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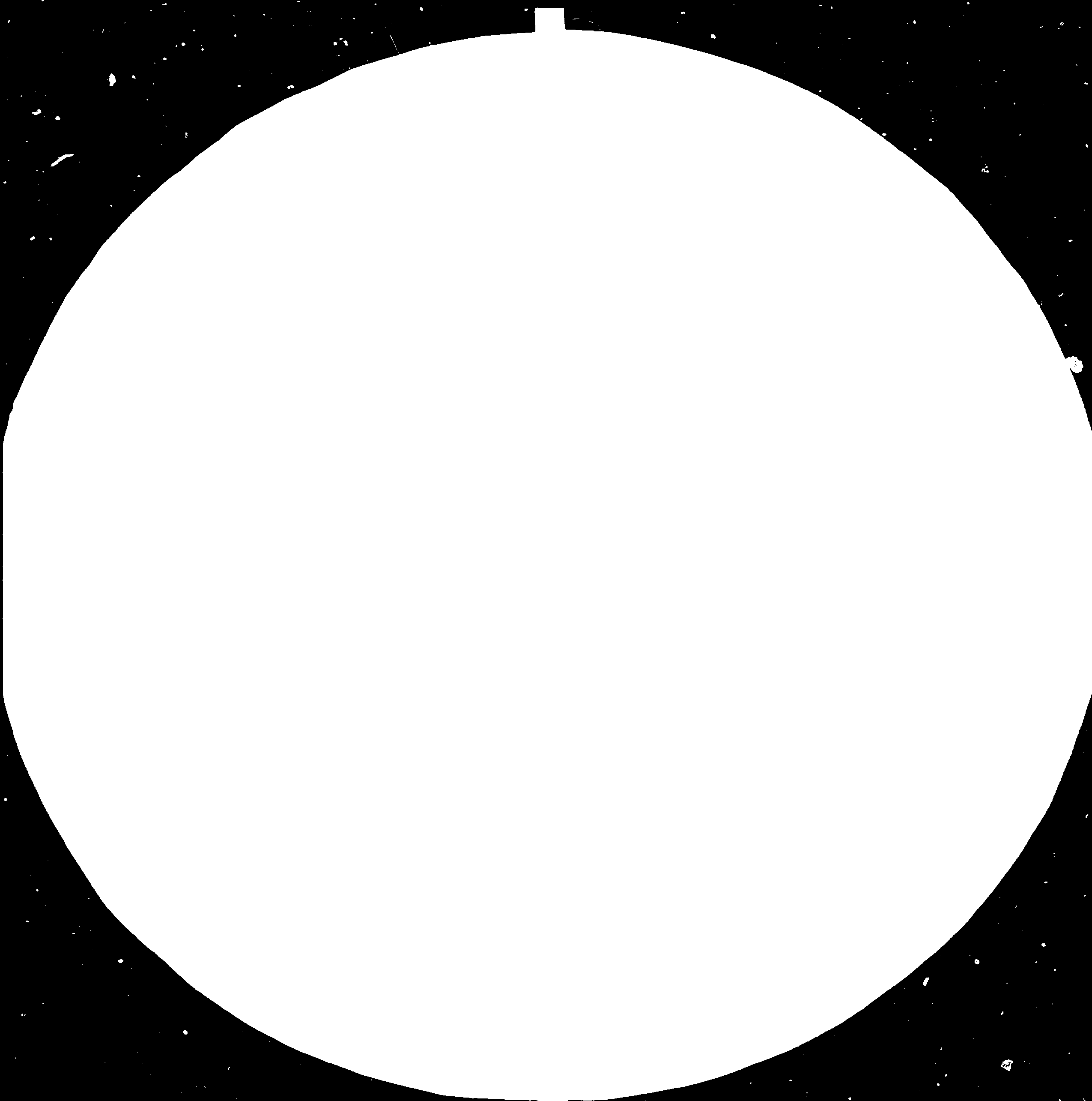
Vienna

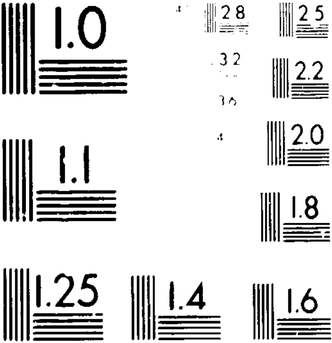
INDUSTRY AND DEVELOPMENT

No. 9

UNITED NATIONS

New York, 1983





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INDUSTRY AND DEVELOPMENT No. 9

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AIMS AND SCOPE OF *INDUSTRY AND DEVELOPMENT*

Industry and Development attempts to provide a link between practitioners and theorists working on economic and related aspects of industrialization. The focus of the journal is on applied economics, particularly in areas emphasized in the Lima Declaration and Plan of Action on Industrial Development and Co-operation.

