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1. INTRODUCTION

Since this Seminar is organized by the Near East Office of FAO, this paper is confined to rainfed agriculture in semi-arid zones under conditions of dualism where there is both a modern and traditional sector. The first is characterized by large-scale mechanized production units, the second by traditional small peasant cultivators who often keep livestock under transhumant systems and supplement their incomes from gathering wild products from the wastes. Another common traditional form of land use is for nomadic pastoralism; a system which in the past used resources for which there were very few, if any, alternative uses. Competition between nomads and cultivators was mainly confined to disputes over access to water.

Few of the traditional land users had any title to access to land and consequently are very vulnerable to the alienation of their land to the modern sector whether state or privately operated. Enclosure of the wastes threatens the continuation of stock grazing and the gathering of wild produce and in the vicinity of existing settlements may well shorten the resting period under shifting cultivation systems. If this occurs at a time of population pressure, then the settlement could well become unviable and the surplus population forced out. Seasonal employment may be available in the modern sector but the opportunities are rather limited in extensive mechanized agriculture. The nomad also faces the problem of access and often reacts violently to land enclosure. In some countries this has resulted in considerable crop losses by fire and animal trespass and armed conflict between nomads and the cultivators is not unknown.

Risk has always been a feature of the exploitation of semi-arid regions. The great problem is not that average rainfall is low but that in a given year it is uncertain. In the past, people have tried to adapt themselves to the situation, the cultivator by depending on other activities besides the produce of his farm, the nomad by migrating to other areas. Now with land enclosure, this is more difficult and pressure on the remaining land often accelerates soil degradation. The mechanized farmer is more vulnerable to climatic risks through his failure to obtain adequate returns to meet his cash flow requirements. Where money is short, he may farm badly and so accelerate the rate of soil degradation. Erosion may well be a problem especially where the ground cover of the land has been cleared over wide areas. Soil conservation measures are then important, especially the planting of windbreaks and farming with full regard to the contours of the land surface.

The modern, unlike the traditional sector, depends heavily on purchased inputs. This introduces a further risk element in that the ratio of unit prices for inputs and outputs, the farmers' "terms of trade", may move against him. Agricultural prices are volatile and farm gate prices tend to be considerably lower than those paid by consumers partly because of the poor bargaining power of farmers and other

imperfections in the marketing system. Prices of inputs, however, tend to rise, especially fuel, lubricants, machinery, spare parts and repair costs. Where the mechanized sector is large and the country's balance of payment precarious, then shortages of vital imported supplies can develop.

The mechanized sector also faces a credit problem. Investment capital is required for land clearance, buildings, water and roads and perhaps fencing. Equipping the farm with machinery is also expensive while the dependence on purchased inputs demands considerable working capital. The risks of climate and prices effect the steady process of building up financial resources and a series of poor years could well affect a farmer's capabilities to service his loans. Once this happens, he may lose his credit worthiness. Then to survive, he will cut down on his standard of farming to save expense, so entering a vicious cycle of poor yields, higher vulnerability to risk and in the last decade deteriorating "terms of trade" between input and output prices. In the private sector, he may give up. The state sector may survive longer provided that the government is prepared to bail it out. The record of cooperatives is not encouraging either.

One problem on newly cleared land for mechanized agriculture is a tendency, after the initial years, for crop yields to fall until a low yield plateau is reached. The reasons for this are not fully understood, but among the various factors blamed are the depletion of soil humus and nitrogen supplies and growing weed populations which compete with the crop for soil moisture and nutrients. A common feature is that because of poor husbandry methods and the lack of a proper rotation, the weed population builds up rapidly. The traditional cultivator faces the same problem but his solution is to practice shifting agriculture. The mechanized farmer may well try and adopt a similar system but the long-term effects on the eco-system could well be drastic.

One possible approach to the problem is to incorporate livestock into the farming system. Leguminous crops could be grown and either grazed in situ or conserved. Cereal stubbles and the surface weed cover could also provide grazing and crop by-products utilized. Drinking water supplies may prove a constraint and rule out stock breeding and rearing but not the short-term final process of fattening. The nomads are an obvious source of immature cattle and sheep. The sale of immatures on a large enough scale would increase annual take-off rates from the rangelands, so reducing the excessive pressure on the grazing. The farmer would benefit too, not only from the soil fertility and weed control aspect, but also from the adoption of a new enterprise which should diversify his risks. Too often, he is dependent on a very narrow range of enterprises indeed.

