furnished in this paper, we believe, will help the farmers in preventing a lot of accidents that happen at home and at the farm shop. Besides, the precautions outlined here will go a long way in keeping the farmers and farm labour healthy and fit and, to that extent, will prove economical to them in terms of reduced medical bills and the time saved from incapacitations due to accidents.

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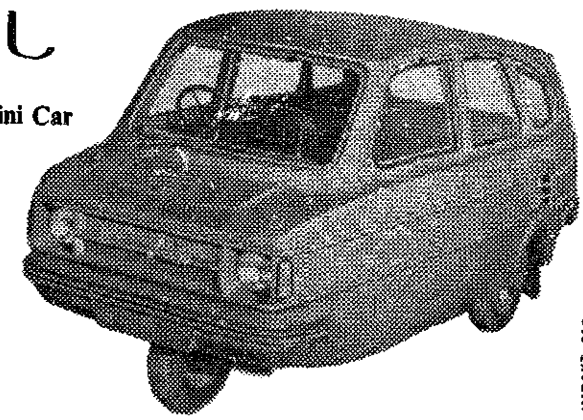


READERS' FORUM

Appropriate technology for rural areas

Problems of rural India are many and varied. Even today, when the 'smoke' generated by technology has reached the danger mark in most cities, at least 250 million people in our rural areas are still deprived of basic necessities like food, clothing and shelter. In this context, there can hardly be two opinions about the imperative necessity of transferring appropriate technology to rural areas with a view to improve the lot of the people.

Appropriate technology depends on the requirement of the situation, which differs from region to region. The prerequisite of any technology for the village should be its relevance to the rural conditions which call for an unbiased and frank assessment of rural needs and levels of achievement. It should primarily aim at reducing the toils and tears of the villager, raising his productivity and earnings, utilizing local resources, and harnessing local talents. No less important is the viability of a given technology destined for the village. Too sophisticated or expensive a technology would be self-defeating and counter-productive.

While surveying the areas where use of technology is most needed one cannot but pause at agriculture: over 70% of our population living in rural areas is engaged in agriculture and about 50% of our GNP is derived from it. Being the principal rural activity, countless problems arise in agriculture, starting with the preparation of the soil. Everybody knows that agriculture is best done by modern mechanical implements, but their maintenance and operational cost would negate all the benefits from them in a country where land ceiling has been fixed at 15 acres. Let us, therefore, find out ways and means of improving the present system of preparing soil by using bullocks and ploughs.

Another area of great importance is the evolution of high-yielding and drought-resistant seeds. Although very commendable work has been done in wheat, cotton and even castor seeds, there are still very important crops, like oilseeds, that remain neglected.

The present inability of the farmer to raise nurseries and transplant the saplings at the most propitious time, poor water and soil management, failure to keep pests in check, and the primitive state of post-harvest technology are no less important problems. Yet another facet of agriculture is the proper use of animal, agricultural and forest wastes. The production and use of gobar gas is an example. However, the biggest waste product of agriculture is the cellulosic material. Can a technology be evolved to upgrade it for human or animal nutrition?

Besides agriculture and animal husbandary, there are other spheres—sanitation, cheap housing, inexpensive roads, transport management, efficiency of the bullock-cart, forestation and plantation, irrigation, energy, drinking water, small and cottage industries, storage and marketing, education, health, old crafts, etc—which need technological solutions.

The drift of population from the villages to the cities is a well known problem. This can be overcome only by invigorating the traditional arts, giving incentives and necessary inputs to artisans, spreading education, and changing the general landscape of the villages.

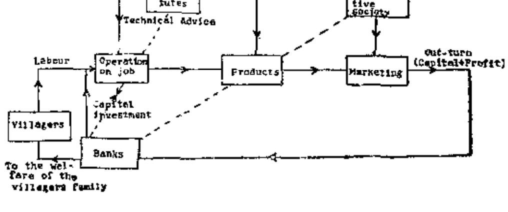
—**M.M.S. Karki,** *1/16 East Patel Nagar, New Delhi-110008.*

A strategy for rural development

The economic development of countries like India, where about 80% of the population lives in villages, lies in the uplift of the living standard of the masses. Our villagers are wellknown for their ceaseless effort and tough manual labour. In spite of introduction of the latest developments in agriculture, which is the main occupation of the masses, the wide gap between the rich and the poor in the country has not been bridged, and the living conditions of the latter are the same as were in the fifties.