The journal is published an average of four times a year as an integral part of the work programme of the Division for Industrial Studies of the United Nations Industrial Development Organization. It is prepared under the general guidance of a supervisory panel, composed of staff members from the Division, with the Head of the Global and Conceptual Studies Branch as its chairman. Responsibility for the detailed supervision of a specific issue is rotated among the members of the Panel. The responsible member for this issue was J. Cody.

The supervisory Panel of *Industry and Development* welcomes readers' opinions and comments.

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Preface

As in the previous issue, the focus of this issue of *Industry and Development* is on the least developed countries and developing Africa, and in particular on three industrial activities—power generation, agricultural machinery and textiles.

The three articles on specific industries all relate, among other things, to the question of choosing appropriate technology. In the paper by Parikh on power industries in the least developed countries, the author compares the costs likely to prevail in the Sahel area of Africa of electricity generation for hydro, steam and diesel plants. Parikh also examines the existing power situation in the least developed countries, identifies various problems and discusses future prospects, especially for regional and other forms of co-operation in power generation. The paper is based on a more extensive study prepared by Parikh for UNIDO.[1]

The paper by Muchiri on production and use of agricultural machinery in Kenya is focused particularly on the question of appropriate farm technology in the form of hand tools, animal-drawn equipment or tractors. The author shows that tractorization programmes in Kenya, as in most of tropical Africa, have been expensive and largely unsuccessful. For example, he presents statistics showing that in the tractor-hire scheme productive operations amounted to not more than 10 per cent of possible operating time in the period 1978-1980; most of the time tractors were either broken down or in workshops. The paper confirms, in a specific context, many of the observations and ideas contained in a recent report of the World Bank,[2] including the need to encourage small farmers by supplying improved hand tools and other low-cost equipment, as well as by institutional and policy changes such as improved borrowing facilities and increased prices for farm products where such prices are kept artificially low through trade policies, price controls etc. Space does not permit a discussion of the many other issues considered by Muchiri. The article is a condensation of a paper prepared, along with other country studies, as background information for a UNIDO consultation meeting, held in 1982, on the African agricultural machinery industry. These and other studies prepared especially for that meeting provide the most comprehensive analysis yet available of Africa's agricultural machinery industry, a major linkage between agricultural and capital goods development.[3]

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[1]"Investment requirements of developing power industries for the industrialization of developing countries" (UNIDO/IS.359, 1982).

[2]*Accelerated Development in Sub-Saharan Africa: An Agenda for Action* (Washington, D.C., 1981).

[3]These studies are synthesized in "Diagnostic study of the present situation and trends in the production and utilization of agricultural machinery in African countries" (UNIDO/IS.288); "Present situation, prospects and strategical choices for development of agricultural machinery in Africa" (UNIDO/ID/WG.365/1); and in a forthcoming sales publication.

Kibria and Tisdell examine technological change in jute spinning in Bangladesh using econometric analysis of data collected from a sample of 57 mills. They conclude that the capital-intensity of jute spinning in that country has been increasing and the share of output attributable to labour supply and small capital stock, seems to contradict accepted notions of appropriate technology. They further find that economies of scale have been little altered by technical change and are close to constant. Aspects of learning-by-doing are also examined.

The article by Boon, based largely on several of his earlier writings, provides a more general assessment of the relationship of technology to economic development, and of technical dualism in particular. Dualism, the existence of a modern sector using technologies transferred, perhaps with some modification, from more advanced countries, alongside a more traditional, or informal sector, is a commonly observed phenomenon in developing countries. Boon is concerned with reducing such dualism, and creating technological harmony by encouraging the development of the less modern sector where analysis shows this appropriate. He suggests a framework for such analysis. However, a two-tier system of economic development may be appropriate in some cases, if the two tiers can be developed on a more equal footing than at present. Possibilities for implementing such a system, including several institutional mechanisms, are examined. The general arguments are developed more specifically for the textile industry.

EXPLANATORY NOTES

References to dollars ($) are to United States dollars, unless otherwise stated. One hundred cents or one thousand mills are one dollar.

Use of a hyphen between dates (e.g. 1960-1965) indicates the full period involved, including the beginning and end years.

A slash between dates (e.g. 1970/71) indicates a financial or academic year.

The following forms have been used in tables:

A blank indicates that the item is not applicable.

A dash (—) indicates that the amount is nil or negligible.