The Central Rainlands of the Sudan, which are covered by the FAO Near East Office, provide a case study of the problems of rainfed agriculture, especially the socio-economic effects of the development of mechanized agriculture.

2. THE SUDANESE EXPERIENCE

2.1 The Pre-Development Situation

The Central Rainlands form a belt across the Sudan, South of the Sahara between approximately latitudes of 10° and 14° North. Rainfall increases rapidly away from the Sahara with annual averages varying from 450 mm in the North to 900 mm in the South. Rain falls mainly in thunderstorms, so increasing erosion risks; the wet season lasts for approximately 3 months in the

northern part of the belt to 5 months in the southern part. Plant growth is rapid once the rains have soaked the soil, but high temperatures lead to high evapo-transpiration rates, so the effective growing season is limited to 5-7 months a year. Temperatures are high reaching an annual average daily maximum of around 40°C before the onset of the rains and the lowest daily mean temperature, around 35°C, occurs in December and January. The eastern portion of the area has heavy black clay soils, while in the West, lighter soils predominate. The region is characterized by strong Trade Winds in the winter, another source of possible erosion.

The natural vegetation is savannah with the density of tree cover increasing southwards. Early mechanized developments started in the North-East of the region in 1945 where the land had light tree cover and so was cheap to clear. Since then, mechanized development has moved South and West, so incurring higher clearance costs and longer lines of communication. By 1976/77, some 1.47 million hectares were under mechanized cultivation out of the total of an estimated 250 million hectares suitable for arable farming. The whole area represents one of the largest land reserves in Africa and it is little wonder that the Sudan has been marked as "the new Argentina" and "the bread basket of the Middle East".

The availability of permanent water supplies determines the pattern of settlement. This differs on the permeable sands and the non-permeable clays, where the possibilities of tapping underground water are rather limited. Villages are consequently more common on the sands, and the clays are very sparsely populated indeed. The villages base their economy on shifting agriculture and because of the shortage of drinking water during the long dry season, livestock is often sent away elsewhere - transhumance is important. The system of farming is simple in the extreme. The farmer has scattered plots (bildats) which are cleared before the rains start by hacking down the vegetation and then burning. Seeds are poked into the ashes with a stick and once the rains come, crop and weed growth are rapid. Weeding and thinning are done with small primitive hand hoes. Sorghum and sesame are the main crops grown; the former for subsistence, the latter for sale. All harvesting and threshing are carried out by hand. Average crop yields are low; a recent study reports yields for sorghum and sesame in the region of 750 kg and 180 kg per hectare, respectively (Simpson, 1978). These yields are higher* than those reported for mechanized farms in the same study, a disturbing situation. As the large farm depends more heavily on purchased inputs than the small farm and the intensity of manual labour employment is not significantly different, then it follows that value added per man is higher on the small farms, despite the neglect of small farms by the research and extension services and the absence of expensive imported inputs.

The other traditional form of land use is for nomadic pastoralism. This allows for the economic exploitation of the desert fringes of the northern savannahs and the swamp fringes of the South; areas which probably would only be little used otherwise and so have very low opportunity costs. The wet season is spent in the North, near the desert, the dry season in the South, by the swamps, so passing through the intervening savannah twice a year. The nomads move quickly almost "at the gallop", in the dry season in case water supplies run out en route, in the wet season to keep ahead of the heavy rains with their concomitant mud and biting flies. The whole migratory cycle is now threatened by large-scale enclosures for mechanized agriculture in the intervening savannah areas between the desert and the swamps. A further complica-

* 390 kg and 110 kg per hectare, respectively, for sorghum and sesame.

tion is that , while land is being lost to mechanized farming, the size of nomadic livestock population is building up due to the control of epidemic disease. An additional factor is that the Sahel Drought has forced western African nomads into the Sudan.

A serious confrontation is developing between nomads and the large farmers. The nomads term them "colonialists" and have no scruples at all in letting their animals, usually at night, into the cultivated areas for grazing. As the nomads are often armed, farmers and their workers are terrorized and before the police arrive, the nomads literally have vanished into the night. Another source of crop damage associated with nomads is fire. It is a common practice for nomads when moving southwards during the dry season, to burn grasses in advance of their passage through a district, in order to encourage new growth and kill off ticks and other pests. In an area of strong Trade Winds, such fires spread rapidly and engulf standing crops.

