FOOD SELF SUFFICIENCY AND ENERGY RELATED CONSTRAINTS IN SUB SAHARAN AFRICA - CRITICAL REVIEW

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ABSTRACT

Agricultural production in a selected number of countries in Sub Saharan Africa (Tanzania, Kenya, Zambia, Botswana, Ethiopia, Zimbabwe and Malawi) over the past decade is reviewed. With the exception of Zimbabwe, agricultural production has in most of these countries relied on hand tool technology and is mostly rainfed agriculture. The adoption of a more settled type of agriculture in place of the shifting type of agriculture will undoubtedly necessitate increased utilisation of support energy inputs such as fertilisers, pesticides and machinery which may be beyond the capacities of these countries and the international aid programmes. It is argued that the current policy in agricultural research and extension in most African countries of emulating the green revolution type of technology is unlikely to solve Africa's food problems. Irrigation would seem to be an appropriate solution, but is expensive and demands technical expertise lacking in most African countries. Various other options are discussed and reviewed.

INTRODUCTION

Within less than fifteen years Sub Saharan Africa is again featuring prominently in the world press due to the severe food crisis and famine. Virtually all the countries in Sub Saharan Africa have been affected by the current crisis unlike the 1973-75 crisis which was more serious in the Sahel Region. The poor crop can again be explained partially by the drought. However the continent's vulnerability to famine would seem to be increasing and a recurring event.

The annual rates of increase of the major staple food crops in the region was about 1.3% during the 1960's and early 1970's compared to 3% in Asia and Latin America. Population growth in Sub Saharan Africa however has been quite high averaging around 2.7% in the 1970's and is projected to be 3% per year over 1980-85 with some countries having a growth rate of as high as 3.5% (IBRD 1982). The increases in production of major crops have come about through increases in area under cultivation rather than through gains in productivity per unit of input. Per hectare yields of many subsistence food crops have stagnated and in some cases have declined and are quite low compared to those of other continents.

The majority (60-90%) of the population in Sub-Saharan African countries live in rural areas and engage in subsistence farming. These farmers practise low input/output agriculture. Fertiliser application rates are the lowest in the world. Hand tool technology predominates. Animal powered technology is used in only about 10-15% of the cultivated land and mechanically powered technologies in less than 5%.

Increased productivity will only be possible if the vast majority of the farmers switch from traditional and subsistence agriculture to modern agriculture involving the use of high yielding varieties, irrigation, fertilisers, and better implements including animal and mechanically powered tools for field operations. All these inputs are energy intensive and their increased utilisation in particular on the Asian Subcontinent has significantly increased food production. This green revolution technology however seems to have eluded Sub Saharan Africa.

It is unlikely however that any of the countries in Sub Saharan Africa can afford such an energy intensive agriculture. In this paper energy related constraints affecting food production in Sub Saharan Africa will be reviewed. Medium and long term implications of the current low input agriculture will be presented and policy options discussed.

FACTORS AFFECTING FOOD PRODUCTION

Production of food is influenced by:

i. solar energy;
ii. land availability;
iii. moisture in the soil;
iv. labour;
v. soils and soil fertility;
vi. machinery and implements;
vii. plant protection measures.

Although there are some intervening economic factors, eg agricultural marketing, pricing, land tenure, I believe these are of secondary importance to the lack of farming technology. Of the factors listed above, solar energy is more than adequate and only in a few countries such as Zimbabwe and Kenya is land tenure a problem.

Moisture in the soil

Most of Sub Saharan Africa practises rainfed agriculture and less than 5% of the cultivated land is irrigated (IBRD 1982). Rainfall exceeds evaporation for only a very short season. The timing of field operations (land preparation, planting, and weeding) is therefore critical for crop production. To most farmers therefore, the most critical scarce resource is labour at the start of the rainy season. To overcome this constraint farmers have two options:

i. Develop irrigation farming
ii. Grow drought resistant plant varieties

Irrigated agriculture has not traditionally played a significant role in Sub Saharan Africa, but the potential for irrigation is quite high (Mrema 1984; Toksoz 1981). The main constraints to increasing the role of irrigated agriculture in Africa are the capital costs involved and the lack of trained manpower to profitably manage such schemes. It is estimated, that in 1980 the capital costs involved in bringing one hectare of land under irrigation in Africa was in the region of US $10,000 (IBRD 1982). In addition, many of the existing irrigation projects are not well managed and hence not profitable due to lack of adequately trained manpower (Chambers and Morris 1973; Mrema 1984; Palmer Jones 1981). Irrigation may however be the answer for the future if properly and gradually developed.