The following abbreviations have been used:

AMTU	Agricultural Machinery Testing Unit
CBC	carpet-backing cloth
GNP	gross national product
FAO	Food and Agriculture Organization of the United Nations
R and D	research and development
UNDP	United Nations Development Programme

NOTE TO READERS

To reduce production time and costs, the following changes will be put into effect starting with the next issue:

1. The text will be typed using a word processor and printed by offset.*

2. Instead of separate English, French and Spanish versions, there will be a single issue in which the articles appear only in the language in which they are submitted. The preface, however, which summarizes each article, will appear in all three languages.

We apologize for any inconvenience these changes may cause, but believe that most readers will welcome the considerable reduction in time lag between submission and publication of articles that will result. The frequency of publication has also been increased to an average of four issues per year.

This change became effective earlier for the French and Spanish versions, starting with No. 7.

Power industries in the least developed countries

*Jyoti K. Parikh**

Although usually accounting for only a small part of total production cost, electricity is an essential input to all but the most simple manufacturing activities. This paper provides an analysis of the electricity generation problems of the least developed countries. In particular, the following points are examined:

(a) Survey of the past and present situation of electricity consumption, power capacity and comparison with other developing countries;

(b) Special difficulties of the least developed countries with regard to the power sector;

(c) Comparison of the investment requirements and the costs of electricity generation for hydro, steam and diesel plants under soft and hard loan conditions;

(d) Future prospects and possibilities for the least developed countries, in particular through bilateral, multilateral or regional co-operation.

Survey of the past and present

According to P. Comoli (1982) in 1979, per capita electricity consumption of the least developed countries ranged between 8 kWh for Burundi and 192 kWh for Samoa. The average for these countries in 1978 was 28 kWh per capita, which was much less than the average of 360 kWh in the developing countries. However, during the period 1960-1979, most of the least developed countries increased their production sevenfold, e.g. Afghanistan, Chad, Ethiopia, Malawi, Mali and Niger. Of course, some did even better (Botswana, Nepal), but others achieved only a much smaller increase. Some failed to achieve any increase at all (Benin, Burundi, Uganda). The progress is not at all impressive when one considers economic growth between 1970-1979. Major accomplishments of threefold to fourfold increases were made only during the 1960s. During the 1970s the increase was only twofold or less. In fact, the per capita average improved from 21 kWh in 1970 to only 29 kWh in 1979, whereas the corresponding increase for developing countries was from 204 kWh in 1970 to 360 kWh in 1979.

Table 1 gives data on total installed capacity in 1970 and 1979 and average capacity utilization in 1979 (in terms of annual consumption per unit of installed capacity). The total power plant capacity ranges from a few MW to

*International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria. This paper was prepared for UNIDO as part of a larger study while the author was a UNIDO consultant.

Table 1. Total capacity and hydropower capacity in least developed countries and capacity utilization

Area and country	*1970* *Total (MW)*	*1970* *Hydro (MW)*	*1979* *Total (MW)*	*1979* *Hydro (MW)*	*1979* *Capacity utilization (kWh kW)*
Africa					
Benin	10	0	15	0	333
Botswana	—	—	96	0	4 375
Burundi	7	0	7	0	143
Cape Verde	5	0	5	0	1 500
Chad	16	0	38	0	1 658
Comoros	1	0	1	0	4 000
Ethiopia	170	91	330	206	2 182
Gambia	9	0	10	0	3 500
Guinea	100	25	175	50	2 829
Malawi	49	26	110	70	3 091
Mali	27	5	42	6	2 381
Niger	15	0	20	0	2 300
Rwanda	23	22	38	35	4 211
Somalia	15	0	30	0	2 400
Sudan	117	30	220	110	4 091
Uganda	162	156	163	156	3 988
United Republic of Tanzania	143	49	258	188	2 713
Upper Volta	14	0	30	0	3 000
Asia and the Pacific					
Afghanistan	207	190	380	286	2 316
Bangladesh	704	80	982	130	2 398
Lao People's Democratic Republic	19	2	70	50	—
Maldives	1	0	2	0	5 450
Nepal	46	26	65	37	3 000
Western Asia					
Democratic Yemen	6	0	24	0	3 000

Source: Compiled by the author from various tables given in *1980 Yearbook of World Energy Statistics* (United Nations publication, Sales No. E/F.81.XVII.10).

100-200 MW. Assuming that the total capacity consists of a network of smaller plants, individual plants could range from less than 1 MW to 30-50 MW capacity. Many countries have no hydropower capacity at all, and some, such as Afghanistan, Rwanda and Uganda, have predominantly hydropower capacity.