In some areas, corridors have been left through the cultivated areas for the passage of nomads. Farmers are naturally anxious to prevent nomads from passing along the boundaries of their land, so some have pulled up the boundary markers and cultivated the corridors. The numbers of livestock passing through the cultivated areas, twice a year, are considerable. It is estimated that, in the Blue Nile Province alone, nearly one million cattle and over one million sheep pass through the province twice a year (Ministry of Agriculture, Food and Natural Resources, 1977).

A recent estimate puts the loss of net output, resulting from the enclosure of waste land, at around LS 2.38* per hectare, of which 60% represents the loss of net output from charcoal, firewood and timber, 30% from gum and only 10% from grazing (Simpson, 1978). Land clearance involves the wholesale felling of trees and bushes, all of which are normally burnt in great open fires and no attempt is made to use them for timber or charcoal production. Many of the trees are either Acacia Senegal or Acacia Seyal which yield gum arabic. The Sudan produces 80 percent of world supplies. The felling of gum trees robs the traditional sector of a valuable income supplement, while the country's foreign exchanges' earnings are reduced. Tree clearances also encourage wind erosion.

2.2 The Mechanized Sector

The ease with which the wastes were enclosed for cultivation is partly due to the fact that the traditional land users mostly have no legal rights to the land at all, so the stage can and does demarcate land for mechanized farming, usually on 25 year leases. Blocks of land are laid out on a grid system with no regard to the contour of the land; again where slopes are unfavourable, encouraging erosion. Land concessions, up to 420 000 hectares, have been granted to Arab-Sudanese companies, but the standard system is to let the land in either 420 hectare or 630 hectare holdings to private tenants. This latter form of tenure accounted for 90 percent of the land under mechanized farming in 1977. Land was also taken for state farms which proved an increasing financial liability to the government and for a few cooperatives, most of which collapsed rapidly. The whole mechanized sector is controlled by a State Organization, the Mechanized Farming Corporation, whose activities are constrained by the lack of resources.

As regards land tenure, this is governed by the 1925 and 1970 Land Registration Acts. The first Act provided for the registration of both land

* LS = Sudanese Pounds.

ownership and rights of access. The traditional land user neither knew of the Act, nor if he knew, had the resources to register his usufruct rights. The 1970 Act extinguished unregistered rights, leaving the state free to dispose of the land. As regards the Central Rainlands, the allocation of land is controlled by the Mechanized Farming Corporation. Land for private standard tenancies is let on 25-year leases at a nominal annual rent of approximately LS 0.12 per hectare. Conditions stipulated in the standard lease include an obligation to cultivate the land according to the regulations of the Corporation "and to keep the fertility unimpaired". The tenant is also required to live "in the project area" during the farming season. The tenant is also to give access through his land "to the public and their animals" if so directed by the Corporation. Failure to fulfil the conditions of the lease can lead to the termination of the tenancy without compensation.

So, on paper, at least, there are considerable powers to control the private tenant and to allow the passage of nomads. Leases, however, are not effectively controlled and few tenants, if any, have been evicted. Nor have the very nominal rents been collected in full. Some tenants have cultivated further land adjacent to their farm boundaries without permission, including the corridors left for the passage of nomads. The ineffectiveness of the Corporation in preventing all this is due both to its lack of resources and to the desire to increase the cropped area in the short run.

The main criterion for the selection of tenants is the ability to raise the minimum capital necessary to obtain loans for initial land clearance, purchase of machinery and the financing of cultural operations. The balance can be borrowed from the Agricultural Bank of the Sudan. A considerable proportion of these loans have not been recovered, partly because the Bank has not got the resources necessary to check on the farmers' failures to repay. The recent cash flow problems of the Bank have resulted in an application to the World Bank for a loan to strengthen the former's resource base.

Tenants are mostly urban-based entrepreneurs or professional men; few have agricultural backgrounds. Most are absentees and are known as "suitcase farmers". Day-to-day management is left to a "wakeel" who usually has received little or no formal education and can be regarded as a foreman rather than a trained and experienced manager. Normally, his rate of pay is low. In theory, a tenant is only supposed to have one holding. In practice, multiple holdings are common, especially in the Gederef district, where some individuals hold up to 25 separate holdings. These are often merchants who, over a period of time, have proved successful farming entrepreneurs. They diversify against the risks of rainfall, diseases and pests by spreading them over farms in different localities. They have sufficient capital to farm well and are in an advantageous situation as regards marketing, especially their ability to hold onto their crops until seasonal price rises follow the harvest price lows. Some of these entrepreneurs are innovators. For example, one tried herbicides and the folding of store sheep on sorghum stubbles. These practices proved successful and are now being adopted by other farmers in the district.

