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AGRICULTURAL TECHNOLOGY DEVELOPMENT IN THE THIRD WORLD

by

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ABSTRACT

This paper reviews agricultural modernization strategies that many TWCs have tried during the past three decades and the socioeconomic consequences they had in the farming regions. These consequences (ie. overwhelming polarization of rural income, landlessness among peasants, large-scale farmers pre-empting the benefits from modernization schemes, ecological hazards from modern technology etc), have strongly influenced many peoples thoughs about agricultural technology development in the TWCs. The current view favours the development of indigenous technology based on local skills and resources, and the kind of technology that could more appropriately fit into their local circumstances. The unsettled question, however, is how local resources can be organised to achieve this goal and this is an area for further research.

AGRICULTURAL TECHNOLOGY DEVELOPMENT IN THE THIRD WORLD*
A Review of Past Strategies and New Orientations

1. INTRODUCTION

The problem of rapid agricultural technology development in the Third World Countries (TWCs) has engaged the attention of planners, researchers, and international aid agencies during the last three decades. Many ideas have been developed and schemes undertaken to modernize the agricultural sector in many of these countries. The results have, however, not always been positive. While the improved technology increased farm output, it also engendered a range of far-reaching social, economic, political and, in some cases, ecological problems. Recent writers on the subject have therefore seriously questioned the replicability of past and current projects. There has also been a continual search for alternative technologies (and alternative approaches to technology diffusion) which can more effectively solve the problem of declining output without severe unintended consequences.

The purpose of this article is to review the experiences of the past, focusing on (a) the theoretical underpinning of agricultural modernization (b) the approaches to modernization, (c) the results of past schemes, and (d) the current trends of thought on the subject. It also aims at identifying some unexplored technological options and suggest areas for further research.

2. THE NATURE OF THE PROBLEM

The needs of a rapidly expanding industrial sector and the increasing food requirements of a rapidly growing population have

* The author acknowledges helpful comments from the Development Research Group of Aalborg University to an earlier draft of this article.

been the major factors that influenced planners' perception of the agricultural problem during the 50s. The problem formulation has, however, changed in recent years as a result of the additional problems created by the failure of the industrialization strategies of the 60s, their consequent increase in unemployment and balance of payment problems. Now, the agricultural sector is seen not only as a producer of food, raw materials and export produce but also as a major "job-giver" and the pivot of rural development in general. The experiences from three decades of modernization have also taught that the development of the sector must be subject to a set of constraints aimed at checking the sociopolitical problems that modernization had generated.

In a very general sense, the problem may be stated today as how to raise the output and productivity of a predominantly peasant agricultural sector so as to:

a) increase food production and the nutritional level of the people

b) increase the production of export produce

c) increase raw material production

c) create rural jobs and raise rural living standards

without creating problems of

a) inequalities in income distribution, particularly in farming regions

b) ecological hazards

c) over-dependence on imported inputs etc.

It needs to be emphasised, however, that different countries would perceive the problem differently, either increase or reduce the goals and/or the constraints. Furthermore, although no feasible development programme can be expected to satisfy all the conditions, the formulation of the problem in this manner gives planners a complete view of the overall objectives and constraints within which to operate.

3. THE NATURE OF AGRICULTURAL TECHNOLOGY

In the light of the above problem, the technological debate has been primarily aimed at determining the most suitable combination of technological inputs that can most effectively solve the TWC agricultural development problems and help attain the dual objectives of equality and growth. Before pursuing the discussion on how the choices have been made, it is purposeful to gain some insight into the nature of technologies in general and the options within the agricultural technology development.

There is a growing view that technology is not a neutral factor of production influencing only productivity. It is better perceived as an intergral part of the culture as well as the socio-economic and political life of a society in which it is developed and applied. From this viewpoint, a "transferred technology" is seen not merely as a bunch of imported machines but as an imported mode of production, labour organization and even a culture.