The second option of growing drought resistant varieties seems to be more feasible. However, drought resistant varieties are generally low yielding (eg drought resistant Katumani maize variety in Kenya yields less than 1000 kg/ha while hybrid maize grown 100km away can yield up to 6000 kg/ha (Alcober et al 1983).

Labour

Since quite a high percentage of the population in Africa is engaged in agriculture (60-90%) it would seem that there is no shortage of labour for agricultural production. This is however quite misleading. When account is taken of the age/sex distribution of populations, less than 40% of the economically active population of most countries is engaged in agriculture. If the role of women is considered (since they perform most of the life support jobs - eg fetching water, firewood, child caring etc) then the percentage of the population fully engaged in agricultural production is greatly reduced.

Therefore, in essence about 20% of the population are required to produce enough food not only to feed themselves but to feed the remaining 80% (children, old people, lactating mothers, urban dwellers).

This would be quite possible if the productivity per unit of labour input in agriculture were high. But, farming carried out using handtool technologies can rarely exceed subsistence level. Brandt (1979) has argued that an annual labour input of 1100-1200 hr per year represents an upper limit for many farmers unless new production techniques are introduced. Given that the labour in handtool agriculture is in the region of 120 man days/ha it is unlikely that a family can handle more than 2 ha of land. If draught resistant varieties of maize are grown this will yield less than 2 tonnes which is barely sufficient for subsistence.

Labour therefore represents a major constraint in food production. Given that land is not a major constraint in Africa, efforts should be directed more at increasing the productivity of labour inputs rather than productivity of unit area of land as was done in Asia in the green revolution system.

Soils and soil fertility

The application rate of fertiliser is quite low in most of Sub Saharan Africa at less than 5kg/ha (Mudahar 1980). The increase in population and the change from shifting cultivation to a more settled type of agriculture has resulted in a serious decline of soil fertility in many countries in Africa (Eicher and Baker 1982) due to continuous tilling of the same land. Methods of restoring soil fertility such as use of animal manures are difficult to practise because of labour shortages and the large amounts which need to be applied (30-50 /ha) (Mrema 1985) to be effective.

The solution suggested by most agricultural research scientists is to rely increasingly on inorganic fertilisers. What is often forgotten is that inorganic fertilisers are quite energy expensive. For example a tonne of nitrogenous fertiliser is equivalent to two tonnes of crude petroleum (Leach and Slesser 1973; Pimentel 1973; Smil et al 1983). To this must be added energy used in the distribution and freight. This is estimated at about 10% of the manufacturing energy costs in the more advanced countries (Fluck and Baird 1979). Given the poor infrastructure and inefficient transport system this is likely to consume about three times that figure in most of Africa.

If the agronomically recommended rates of fertiliser application were to be applied for only nitrogen, the total nitrogenous fertiliser requirements for Sub Saharan Africa would be about 15 million tonnes for 1980, instead of the about 600,000 tonnes used. This will be equivalent to 30 million tonnes of crude petroleum in energy terms, and if the distribution energy costs are to be added this represents an equivalent of total energy expenditure of about 40 million tonnes of crude petroleum. All the nine countries in SADCC consumed only about 3.42 million tonnes of crude petroleum and 3.78 million tonnes of refined petroleum products in 1980 (Simoes 1984). In addition the logistics and managerial capabilities of distributing such a huge amount of fertiliser would seem to be beyond the capacity of most countries in Sub Saharan Africa.

Fertilisers can only increase yields when the other inputs (rainfall, crop husbandry) are present in optimum amounts. Given the uncertain nature of the rains the feasibility of fertiliser use at the rates recommended by research agronomists is doubtful. It may be more economical to aim at lower yields, and hence lower levels of fertiliser application and other soil fertility restoration techniques (crop rotation, growing of N fixing varieties), and cultivate more extensive areas. This type of system has been quite successful in Australia and New Zealand (McChesney et al 1981). This however requires greater mechanisation of farming.