The government's attempts at research and extension have proved ineffective. The Sudan has research stations with international reputations, but their work has concentrated on cotton at the expense of other crops. The Research Station for the Rainlands, at Abu Na'ama, had done useful work, but is seldom visited by farmers, extension workers or "investors". In 1977, staff commented that they had not seen a farmer or an extension worker there for a year. The extension service is also a subject for criticism. Many farmers complain that they have never seen an extension worker. The extension service, in turn, ascribed the situation to its lack of resources. In Damazine, for example, a regional headquarters responsible for 19 percent of the total national area

under rainfed mechanized farming in 1977, the only extension worker had no office and very little in the way of transport facilities. He worked in the house and very few farmers sought him out for advice.

Given the institutional situation, it is not surprising that the mechanized sector got into difficulties. The basic problem is the inappropriate farming system, with its tendency towards the monoculture of sorghum and the neglect of rotations. To call the system mechanized is somewhat of a misnomer. Tractors and disc harrows are used to prepare a rough seedbed once the first rains have fallen and the crops are generally sown by seed drills mounted on the discs. The rest of the cultural operations are usually done by hand by casual seasonal workers. Crops are weeded and cut by hand and even threshed by hand, although it is common practice to hire combines which are used as stationary threshers*, for sorghum. The harvesting of sesame is unmechanized because of the dangers of seed losses through shattering.

A cost of production survey, carried out in the Damazine area in the crop year 1975/76, shows an average cash outflow of LS 16.35 per cropped hectare, of which approximately 63 percent is for labour and 23 percent for machinery costs. These figures exclude depreciation and loan servicing. Against this, can be offset a cash inflow (net of produce taxes) of only LS 9.11 per hectare, leaving a cash deficit of LS 7.24 a hectare. This deficit is associated with low crop yields** and conditions of imperfect competition in marketing. The former is, by far away, the most important, but the latter will be discussed first.

The two main crops of the mechanized sector are sorghum and sesame. Sorghum marketing is dominated by a tight oligopoly of traders, while sesame marketing is regulated by the parastatal Oil Seeds Marketing Company. There is evidence of excessive distributors' margins being earned in the sorghum trade, while with oil seeds, there appears to be excessive costs because of the inefficiencies of the marketing system.*** Both excessive profit margins and excessive costs are borne by the producers in the form of lower prices than they would otherwise attain in the absence of imperfect competition. Farm gate prices also are subject to local taxation, levied on a flat rate basis per sack sold in some provinces and in others on the estimated output at the farm. Farmers also have to bear the incidence of import duties on fuel and machinery.

Since the surveys were carried out, input prices have increased rapidly, but farm gate prices have not. In that crop yields show a tendency to fall with the increasing number of years a farm is cultivated, this means that the economic viability of the whole mechanized sector is questionable. The pressure of unfavourable terms of trade means that crop yields have to rise to ensure that returns do cover costs, but this need coincides with a tendency for yields to fall over time, given the present farming systems.

*The long strawed multi-headed varieties grown are unsuitable for direct combining. Most of the combines are hired from the Agricultural Bank who provides the service in order to monitor crop yields.

**In the survey, average crop yields obtained were 390 kgs for sorghum and 107 kgs per hectare for sorghum and sesame, respectively. The weather was considered normal. These yields are considerably lower than those returned by the small traditional cultivators in the same survey.

***This information was supplied by Omer El Farouk, a doctoral Student at Leeds University, working on the problems of sorghum and sesame marketing in the Central Rainlands of the Sudan.

2.3 Crop Yield and Time

The fact that crop yields fall over time is fully recognized by farmers in the Central Reainlands. The survey quoted earlier suggests that yields peak in the second year after initial clearance, all other things being equal, fall yearly until the 7th year and then stabilize at a low plateau. The range suggested is between a peak of 1 730 kgs per hectare for sorghum and a plateau yield of 430 kg per hectare, while with sesame, a peak of 730 kgs a hectare and a plateau of 180 kg. The main reason given by farmers to explain this decline is the build up of weed populations over time.