In line with this perception, Müller (1980) developed a conceptual framework for technology in which he identified four components of technology - namely (a) techniques - ie. a combination of machines, labour and materials; (b) knowledge - i.e. a combination of applied science, accumulated experiences and skills; (c) organization, or the management of (a) and (b); and (d) the product which is the output from combining (a), (b), and (c). It becomes clear (when agricultural technology is placed within this framework) that the type of technology a country encourages within the agricultural sector would be a major determinant of farm sizes, production methods and the method of organising labour within the sector. Indirectly too, the adopted technology would determine the pattern of wealth and power distribution within a farming region. These issues are returned to when we evaluate the effect of agricultural modernization subsequently. The rest of this section is, however, devoted to a closer analysis of the nature of agricultural technologies. For the purposes of this article the technologies are classified in terms of their

a) functional characteristics, and
b) levels of complexity.

3.1. Functional Characteristics

In terms of their functions, agricultural technologies may be classified into three principal activity areaes - (a) pre-harvest (b) harvest, and (c) post-harvest technologies. Pre-harvest activities include land clearing and preparation, sowing, irrigation, manuring, crop attendance and other activities related to the vigorous growth and fruition of the crops. These activities are usually undertaken by using various types of mechanical inputs together with bio-chemical inputs such as fertilizers, seeds and pesticides.

Harvesting simply entails cutting and gathering in of the mature crops and it involves the use of machines and/or simple tools as well as labour. Post-harvest activities are, however, much more involving. Part of the marketable portion of a crop must be stored if the urban or non-farming rural consumers are to enjoy regular supplies until a new crop comes on the market. In TWCs, storage schemes are usually designed to serve other purposes. They, for example, act as guaranteed market outlets for growers who wish to sell large portions of their crops during or soon after their harvest time.

They may also provide agro-based industries with guaranteed sources of raw materials. Third World governments can also use them as an important element in their food price stabilization efforts. For these purposes to be achieved, the harvested crops must be properly packaged, transported to their storage points and properly stored. Packaging, transport and storage facilities are therefore as important components of agricultural technology as the pre-harvest inputs mentioned above.

It is essential to note further that these inputs constitute a package composite and are synergistically complementary. That is, the optimal efficiency of each input depends on the availability of the other inputs. While the levels of technological complexity might vary with types of farmers (see section 3.2), there can hardly be any substitution of one activity for the other. In other words, every agricultural development strategy must ensure that the inputs required for each type of activity are available to the farmers in the right proportions.

Attempts at rapid agricultural growth by using advanced inputs tend to accentuate the functional interdependence of the inputs and thereby raise the aggregate investment in technology. Assume, for example, that the peasants in a given country originally sell only one-fifth of their output. A modernization strategy which enables them to immediately increase their yields by 20 per cent will double their marketable surplus. The post-harvest technology units must therefore be sufficiently and simultaneously improved to absorb the increase. For example, if no idle storage capacity existed, the increase in production would necessitate a hundred per cent expansion in such facilities. Under such conditions, the existence of government storage schemes and infrastructure do normally help to reduce the investment cost and facilitate technological innovation at the farm level. It has been suggested that farmers would eagerly patronise such facilities because of the need immediate cash to repay loans and production credits (Reusse, 1976).

Researchers have shown further that the composite of inputs constituting modern pre-harvest technology package are even more functionally interdependent. According to Marsden (1973) the use of High Yielding Varieties of seed (HYVs) demand regular supply of water, the availability of properly levelled fields, prompt and proper seedbed preparation, constant weeding and pesticide application, large dosses of fertilizers, and timely harvesting. Farmers' ability to use the HYVs would, therefore, depend on their access to credit, land, technical advisory services and the other inputs that complete the package.

3.2. Levels of Complexity

Agricultural technology may also be classified in terms of complexity into three categories - namely, simple (type 1); intermediate (type 11); and complex (type 111) technologies.

3.2.1. Simple (Type 1) Technology

This is the predominant technology among peasants. The mechanical components are simple matchets, the farms are rain-fed and considerable amount of labour energy is used per plot. Soil fertility is restored through land rotation and not by means of fertilizer. The post-harvest technology is also very simple, in some cases, non-existent.