The main drawback in the management of Indian villages is that the products of the villagers do not find a profitable market and where they do find, the middlemen usually take the lion's share of the profits. The village economy will improve only if the Government can assure a reasonable price for the villagers' products with the help of co-operative societies. In the absence of such help, the villagers usually forgo their stock at throw-away prices at times of need for money or they land themselves into the clutches of unscrupulous money-lenders. Rural banks may lend a helping hand to the villager at such times of need.

The management of villages may be entrusted to such agencies as banks, societies, and different institutions with result oriented activities. The block-diagram depicts the method of organizing the village labour force for better out-turn and uplift of the villagers' standard of living.



Develop a balloon for methane gas

The following letter is reproduced from the Times of India, 2 October 1976, to provide food for thought to inventors—Ed.

Sir,— The gas produced from dung is methane. The main problem after its production is storage and distribution. Mathane cannot be compressed. It will be difficult, therefore, to liquefy and put it in cylinders for distribution as in the case of liquid petroleum gas (LPG)

I recollect having seen some years ago a picture in a foreign magazine of German housewives carrying home kitchen gas in balloons. We should try and evolve a balloon container of a suitable size for the methane gas. The container and its nozzle must be safe, without leakage and easy to connect for use in the kitchen. The total quantity to be carried in a single balloon should not be less than that required for at least a week's consumption by a family of four. And the cost should be low.

The balloon can have a flexible tube like that of a tyre or a football and a protective hard and durable cover. Only if this can be done will there be scope for propagation of the use of methane gas as fuel in the villages.

—**Shantilal H. Shah,** *Bombay*

There are many viable schemes that could be executed by the villagers with minimum capital investment. The fact that the villagers are themselves not capable of visualizing such schemes, because they are more familiar with the traditional business of agriculture is one of the reasons why such schemes do not flourish in rural areas. Only a few who have an enterprizing bent of mind are taking up such schemes as poultry, dairying and handicrafts on their own. However, most of them need expert guidance untill they can stand on their own.

Educating the villagers through practical demonstrations may yield good results. To cite an example, the use of chemical fertilizers has been increased manifold by making the villagers aware of the importance of the application of fertilizers to crop yield. It is of utmost importance that the villages are provided with training institutes to assist and guide the villagers on the economically viable schemes and to keep them in touch with the new techniques.

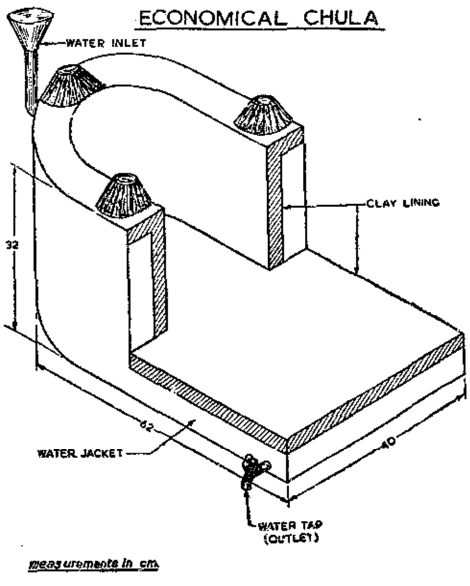
Another change required among the villagers is in their outlook on the developments in science and technology. Being illiterates, they view the achievements of science and technology with wonder and look bewildered when they hear of rockets and satellites. There is a widening gap between the understanding of the villagers and their fast developing environment. This gap is now too wide to convince them of human potentialities. They still talk of the powers of the Almighty and they are reluctant to think in terms of science and technology. This is all because they are not aware of even the basic concepts of science and technology. The villagers should be educated in the basic concepts of science and its role in the modernization of society. This will certainly stimulate new ways of thinking among the villagers and make them worthy of accomplishing what they could not achieve earlier for want of understanding.