The crucial economic point is the relationship of plateau yields to the prevailing output/input price ratios; the latter determine the break even yields where costs are balanced by returns. If break even yields are above plateau yields, then farming will become unprofitable within a few years after first clearing the land.

That this indeed is the situation is supported by the experiences of two major mechanized farming projects financed by the World Bank in the Sudan. Post mortem reports suggest that the final internal rates of return on the projects are likely to be negative instead of the high positive rates suggested in the original appraisals. The basic reason for this is that the crop yields figures taken, turned out to be completely unrealistic. They were assumed to rise over time on the grounds that farmers would gain greater experience of local conditions. In fact, they fell. A new category of farmers came to be distinguished, "the deserters"; farmers who had either given up farming altogether or had moved on to new land.

The economics of this horizontal movement are clear. A farmer can take the profits afforded by the initial levels of crop yield and also pay off his land clearance and machinery loan. Then, by moving on to virgin land, before crop yields reach financially unviable levels, he can avoid losses and remain credit worthy with the Agricultural Bank. Fresh tenancies are easy to obtain and loans for land clearance and machinery purchase are available to those with a good repayment record. Unfavourable climatic conditions may result in low crop yields in the early years, but conditions unsuitable for crops, equally affect most weeds.

What, however, may make sense to the private farmer, is not necessarily good for the Sudan. Horizontal expansion involves the replacement of the original open Savannah by dense thicket of thorn bushes of no economic value. Thorns do not yield timber or gum arabic, nor can livestock more freely let alone, find much in the way of grazing or browsing. In the period before the thorn develops, the danger of wind erosion has been increased and where slopes are favourable, the possibilities of water erosion are high. It is not surprising that allegations have been made that a small class of "capitalist farmers" are "strip mining" the soil in attempt to snatch a quick profit (O'Brien, 1977).

The dangers of a horizontal development which left a trail of ravaged land in its rear, were recognized by a recent World Bank Mission to the Sudan, 1977. The mission recommended a "vertical" approach, increasing crop yields on existing land and providing local infrastructure, especially all weather roads to encourage the permanent settlement of the area. To raise yields, it was felt that the existing farming systems should be replaced. A loan has recently been granted for applied research into improved systems and technology. Once suitable alternatives have been identified, the objective is to diffuse the results as quickly as possible to the farming community.

2.4 The Socio-Economic Consequences of the Central Rainlands Developments

A large area of savannah land has been cleared in order to secure a mediocre output of sorghum and sesame, for what appears to be only a few years. From an ecological aspect, this seems somewhat disastrous. Tree felling and the large-scale destruction of wildlife have disrupted existing eco-systems and the former has increased the risks of erosion.

An individual could have a good chance of making profits by practising what may turn out in the long run to be a system of shifting mechanized farming. However, from the aspect of the community, as a whole, the output obtained represents a negative net output because of the high direct and indirect costs involved. The former include a large foreign exchange component for fuel, machinery and loan servicing. The latter cover the loss of pre-development net revenue from other forms of land use and the damage to the environment and the long-term effect on the productivity of the soil - somewhat of an unknown factor. Nor has the image of the bread basket been fulfilled. The Sudan is now a net importer of grain.

All this development has seriously disrupted the local people. Up to the present, the effects on the nomads are almost entirely adverse. There is talk of allocating land for mechanized farming and cattle ranching to selected groups of nomads, but nothing much has materialised. In the meantime, the growing hostility between nomads and farmers will continue to escalate unless some remedial action is taken.

The subsistence farmers, however, have done rather better, unless a mechanized scheme is started in the immediate vicinity of their village. Normally, only wastes are taken, but these represent the grazing land for the local livestock, the source of firewood, possibly gum arabic and some may well be land being rested under bush fallows. If the matter is so, then the result will be to shorten the fallow break with a consequential effect on soil fertility - an important point when rural population is rising rapidly.

When a village has no mechanized scheme in the farms in the immediate neighbourhood and also where transhumance is relatively unimportant, then the effects of development are almost entirely beneficial.

The major benefit is the creation of part-time job opportunities for the weeding and harvesting work peaks on mechanized farms. A recent estimate puts seasonal worker requirements at about 260 000 for weeding and 270 000 for harvesting. New developments in both the rainfed and irrigated agricultural sectors are leading to increasing competition for labour and the piece rates paid for weeding and harvesting have risen sharply in the last few years.