The simplicity of this form of technology makes it suitable for peasants because the investment requirement is minimal and the inputs suit the cultivation of very small plots. It is, at the same time, the primary weakness of the peasant system when viewed in terms of its ability to produce marketable surplus and to generate resources for re-investment. The productivity of peasants is usually low, and as population pressure on land increases in the region, they can hardly allow sufficient time to elapse for the soil to regain its full fertility before coming back to it. Also, because the farms are rainfed, farming activities are limited to only a few months of the year thereby creating the problem of under-employment of farm labour for greater part of each year, especially in places having only a single annual rainy season. Single cropping also creates enormous storage problems because each harvest has to be spread over a long period. These shortcomings indicate that simple technology can provide its users only a bare subsistence, with a risk of famine in cases of natural hazards such as draught or fire outbreak.

3.2.2. Intermediate (Type 11) Technology

The intermediate technology is a level above the simple in terms of complexity and represents a range of choices available to the small farmer to raise his productivity (see table 1). He may, for example, introduce simple mechanical and/or animal power such as ox ploughs into his technological package to expand his production capacity (ie. engage in extensive cultivation). Alternatively, he may only introduce simple irrigation techniques and thereby increase his number of croppings in a year (i.e. engage in intensive cultivation). Either of the two alternatives could raise his productivity but with different consequences. Extensive cultivation requires an expansion in post-harvest storage capacity as well as packaging materials. It also increases labour requirements for harvesting. Intensive cultivation on the other hand gains an advantage in this respect because it spreads the demand for these resources over two or more cropping seasons each year. It however has other disadvantages. It depletes the soil nutrients at a faster rate and, for this reason, must be combined with fertility replenishing inputs or techniques such as manures, fertilizers and crop rotation methods.

It must, however, be noted that intensive and extensive cultivation techniques are not substitutes. Both methods can be applied simultaneously. A farmer with only five acres of land at his disposal can place all of them under cultivation for two or more times each year by employing a few oxen, ploughs, irrigation techniques such as water pumps and using a combination of manure and crop rotation techniques to replenish the soil nutrients. This constitutes intermediate technology package.

LEVELS OF TECHNOLOGICAL SOPHISTICATION

Level of Sophistication	Mechanical		Bio-Chemical/Husbandry		Post-harvest
	Cultivation	Irrigation	Preservation of soil Fertility	Seeds	(Packaging, storage preservation/processing
Simple (Level I)	Simple farm implements such as hoes, cutlasses, axes etc.	No irrigation (Rain-fed farming)	Land rotation or Bush fallow system	Seeds reserved by the farmer from earlier harvest.	Simple farm level storage.
Intermediate (Level II)	Ploughs and/or hand operated machines in addition to farm implements.	Tube wells, pumps, rain water harvesting techniques etc. (simple decentralized irrigation).	Crop rotation, manure, and/or chemical fertilizers.	Improved seeds.	Slight improvements upon the simple (Level I) technology.
Complex (Level III)	Tractors, harvesters etc.	Large-scale irrigation systems.	Fertilizer adoption on a large-scale	High Yielding Varieties (HYVS) scientifically developed	Large complex silos, cold stores etc.

Source: Author's classification.

Note: The groupings are not to be viewed rigidly. Various combinations across the levels are possible in practice.

3.2.3. Complex (Type 111) Technology

This refers to the type of agricultural technology usually used by farmers in the developed countries. The mechanical component consists of combined harvesters,tractors and modern irrigation equipment all of which are most economically used on large tracts of land. The other components include chemical fertilizers, pesticides and HYVs. Agricultural modernization strategies in the TWCs have been based on the use on these inputs and therefore involves a transfer of technology from the developed to the TWCs.

4. THE THEORETICAL JUSTIFICATION FOR AGRICULTURAL MODERNIZATION

The basic problems of economic growth in the TWCs in the 1950s were seen as (a) generating investment resources for the growing industrial sector, and (b) expanding the market for the increasing manufactures (Killick, 1978 p. 12-13). Many economists of that period saw the solution of these problems primarily in the rapid growth of the agricultural sector. Prominent among them were Lewis (1954), Fei and Ranis (1961) and Jorgensen (1961), who in separate writings developed what came to be known as the Dual Economy Model. The model identifies two distinct sectors in a developing economy: (a) a relatively large and overwhelmingly stagnant subsistence agricultural sector co-existing with (b) a relatively small but growing commmercial and industrial sector. Economic development, according to it, entails reallocating resources from the subsistence sector to the modern or industrial sector. Increased productivity in the agricultural sector was therefore considered imperative for a feasible and continuous reallocation of resources in that direction (Ruttan, 1968).