—**T. Theivendran,** *Jr. Engineer, Electricity Board, 3, Nadupettai Street, Tenkasi, Tamil Nadu.*

An economical chula

■ In the villages the most commonly used fuel for cooking is wood. If somehow a saving could be affected in the amount of fuel used then a lot of fuel wood could be saved. Keeping this point in view, the author has designed an economical *chula* for burning wood, cowdung cakes etc as fuel. It is so designed that the heat losses through its walls are utilized to heat water. So, while you cook your food you get hot water as a bonus. The use of this *chula* will thus conserve lot of fuel as about 80% of our population uses *chulas* for cooking food.

The new *chula* is like an ordinary *chula* being commonly used in the villages, except that its outer casing forms a double walled chamber which serves as a water jacket.



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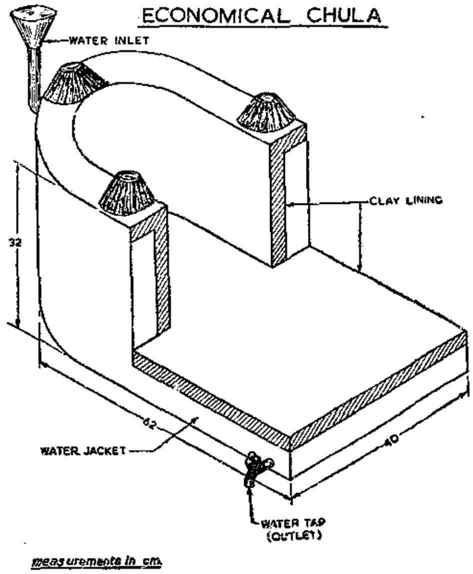
ECONOMICAL CHULA



measurements in cm.

Homes that rise from the soil

■ The use of simple compacted soil (natural earth) as a building material dates back to times immemorial, and it has been used for building houses, down to the present day, because of its constructive qualities. Yet, despite its good insulating and other properties, there are limitations to the use of earth owing to its lack of strength and vulnerability to moisture and erosive influences of the elements.

Provided natural soil possesses a combination of certain characteristics, however, it can be subjected to the process known as 'stabilization'. The effect of adding a stabilizing agent, like Portland cement, is not only to enhance its best qualities but also impart to it other properties which soil alone does not possess.

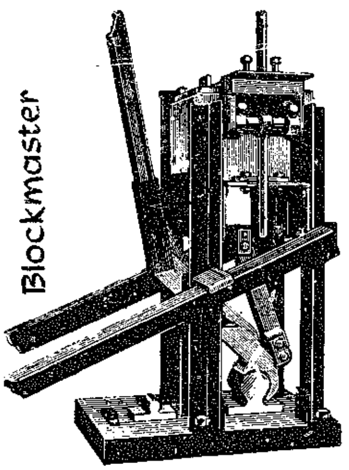
The stabilization process involves taking soil from the earth and pulverizing it, mixing a certain small amount of cement, adding water until an optimum moisture content is obtained, and subjecting the dough to moderate pressure, thereby producing a mass which, when set, possesses great strength. This material is able to bear a much higher work-load than could be carried by soil without cement, and durable enough to withstand continuous effects of atmospheric agents.

The compound of soil, cement and water, mixed in proper proportions and compacted to a proper degree, constitutes "soil cement".

Soil-cement has acquired a good name as a building material, and it can compete in technical quality with materials commonly used in low cost constructions. Its use is steadily increasing in all countries, particularly for building houses in rural and suburban areas. The simplicity of the technique involved enables peasants and workers, without special training, to build their own homes inexpensively, without the use of complicated and time consuming skills.

Our company has been offering Ellson Blockmaster for making home building blocks out of soil cement. It basically consists of a metal box mould in which prepared earth free from organic matter, previously mixed with stabilizer and water, is mannually compressed by a plunger actuated by a level-linkage mechanism. The extreme pressure so developed is sufficient to produce blocks which after 15 days' damp-curing are ready for use.