A man, it is said (1977), could earn LS 60 a year clear from local part-time employment and yet supervise his own small holding. This has already led to adjustments in village farming systems. Women are seen more often in the fields in order to free their men folk for casual work outside the village. Adjustments to traditional sowing times have been made to help ensure that the peak work periods on small holdings do not coincide with those for casual work.

These increased incomes have freed many villages from the notorious sheil system, in which farmers sold their crop forward at a highly discounted price in order to obtain credit* for the basic necessities of life. In fact, it is

*Large farmers are often forced to Sheil when they cannot obtain credit elsewhere. At Damazine in 1977 sheil prices quoted were around 60% of the expected harvest price for transactions to finance harvesting.

often said that the grain they sold under shell was sold back to them at a greatly enhanced price a few months later. Freedom from shell, therefore, has meant higher crop prices, so increasing cash incomes.

The growth in prosperity has led to an increase in the hire of tractors for land cultivation, so enabling larger holdings to be cropped. Leeds University surveys show the emergence of a "Kulak" class of larger peasant cultivators, who either hire tractors from the larger farmers or buy a second-hand tractor themselves for use both in their own holdings and for contract work on their neighbours' land.

3. A GENERAL REVIEW OF THE PROBLEMS AND POSSIBLE REMEDIAL ACTION

The Sudanese Case Study makes depressing reading, but does highlight the mistakes that can be made in ambitious plans to transform the savannahs into productive farming land. The so-called 'Bread Basket of Africa', at present, appears to be heading for economic and ecological disaster. Yet in the early 1930's, a similar fate appeared to be destined for the semi-arid regions of the Great Plains of North America, now they form part of the "World Bread Basket". Even Russia and China, in years of poor harvests, resort to buying American and Canadian grain. The Sudan was hailed as the new Argentina, but the Sudan has a long way to go to attain Argentinian levels. One province, Las Pampas - a semi-arid area - produced a greater output of sorghum than that for the whole of the Sudan, over 2 million tons compared with 1.7 million tons in 1976/77. Yet, a few years earlier, the province faced ruin because of the loss of beef export markets in Europe.

Both the North American and the Argentinian successes are due to the introduction of new farming systems in which leguminous crops and cattle fattening enterprises were combined with grain production both for direct sale and stock feed. Land fertility is maintained and the risks of erosion reduced by the introduction of good conservation practices. All this is associated with the permanent settlement of land and rising crop yields over time. Incorporating a cattle enterprise into an arable farming system helps diversifying against risk. Leguminous fodder breaks help maintain soil nitrogen levels. In Las Pampas Province, farmers achieve high yields without the application of nitrogenous fertilizers*.

The North American success also involved changes in farming systems. Many of the improvements resulted from the research and extension efforts of the local State Land Grant Colleges, in particular, the Montana State College and its extension service. The broad approach was to identify successful farmers and then study their systems in detail, then a set of revised principles of management were developed as a standard procedure for semi-arid agriculture. These principles were rapidly diffused among the farming community and, within a single decade, became standard practice. The regeneration of the semi-arid prairies followed (Starch, 1970). In fact, in many references to the problem of farming in semi-arid areas, it is claimed that the Americans have solved most of them. In the Argentine, applied research and extension also played a major role in the widespread adoption of new farming systems. The Organization responsible for much of this work, INTA**, is a network of local provincial cultural research and extension in each province.

*On one farm visited by the writer, sorghum yields in 1977 averaged 4,061 kgs/hectare (compared with 390 kgs for the Sudanese sample. The crop followed leguminous fodder used by purchased store cattle, sold fat at around 440 kgs liveweight at around 18-24 months old. Average annual rainfall on this farm was 650 mms.

**Institute National de Tecnologia Agropercuria.

Neither the United States nor the Argentine faced the problem of coping with the traditional users of the land when opening up their plains to large-scale arable farming. Nor for that matter, did Australia, another successful example of mechanized agriculture in semi-arid regions. Military conquest disposed of the pre-development subsistence sector.

3.1 The Mechanized Sector

In transferring technology from developed countries, trials should be made under local conditions before applying the new farming systems over a wide area. Such testing could most effectively be done by a network of local institutes to which extension workers are attached. As has been seen in the Sudan example, the links between research stations, extension workers and the farmers are very weak indeed. The objectives of the World Bank loan to finance applied research and extension is to devise new farm systems which both conserve the fertility of the soil and are financially viable. The results are then to be diffused to farmers as quickly as possible. The whole programme is on the Montana lines.