This position was supported by Rostow in his Stages of Growth Theory of economic development. In his view, the agricultural sector must:

(a) provide foreign exchange for the importation of modern technology,
(b) provide food for a rapidly increasing population,
(c) provide mass market for the manufactured products, and
(d) generate the investment funds for the industrial as well as the service sector.

These models placed no limit on the absorptive capacity of the growing industrial sector (at least not in the short run). Industry was expected to demand more labour and capital than the growth in the subsistence sector would allow. The writers also vigorously insisted on the rapid modernization of the agricultural sector to enable it to provide the industrial sector with the requisite conditions for growth.

With the above models as basis, agricultural economists such as Perkins and Witt (1961), Johnston and Mellor (1961), as well as Hill and Mosher (1962) developed policy prescriptions to guide the modernization process. Generally speaking, they considered TWC agricultural development as proceeding from Static Stage (I), through Transitional Stage (II), to a Dynamic Stage (III) (Ruttan, 1968).

In their view, rapid innovation and diffusion of modern technology within the sector can duly take place when agriculture is highly commercialized.Commercial farmers, with profit maximization as a primary goal, would be more receptive to new ideas and would use capital-intensive (as opposed to labour-intensive) technology (Gittinger, 1966).

This viewpoint was confirmed by further studies during the 1960s. Rogers and Herzog (1966) and later Roy (1968) suggested in their studies that education and the degree of social contact of farmers enhance their technological absorptive potential. These farmers, they maintained, would cultivate crops of more immediate commercial importance - eg. tobacco, vegetables and cotton.

These theories and their supporting studies provided TWC planners with the general guidelines for agricultural development strategy formulation during teh 1960s and the 1970s. The guidelines suggest a functional relationship between agricultural technology innovation on the one hand a set of variables on the other. For purposes of clarity this relationship is presented in a mathematical form as follows:

> Agricultural technology innovation/diffusion (D) is a function of farmers' characteristics (FC) + market characteristics (MC)+ scientific support services (S) ++ an incentive package (I)
>
> $D = f(FC + MC + S + I)$
>
> where
>
> FC is composed of: size of farm, degree of farmers social contact, and level of education
>
> MC is composed of: size of market (ie. ability to asorb the surplus), the channel system (ie. larger outlet to support modern farmers), effective inputs marketing etc.
>
> S is composed of: scientific research to improve inputs performance, and extension services to disseminate scientific knowledge
>
> I is composed of: good prices for the output, credit facilities, input subsidies, land reforms (where necessary).

5. TECHNOLOGICAL DEVELOPMENT STRATEGIES

Many countries started their ambitious agricultural modernization programmes in the 1950s with strong commitment to mechanised farming (Mardsen, 1973). Mechanization was vigorously encouraged by exempting agricultural machinery and spare parts from all kinds of import duties (Gill, 1975), by establishing mechanization centres and tractor hire services, and by providing credit facilities to would-be purchasers.

The innovation promotion strategies followed the guidelines described above very closely. Nearly all TWCs had some form of agricultural credit and subsidy schemes which were to facilitate farmers' use of modern inputs. The Nigerian example cited by Mirchanlum (1975) can be considered a representative picture. In that country, fertilizeres and pesticides attracted 50 per cent subsidy, tractors were hired to farmers at between 25 and 50 per cent, the state government and marketing boards shouldered the cost of seed multiplication, storage and distribution, (the farmers receiving the seeds free of charge.)[1)]

Some governments were even prepared to use ruthless coercion to get farmers to adopt the modern inputs. In Mwanza, Tanzania, for example, the regional commissioner found it necessary in the early 70s to send a para-military unit of the police to Ukerewe to force farmers to apply fertilizers to their cotton crops (Finncan, 1974).