The 20-point program has laid great stress on providing house sites to landless agricultural labourers and building houses for them. Many States have enthusiastically launched housing programs. Of the estimated 10 millions eligible landless families all over the country, some 6 millions have already been allotted house sites. A housing program of this magnitude calls for building cheap houses mainly with locally available materials to save transportation costs. For those being offered housing plots, it would be a life's dream come true. It would be in the fitness of things, therefore, to guide their new born enthusiasm along right lines in order to avoid another generation of substandard housing in the villages. In view of the great potentialities that soil offers as a construction material, combined with the advantages that stabilization offers by ensuring strength and durability to compacted earth, a concentrated effort at a fairly high level is called for to enforce its use for rural and sub-urban housing.



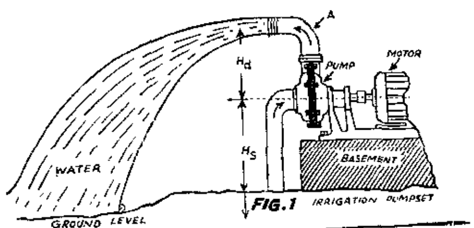
Blockmaster

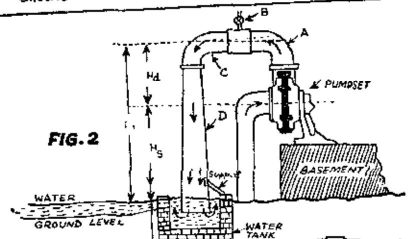
—Dinker Pranlal Joshi, *Ellson Division, Kathiawar Metal & Tin Works, 9, Lati Plot, Near City Station, Rajkot, Saurashtra.*

Reducing the fuel consumption of agricultural pumps

■ In India millions of pumpsets are employed for pumping water for irrigation. While a majority of the pumps are run by electric motors, a sizable number still depends on diesel engines. The conventional system of pumpset installation suffers from certain drawbacks and calls for technological means of achieving maximum efficiency and economy. The author would like to suggest a new method by which the energy requirement of each pumpset could be considerably reduced, effecting appreciable savings in electricity and fuel consumption on the national scale.

Fig. 1 shows the common arrangement of a pumpset discharging water horizontally; some cases of vertically downward discharge using a small elbow are also noticed. In either case energy is wasted in the discharge water as pressure and velocity heads. Further, there is a constant load due to the discharge head (Hd.).





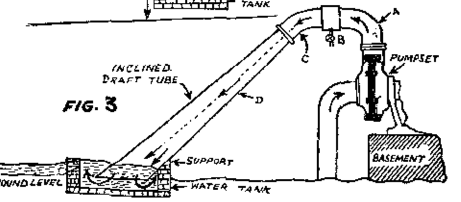


Fig. 2 shows a proposed syphon return system. An elbow (C) coupled to the existing design would discharge *the water vertically downwards. A draft tube (D) should* be connected to the elbow (C), with its taper size depending on suction and discharge heads, pump capacity etc. The other end of the draft tube (D) is immersed in water in a specially constructed tank from which water issues out to the fields. If the height of the discharge pipe from *free water level is* H_1, *there is a gain of* H_1 *feet from the* total head on the pump due to syphon action. Moreover, the draft tube causes a suction force equivalent to, say, H_2 feet due to the tapering flow chamber and assists in the pumping action by reducing the total head to $H_s+H_d-H_1-H_2$ feet.

If necessary, a bleed valve (B) may be provided to avoid back-pressure while starting, otherwise the discharge side will have to be drained after stopping the pumpset. Efficient operation of the draft tube may be ensured by momentarily opening the bleed valve (B) and checking for air suction. The conventional design suffers from the disadvantage that minor air leakages into the suction line can not be detected, but in the suggested design the discharge end is submerged in water and air leakages into the system manifest themselves by the presence of air bubbles in the discharge water. Fig. 3 shows an alternate design of the system.

Thus, by introducing the proposed or similar system on every irrigation pumpset in India, the residual kinetic and potential energy that is otherwise being wasted could be usefully harnessed. The pumpset owners stand to gain considerably by such an innovation.

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Lifting water from wells for irrigation

■ Though the conventional systems of pumping water from wells for agricultural purposes are being replaced by centrifugal pumps, there is still a very large number of villages where the former systems are in use. However, there is a fundamental drawback in many of the conventional pumping arrangements,

The conventional systems involve the use of bullocks to pump water from wells by a leather bag or a metallic container. Usually an incline is prepared to make it easier for the bullocks to pull. However, to bring the lower end of the incline to the ground level, it becomes necessary to take the upper end 1-2 metres above the ground level (Fig. 1). In this arrangement, it becomes necessary to raise the water to a higher head, although it is to be served at the ground level. So, one has to spend more energy for lifting water than is actually required.