Agricultural machinery and implements

Population trends indicate that less and less people will be engaged in agriculture especially handtool type of agriculture (population growth rates of most cities in Africa are the highest in the World, 6-15% per annum). The logical technological step to overcome labour shortages would be animal powered systems. However about two thirds of Sub Saharan Africa is tsetse infested. The cost of making these areas tsetse free is high and there are associated environmental hazards. In addition it is generally accepted that it requires at least a generation before people who are traditionally not livestock keepers adopt the tradition of keeping livestock and use them for draught power purposes. Further, animal traction may not be that timely compared to handtool technology (Gemill, 1971) and creates subsequent labour bottlenecks, eg in weeding and feeding of animals etc. As Eicher and Baker (1982) have noted there is a range of technical, economic and logistical constraints on the spread of total packages of animal traction in Africa.

Mechanically powered technology is still not very widely used in Africa (less than 5% of cultivated land). However, a significant proportion of the marketed food surplus in many African countries is produced from large scale farms which rely, on mechanically powered technologies (eg Zambia, Zimbabwe, Kenya,). The number of tractors in use in the whole of Africa in 1980 was only 443,000 (compared to 418,000 in India) with only about 27% of them being in Sub Saharan Africa (FAO 1982).

The history of mechanisation in Africa however is littered with failed tractorisation schemes. The main reason for their failure is lack of qualified and competent manpower both at operator and at managerial level, (Gemill and Eicher, 1973; Hall, 1968; ILO, 1976; Kolawole, 1974; Mrema, 1981; Winch 1976; Wuyts, 1981).

The other main constraint of mechanically powered technologies is their fuel requirements especially after the oil price increases of the 1970's. However as shown in Table 1 the energy expended on machinery and implements is much less than that expended in other inputs like fertilisers and pesticides. Studies in India show that energy in machinery and implements as well as in animal feeds in bullock powered irrigated farms is 38.7 GJ/ha whereas on tractor operated, irrigated farms it is 14.6GJ/ha when growing wheat, (Gupta et al 1983; Malik et al 1981).

Plant protection chemicals

The other energy intensive input in agricultural production is plant protection chemicals against weeds, diseases, insects, and other pests. This however is not extensively used in African small holder agriculture and through plant breeding efforts, disease and pest resistant plant varieties may be developed.

FUTURE STRATEGIES AND ENERGY IMPLICATIONS

The advanced countries have increased yields and total food production quite significantly over the past three decades (wheat yields of about 10 tonnes/ha are quite common in Europe and USA) by increasing energy expenditure per unit area as well as per unit of labour. On the Asian subcontinent the green revolution has enabled these countries to increase yields as well as total food production quite significantly by use of more energy per hectare and per input of labour as well as more added labour per hectare.

In Africa however, in the absence of irrigation and with entire reliance on rainfed agriculture, and very little support energy inputs in the form of machinery and fertilisers it is unlikely that food self sufficiency can be achieved if the trend of the past decade is maintained. No precise figures of energy consumed in agriculture in particular the peasant agriculture, are available. However the figures given in Table 2, can be regarded as indicative. Energy consumed is less than 1000 MJ/ha for maize production most of it being animate energy derived from human muscles. This compares favourably with figures from other countries, eg USA between 19,600 and 32,160 MJ/ha (Smil et al 1983) and China with national average 12,000 MJ/ha (Jin et al, 1983). In both cases the bulk of the energy is in the form of chemical fertilisers.

China, with a huge population (1 billion) most of whom live in rural areas and a much smaller cultivated land than Sub Saharan Africa, has managed in the past three decades to mechanise the most difficult field operations (like ploughing, harrowing and planting (ARSSID 1977)) and the average power input in the form of machinery is 0.4 hp/ha with a further 0.23 hp/ha applied in irrigation equipment. This compares with a total of less than 0.1 hp/ha in most of Sub Saharan Africa (Giles, 1975; Mrema, 1981).

In order to overcome their food crisis Sub Saharan African countries must be ready to spend more energy in their agriculture. At the moment less than 10% of commercial energy imports is used directly in agricultural field operations (Simoes 1984). Energy is expensive but there are no alternatives if the increasing population has to be fed. Most African countries have used agriculture as a source of foreign currency. In most African countries there are less than 10% as many tractors as saloon cars. Yet there is more concern on the fuel used in these tractors than the huge amounts used to run these limousines.

RESEARCH IMPLICATIONS

Energy research is quite a recent development, but even in the USA energy research in agriculture has received much less attention compared to the other sectors. In the developing countries the situation is even worse.