Nearly all countries with agricultural development strategies established (or provided for the establishment of) extension service schemes which trained and sent out extension officers to help farmers effectively apply the inputs on their farms.

The focus, as prescribed in the guidelines, was initially on the large scale farmers. In Mexico, for example, all reforms after 1940 systematically organized financial and material resources to support large scale farmers and ignored the request from ejido farmers (De Alcantara, 1973). Countries without any tradition of large scale farming established state farming corporations and placed vast tracts of land at their disposal (Kuada, 1981). Other countries such as Tanzania and, later, Ethiopia adopted collectivization and resettlement farming approaches - i.e. bringing peasants into groups to cultivate

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1) Similar cases were reported form Pakistan (Main, 1975), Bangladesh (Hung, 1975), Ethiopia (Tecle, 1975). Several West African and Latin American countries (Morss, 1976, India (Frankel, 1971) also had similar schemes.

contiguous plots on which modern inputs can be economically applied (Elliot, Charles 1975). The results of these schemes have been analysed below.

Although the above review represents the general pattern, TWCs are not uniform in their implementation of the strategies. Some countries devoted far greater resources and attention to the modernization schemes than others. Those which vigorously pursued the schemes, experienced tremendous increases in output, especially cereals; and even farm labourers in these areas enjoyed higher wages.

It must also be pointed out that many countries applied the prescriptions described above (section 3) rather selectively. Greater emphasis has been placed on the importation of inputs and schemes aimed at diffusing them while supporting policies such as price incentives and improved marketing facilities were ignored in some countries. For these reasons, the evaluative studies reviewed in section 6 of this article have mostly been in areas where substantial local and external resources have been devoted to the modernization schemes.

6. RESULTS OF PAST STRATEGIES

As hinted above, the ability of modern agricultural technology to raise otuput and productivity is no longer in doubt. It has been the backbone of the Green Revolution in several Asian countries (Myint, 1973). In fact, its dramatic impact on the agricultural sector of these countries led to its perception as a harbinger of an era of a new cornucopia throughout the TWCs. This belief also led to the enthusiasm shown by many planners and international aid agencies to accelerate its diffusion.

Earlier appraisal studies identified managerial problems as the main barriers to diffusion and did not question the propriety of the technology itself within the wider socio-economic and political context of the TWCs. Chambers (1974) placed part of the blame on the field workers from the extention service centres who, in his assessment, were poorly motivated, lacked entrepreneurial attitudes, drank too much, worked too little, and spent too much time on their private business. Brown's (1972) studies of the Ghanaian situation noted that the extension officers were too few and ill-equipped to perform their duties effectively. Matts (1969) in his Kenyan studies, noted mistakes such as frequency of transfer of staff, frequent changes in local policy and frequent reorganization of the extension agencies as some of the weaknesses of the diffusion schemes. In the case of post-harvest technology, Reusse (1976) noted a lack of coordination between production schemes and storage projects, resulting, in many cases, in building silos of capacities far beyond farmers' requirements.

Doubtlessly, the problems investigated in these studies require correction if diffusion is to be accelerated. But the concentration of development efforts on large scale farmers has produced a number of negative side effects which now influence the direction of the technology debate. It is to these unfavourable effects that we now turn.

6.1. Social Differentiation

In many Asian and Latin American countries, and also in a few African countries, the acquisition of land for large scale farming led to the displacement of peasants, turning them either into tenants or landless farm labourers (Harvey Charles, 1979; Torp Eric, 1980). The socio-economic consequences have been devastating. There have been increasing exodus of the displaced labour to join the unemployed pool in the urban centres with an attendant increase in social problems. Peasants who attempted to compete with the large scale farmers found their situations persistently weakened as the latter pre-empted the benefits from the various agricultural schemes by usign their economic and social, and in certain cases political influences. Peasants who accepted credits from the large farmers or government agencies landed themselves in the quagmire of debt. Widening income inequalities have therefore become a special feature in several Green Revolution countries. An ILO study presented the situation in the mid 70s as follows:

> "Rural areas of Asia are in crisis. Food scarcity is chronic,episodically becoming severe as to lead to famine. Population growth is rapid and landlessness is rising... The number of rural poor has increased and in many instances their standard of living has tended to fall. Perhaps surprisingly this has accurred irrespective of whether growth has been slow or agriculture has expanded swiftly or sluggishly". (ILO, 1977).