Assuming that the well is 8 metres deep and the incline about 1.5 metres high, the bullocks have to put in about 20% extra effort and time to lift the water.

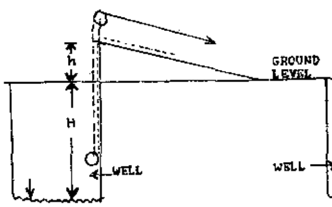

FIGURE 1-
CONVENTIONAL SYSTEM
TOTAL HEAD = H+h

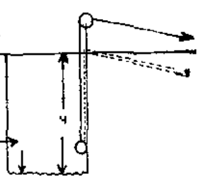

FIGURE 2-
SUGGESTED SYSTEM
TOTAL HEAD = H

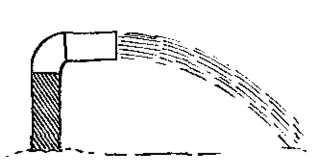

FIGURE 3-
HIGH DISCHARGE VELOCITY

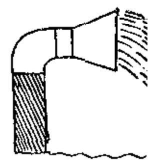

FIGURE 4-
DISCHARGE VELOCITY
REDUCED

The author would like to suggest the use of an incline whose upper end is at the ground level and the lower end below it to provide the necessary angle of inclination (Fig. 2). In this arrangement the bullocks can do about 20% extra work in the same time. Also, it may be noted that the length of the track would be 20% less than in the earlier system.

There may be one difficulty with this arrangement: in rainy seasons the ditch will collect water. However, usually no watering is required in the rainy seasons.

It is interesting to note that when a conventional arrangement is to be replaced by a centrifugal pump, the discharge of the pump is normally put in the old track, with the result that the pump has to work against a higher head. It has also been a practice to extend the pipe above the ground level by about ½ metre. It is suggested that the discharge end of the pipe should be just at the ground level. This will give more discharge with less power.

Usually the discharge velocity of water from centrifugal pumps is considerable. This kinetic energy of water is a total loss. If this loss of energy is reduced, the reduced head on the pump will give more discharge.

The author would suggest a diverging section to be fitted at the discharge end. The angle of the divergent truncated cone should be 7°-12° to avoid separation in the diverging section. Fig. 3 and 4 show the discharge end as used at present and one fitted with a diverging section, respectively.

As the loss of kinetic energy is proportional to the square of the velocity, the proposed arrangement will lead to considerable reduction in loss, and so, the diverging cone will give more discharge.

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Using waste-wood for energy production

■ I would like to propose following ideas for development:

1. In Orissa one finds a huge amount of waste wood in rural areas of many districts; so must be the case with many areas of other States also. At present it is impossible to supply electricity to all villages for lift irrigation and other purposes: indeed, it may take a few decades to electrify these areas. Most rural areas are endowed with rivers, big or small, and water is available in most of these rivers up to February-March; even after March, water is available in abundance a few feet under the river beds. Many times it so happens that while water is available in the rivers, the lands become dry due to scarcity of rain, leading to heavy loss of crop. In these days of energy crisis, waste wood can be utilized for raising steam which, in turn, can be used to rotate turbine pumps for lifting water from rivers, lakes, ponds, wells etc. This will definitely help in getting good crop when there is scarcity of rain. The whole assembly of the system used for his purpose should be mounted on a portable support so that the equipment could be easily transported from one place to another according to requirement. The equipment should be so designed that an ordinary villager could handle it conveniently. If this idea becomes successful, I hope it will solve the problems of both energy and food scarcity to a great extent.

2. Recently there was an article on 'Wood-gas producers give additional energy from waste wood' in *Invention Intelligence* (April 1976, p. 135). If fuel gas produced from waste wood could be supplied in cylinders to the people living in towns and cities for domestic use, it could partially solve the problem of fuel gas crisis and also prevent the wastage of wood that occurs in our country every year.

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