When new large mechanized farming projects are being appraised, the use of risk analysis techniques is recommended. Farming in semi-arid areas is somewhat beset with risks and the success record of both arable and grazing projects is rather disappointing.

In implementing projects, due regard should be given to the layout of farm units and systems of land tenure. In demarcating land for cultivation, attention should be given to the slope of the land and the retention of tree belts or even the planting of trees to cut down on wind and water erosion. Schemes should not be sited in the immediate vicinity of existing villages and adequate provision should be made for the passage of nomads through the area. Systems of tenure could be devised which give the authorities better control over the farmer with low husbandry standards and regulations rigidly enforced. Such farmers should not be allowed new land. Sale versus leasing is another alternative to consider. A farmer who actually owns the land has some motive for keeping it "in good heart". Whether the land is sold or leased, realistic prices and rents should be charged. Size of farms is another consideration. There may be cause for a variety of sizes, partly to provide a "farming ladder" so that good farmers can move to larger farms if they so wish.

Credit is also important. State banks should adopt some of the private sector attitudes; local knowledge of the standing of individual farmers, especially regarding their farming standard and their ability to repay debts. The important point is to secure a high percentage of loan repayments in order to recycle the capital by relending. Private sector banks have to do this in order to survive, state banks do not. Provision could also be made to carry farmers over years with poor harvests, it would be fairly obvious that there was a drought!!! Crop insurances schemes might be worth consideration after enough experience has been gained about local climatic conditions and the probabilities of drought.

Marketing covers the provision of farmers' inputs and the disposal of his outputs. In a market economy, the presence of imperfect competition should be monitored and where it exists, new entrants should be encouraged - a farmer's cooperative by its very presence may well help raise product prices and reduce those of inputs. While marketing is controlled by parastatal organizations, measures need to be taken to ensure efficiency and the State should resist taking any profits to bolster up government revenue.

3.2 The Traditional Sector

The problem of the nomads has been dealt with in Dr. Miller's paper. It only remains here to stress that they too are entitled to benefit from the development of semi-arid areas, and not experience only the costs. Above all, they should be driven by force from their traditional rangelands. A modus vivendi has to be worked out between the herdsman and the cultivator.

In both free market and socialist societies, the small traditional cultivator is often regarded as an impediment on progress and as such, should be swept aside in the course of time.

But the peasant could well be a more efficient user of the community's resources than modern mechanized agriculture as the Sudan study shows. The peasant is far less dependent on purchased inputs, some of which may well have to be imported. He also works largely with renewable natural resources - a point of future significance, especially if the limits to Growth School are right. If they are, then there is a strong case, not only on the grounds of human welfare, but also on the grounds of appropriate technology, to leave the peasant on his land and concentrate on improving his existing farming systems. Too often in the past, research and extension workers have neglected the traditional agricultural sector.

Possible research priorities include the elimination of the need to practise shifting agriculture. Perhaps the adoption of a leguminous fodder crop in the rotation which can be grazed by livestock or green soiled, would prove successful both in controlling weeds and maintaining soil nitrogen and humus levels. Another obvious subject to investigate is that of hand tools. Too often, these are primitive in design and add to the time and drudgery taken to do a job. Nor are they particularly effective.

A necessary infrastructural improvement is the provision of water supplies to the villages; this would not only improve health, but also remove the main cause of transhumance - the shortage of water during the dry season. The drudgery of carting water for considerable distances, usually done by women, would also be reduced. Another time-consuming task, carried out by women, is firewood collection. A possible solution would be to plant coppices by villages, which could fulfil a dual purpose - the provision of firewood and act as a windbreak, so preventing wind raised dust flowing into living areas.

By reducing the time spent in water and firewood collection by women and children, life is made easier and the time saved could be used more productively, especially when the menfolk leave temporarily to work as casual labourers elsewhere. One important factor, not to be neglected by planners, is the need of small cultivators in semi-arid areas, to diversify their income sources. As the Sudanese examples show, casual work on nearby modern sector farms freed families from debt and offered the prospects of accumulating a surplus which could result in the emergence of a class of "large" peasants and the beginning of a "farming ladder".

To conclude, there is a strong case for a dual development strategy in which the improvement of both large and small farms is the objective. In the words of Chairman Mao, the approach to be adopted is that of "walking on two legs".

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