Another study conducted by Griffin (1978) in the same area confirmed the ILO observations. It noted further that in countries where national income have declined, the rich people have nevertheless raised their living standards and the real incomes of the poorer rural farmers in particular have shown deep decline.

Kuada (1981) argued that these socio-economic problems are directly attributable to the nature of modern agricultural technology and not merely any observed weaknesses in the process of diffusion. By their very nature, the technology package is most efficiently applied on large scale farms and this gives the large scale farmers an advantage over small farmers who would like to use it on their farms. This argument is partly supported by the failure of many projects which aimed at reaching the small farmers with modern inputs. The results of these projects were studied by an American research institute, the Development Alternatives, Incorporated in 1976. This study concluded that nearly all the projects had very limited success (reaching an average of only 200 farmers). Besides they were heavily dependent on experts and, although the productivity of the farmers increased, the farmers' aggregate earnings could hardly cover the economic cost of the projects. The study also made a special observation about the category of farmers which the inputs reached. It noted, "those local inhabitants who are already further along the path of development (as measured by per capita income and involvement in the market economy) are more likely to be found in successful projects than the smaller, close-to-subsistence farmers" (vol. 1 33-35).

The general conclusion from all the modernization experiments remains the same: that the peasants have not only failed to share in the gains but have often become absolutely as well as relatively worse off. The TWCs, therefore, require a new kind of technology and/or a new diffusion strategy to improve their situation.

6.2. The Foreign Exchange Problem

Agricultural modernization has also joined the import substitution industries to exert tremendous pressure on the foreign exchange resources of the TWCs. Their chronic balance of payments problems therefore impose a serious limitation on the quantities of inputs that can be imported during each year.

More disturbing perhaps, is the high concentration of the agricultural technology trade which makes it difficult for the TWCs to receive a good offer. In a report of the London based International Coalition for Development and Action (ICAD) entitled Seeds of Earth, it was shown that the biggest seller of seeds in the world is Shell - the Anglo-Dutch petroleum and chemical giant. In addition, just four companies (Delkalb, Pioneer, Sandoz and Ciba - Geigy) control twothirds of the corn (maize) and hybrid sorghum seed market in the U.S.A. In another study the Food and Agricultural Organization of the United nations (FAO) noted that just one company - United Brands (formerly United Fruits) possess about two-thirds of the worlds potential breeding stock of banana (Agarwal, 1980).

7. CRITIQUE OF MODERN AGRICULTURAL TECHNOLOGY

The results from past schemes discussed above provide the background for some of the popular criticisms against the transfer of advanced agricultural technology from the developed countries to the TWCs. The debate has focused on the following aspects of technology difussion:

(a) the factor endowments of TWCs
(b) the absorptive capacity of TWCs for advanced technology
(c) the ecological consequences of technology innovation

7.1. Factor Endowment Argument

It has been argued by such writers as Frances Stewart (1978) that the historical process of technological development in the developed countries has been characterised by the need to save on labour and to reduce the cost of production per unit of output. The outcome has been the development of technologies that are basically capital-intensive. However, the abundance of cheap labour (relative to capital) in the TWCs suggests that labour intensive and capital-saving techniques are more appropriate to these countries.

This argument has given rise to policy prescriptions that aim at encouraging the development of small scale industries and making fuller use of artisanal skills in the TWCs. Peasant farming using intermediate (type II) technology discussed above (section 3.2.2) has also been considered more appropriate to the TWCs than tractorization. The use of intermediate technology, it has been argued, would eliminate the need for acquiring large tracts of land for farming purposes and its related problems of landlessness and inequality.