The need to use more energy per unit land area as well as per unit labour input is not in dispute. The main question is which energy rich input should African governments encourage their farmers to use: fertilisers, pesticides and irrigation, or less fertilisers, no irrigation and extend the area under rainfed agriculture.

Research will assist, at least in the short term, in identifying which energy related constraints will have the most pronounced effect in increasing food production. Answers will be needed to questions such as: Which is the most efficient way of increasing energy expenditure in agriculture? What mix of handtool, animal powered, mechanically powered machinery and implements, fertilizers, pesticides and irrigation is the most efficient energy wise. This area requires urgent and detailed study in Africa to assist policy makers in formulating both short and medium term policies.

CONCLUSION

An attempt has been made to identify the energy related constraints to increased food productivity and production in Sub Saharan Africa. It is shown that energy inputs into African agriculture are quite low compared to other countries whether developed or developing. To overcome their food problems African countries ought to be prepared to increase the use of energy rich input in agriculture like fertilisers, pesticides, machinery and implements as well as irrigation where this is feasible, both per unit of land area as well as per unit of labour input.

Energy studies have grossly under estimated the energy related constraints of agricultural production in Africa and have concentrated mostly at commercial energy resources like petroleum products which are used more by the industrial, domestic and transportation sectors of the economies of most Sub Saharan African countries. Such studies and reports, which are often used by African policy makers as a basis for future policy formulation can provide a misleading picture which may lead to African countries being continuously in famine crisis. With a rapidly increasing population, Sub Saharan African countries have no option but to increase utilisation of energy rich inputs in their agriculture if they are to meet food requirements of their populations which will double in the next two decades.

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Table 1 **Energy consumption per hectare, mechanically-powered-technology Morogoro, Tanzania - maize**

Tractor MF265 - 62hp; disc plough, harrow, planter. Fuel consumption total 150 cc/hp hr. (Bullard et al 1976): 1 litre = 47.3 MJ/litre.

		MJ/hr	MJ/ha
1.	Machinery costs		
	- Tractor	91.5	183
	- Disc plough	24.0	24
	- Disc harrow	28.0	28
	- Sprayer	16.0	16
	- Planter	18.0	18
	Total Machinery Cost	**337.5**	**429**
2.	Fuel Costs		
	- Diesel 9.3 l/hr 47.3 MJ/l x 6 hrs (for ploughing (2), harrow (1), spray (2 x ½), plant (1), harvest (1)		2639
	- Repairs 118 MJ/h x 6 hrs		708
	- Lubricants - 4% of fuel costs		106
	Total Fuel Costs		**3848**
3.	Other Inputs		
	- Fertiliser 100 kg N		4560
	100 kg P205		1400
	Total Fertiliser		**5960**
	- Pesticides 5 kg		3679
4.	**Grand Total**		**13906** MJ/ha

Machinery: Fuel: Fertiliser: Pesticides = 3%: 28%: 43%: 26%.

Human energy contributions insignificant

Yields: 2500 kg/ha poor rains, 4500 kg/ha good rains.

Table 2 **Energy requirements per hectare – using handtool technology: maize plot – Mgeta Village, Morogoro Region (Province), Tanzania** (Mrema, 1983)

	Activity/Input	Man days/ha	Energy MJ/ha
1.	LABOUR		
	Land Preparation	44.5	280.4
	Weeding	37.1	233.7
	Harvesting	24.7	156.6
	Post harvest operations: shelling, bagging	12.4	78.1
	SUB TOTAL LABOUR	**118.7**	**748.8**
2.	OTHER INPUTS	MJ/kg	
	(i) Fertiliser*		
	100 kg Ammonium Sulphate	45.0	4560.0
	50 kg $P2^{O}5$	14.0	700.0
	SUB TOTAL FERTILIZER		**5260.0**
	(ii) Pesticides		
	3 kg	459.9	1379.7
	(iii) Implements		
	6 kg of hoes, axes, matchet	9.96	59.8
	SUB TOTAL OTHER INPUTS		**6698.8**
	GRAND TOTAL		**7447.6**
	Yields 1000 kg/ha		

Sample size 59 households observed over a year. Yields 100 kg/ha.

* Fertiliser application rate is as recommended by research stations and what extension agents recommend to farmers. Actual application rates are however quite low around 5kg/ha giving a total energy input of 748.8 + (5 x 45.6) + 60 = 1040 MJ/ha