7.2. The Absorptive Capacity of TWCs for Advanced Technology

It has also been argued that advanced agricultural technology has been developed without any reference to the infrastructural or "soft ware" facilities in the TWCs. It is therefore imperative for these countries to undertake investment in such facilities simultaneously with investment in the inputs themselves (Edquist & Edquist, 1978; Bhagavan, 1979). For example, skills for maintaining and repairing complex agricultural machines are usually lacking and this reduces the useful life of many of the machines imported. There have also been cases in which farmers could not use electric pumps for irrigation because the electricity companies failed to respond to their application for electric power. Another example is the importation and distribution of fertilizer which requires not only storage facilities but also transport facilities to cart them to the farming areas before the beginning of each cropping season. The poor transport facilities of the TWCs have therefore been a major handicap to their efforts to encourage the use of fertilizers.

7.3. Ecological Inappropriateness

Writers who concern themselves with the ecological aspects of technology argue that the basic farming conditions relating to the soils in the tropical countries are so different from those of the temperate-zone countries that dealing with them requires another body of knowledge alltogether (Kamarck, 1979). Since existing advanced agricultural technology have been developed for the temperate zones they are naturally unsuitable for the tropics. It has been observed in several African countries, for example, that tractorization speeds up soil erosion because it exposes the fields to the sun the backed soil loosens up and is washed away during the rainy season. The differences in the basic soil conditions therefore indicate that the TWCs cannot use even the technology used by the developed countries when the latter in turns were poor.

It has also been argued that since rural folks in the TWCs fetch their water from rivers and streams the excessive use of chemicals such as fertilizers and pesticides could result in the pollution of their main sources of drinking water.

8. THE NEED FOR A NEW TECHNOLOGY POLICY FRAMEWORK

The discussions in sections 6 and 7 indicate that although modernization of the agricultural sector could fulfil some of the objectives in section 2 (eg. increase farm output and productivity), it has failed to satisfy the contraints. In fact it has worsened these problems.

The currently prevailing view on the subject is that the TWCs ought to change their agricultural technology policy framework in order to encourage the development and the use of inputs most appropriate to their specific circumstances. Most of the new ideas stress the need to learn and use the traditional knowledge of the rural people. They reject the hitherto prevalent notion that the only valid and useful knowledge comes from the advanced countries and that rural knowledge is usually "unsystematic, imprecise and even plain wrong". (See IDS Bulletin of January, 1979).

Generalising from the study of economic development problems in Ghana, Killick (1978) expressed the same view by suggesting that TWCs must adopt policies that would enable them to grow from improving upon what already exists (P. 353). A similar opinion was also expressed by Collier (1977) about Java's rural development. He wrote:

> "In Java, there have been many attempts at rural development that have come from outside the village. The time may have arrived to search for institutions and mechanism within the village that can accelerate rural development."

In the same vein Pearse (1977) concluded, after an appraisal of the Green Revolution on a global scale, that a new strategy must incorporate a principle of "deliberate bias in favour of local self-reliance and full exploitation of the potentialities of local resources and knowledge for the improvement of agricultural production and livelihood".

Experts on post-harvest technology also agree with this approach. In his review of storage schemes in small farming areas of the TWCs Reusse (1976) observed that "the socio-economic usefulness and commercial viability of storage schemes will depend on their ability to integrate with the still predominantly traditional post-harvest system in a supplementary way, without aiming at its replacement".

It must be stressed that the essence of this new thinking is not how to assimilate traditional knowledge into modern knowledge in order to make the latter more efficient. Technological development policies must rather aim at a synthesis of modern and traditional knowledge at the level of the rural society instead of the advanced countries. In the words of Swift (1979), "the best future course of action is likely to be eclectic combination of old and new knowledge, in a mixture made and controlled as far as possible by the rural people themselves".

The aim of this approach would be to develop inputs that would fit into an intermediate (Type II) technology described above which would enable peasants to engage in intensive cultivation and raise their output and prodctivity on their small, usually scattered plots. This would help avoid the socially disruptive consequences which seem to follow modernization.

8.1. Feasibility of Rural Technology Development

There are few that would question the wisdom in this thinking. But many people are sceptical about its feasibility. They wonder if the TWCs really have local skill and resources to start such a technological development process, whether such a change (if it happens) would actually eliminate the negative effects for which modernization has been blamed and at the same time ensure rapid increase in output which many TWCs need in order to stave off total famine. If it is infeasible, would it not be justifiable to consider modernization as a necessary evil?

These are genuine concerns which cannot be dismissed without concrete evidences that would establish the thinking as realistic. There are of course many studies providing that considerable artisanal skills exist in almost all TWCs. (See studies by Child, 1979; Muller, 1980; King 1978; Liedholm and Chuta, 1976, among others). What these studies have not proved, however, is if the skills could be successfully applied to the task of agricultural technology development. Kuada (1981), after studying the operations of blacksmiths in Ghana, suggested that it was possible, granting genuine government support and a set of incentives and support services. But further studies are still required in several other countries for a generalization to be made. There are however, scattered evidences of peasants and artisans collaboration at the rural level to develop tools that satisfactorily solved certain technological problems within the agricultural sector. One of the most impressive of such examples was the bamboo tube wells developed in the Saharsa and Purnea districts of India (Dommen, 1975).

8.2. The Bamboo Tube Wells of India

The shortage of water has, for a long time, been a major problem in these districts. As a solution, a big government irrigation project was undertaken but could not completely solve the problem. The farmers could not use the water due to the deposit of large quantities of fine grain silt sediments in the bottom of the main branch and distributory canals which blocked the flow of water to plots further away from the canals. At the same time, lands adjoining many of the canals were waterlogged while the uneven load of the command area left some villages dry. Technical experts had suggested a solution which would involve heavy investment, not to mention long periods of political debate and bureaucratic bottlenecks.

The lure of this water motivated an owner of middle sized farm (6-7 acres) to experiment with the construction of bamboo tube wells which would draw water from between 20 and 30 feet depths. After a brief period of experimentation, the first tube well was successfully sunk in his field. Thereafter the construction of the tube wells became a popular and lucrative business for farmers and local artisans. It was estimated between 1969 and 1973 more than 33,000 of such tubes were sunk and more than 100,000 acres of land had been brought under irrigation as a result.

This widespread use of the invention within such a short span of time stemmed from the following charateristics:

(a) It could be constructed entirely out of indigenous or easily available materials (unlike the iron tube wells which were known prior to this invention).

(b) It was so light that it could be carried by a single man.

(c) It was cheap. Equipped with a standard 5 horse power diesel engine, it had a delivery capacity of 7,000-8,000 gallons of water per hour. It had a useful life between 3 and 5 years. But could be completely constructed at home without any loan.

(d) Since it was cheap, the farmer could afford more than one tube well. This was important because peasants cultivate small plots.

(e) Also since it was cheap, it was expendable in case the well dried up.

The only real bottleneck to further dissemination of the bamboo tube well was the cost of pumping sets. The cheapest pumping set was, at that time, selling at 3,125 rupees and most farmers could not afford anything above 1,000 rupees.

It must be stressed, however, that the success of the farmer's experiment was a culmination of a series of smaller breakthroughs by other experimenters in the districts. In other words, the capacity and interest of the peasants to experiment was widespread in the area. It can also be hypothesised that when rural producers are spurred by circumstances or pressures, they will apply their existing knowledge to their problems. A community in which very little changes occur definitely requires some significant stimulus to generate actions and reactions. In the case of the bamboo tube well, the stimulus was the irrigation project.

Admitedly, Saharsa and Purnea districts' experience with bamboo tupe wells alone cannot provide a conclusive evidence that locally developed peasant technology can be stimulated and diffused. There is a need for a country experiment in which attempts can be made to translate the ideas into reality and clinically examine the specific problems that such a strategy can create.

8. CONCLUSION

It is evident from the above discussions that the experiences with agricultural modernization have further reinforced the wisdom in self-reliance as a guiding principle for planning development process in the TWCs. In terms of technological development, it has been suggested that the TWCs must create their own technology producing sectors in order to ensure that the most appropriate inputs are developed and produced.

The unsettled question, however, is how this sector can be created. How, for example, should artisanal skills be developed and how should they be stimulated to direct their skills to designing and producing improved farm implements? What should be government policy regarding the development of this sector? How would this approach precisely influence wealth and power distribution in the farming regions? How can political forces be mobilised to support such an approach? These are issues requiring further research the results of which can form the basis for formulating guidelines for village-level technology development.

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