In most cases, the capacity utilization of the least developed countries in 1979 was much lower than the average for developing countries (4,200 kWh/kW). Only those countries with thermal power plants such as Botswana (coal-based thermal plants), Maldives, Sudan and Uganda came close to this figure. The rest of them, in spite of having no hydropower, had very low utilization. Nearly 16 out of 23 countries had capacity utilization below 3,200 kWh/kW. Since thermal plants do not depend upon fluctuation due to rainfall, this low utilization could be only due to:

(a) The inability of the least developed countries to obtain oil for running their oil-based thermal power plants;

(b) Frequent breakdown and lack of skills and spare parts to repair the machinery.

Special difficulties of the least developed countries in the power sector

Related to low electricity consumption per capita are several special problems for the least developed countries in the power generation sector.

Economies of scale

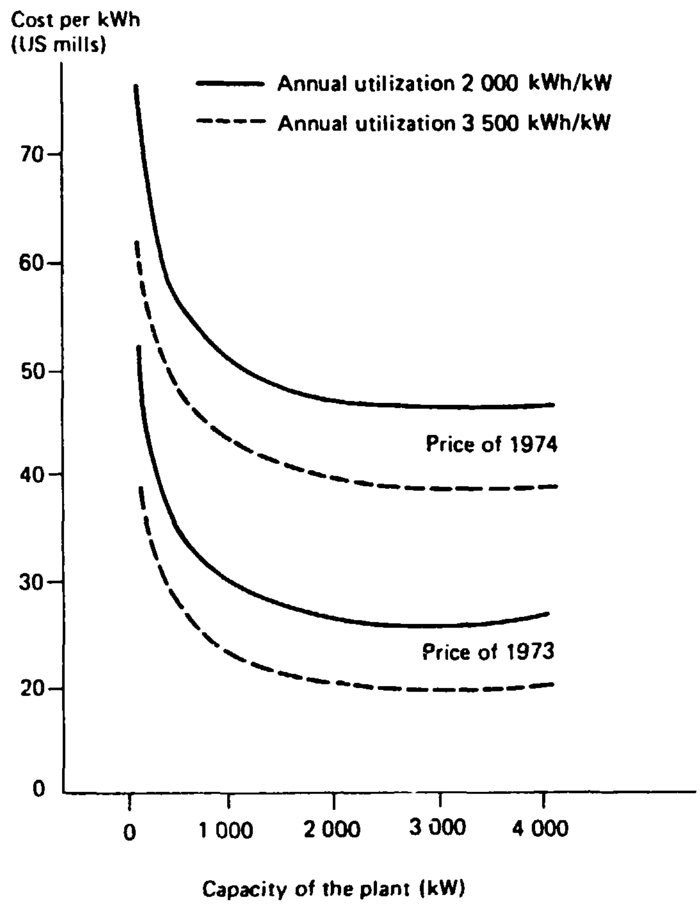
In addition to having low GNP per capita, least developed countries are often small countries in terms of population or area, or they have the geographic disadvantage of being land-locked or an island. Thus, it is not possible to have large power plants; many of these countries could at best have 5-15 MW power plants; some may have power plants measured in kilowatts. They therefore lose out on economies of scale. The developed countries consider 1,000 MW a standard size.

The small unit size raises the costs of power generated from diesel. For example, the figure, which gives data for small power plants in Latin America [1] ranging from 50 kW to 4 MW in size, a relevant range for the less developed countries, shows that the total cost per kilowatt hour for electricity from diesel is nearly double for a power plant of 100 kW capacity compared with that of 4,000 kW. However, after the rise in the price of diesel, the economy of scale has decreased as the increase in operating costs per kilowatt hour is now two to three times greater than the increase in capital charges per kilowatt hour. This raised the total costs from 2.1 to 3.9 cents per kilowatt hour for a 4,000 kW power plant in 1974. In 1973, the capital and operation costs per kilowatt hour were approximately the same. When utilization increased from 2,000 to 3,500 kWh/kW the costs per kilowatt hour fell by 20 per cent.

The costs in power generation from steam produced from coal, on the other hand, have increased by only 50 per cent since 1973 and stand at 2.1 cents/kWh, compared with 3.2 cents/kWh from an oil-based plant [2]. Thus, a larger plant size, especially in steam generation, and higher utilization could bring down the cost of electricity. Unit sizes, however, cannot be increased in the least developed countries until the demand for electricity increases considerably and necessary transmission networks have been established.

Moreover, small demand does not make efforts to develop technology and to train manpower economically viable. The difficulties concerning low utilization possibly due to scarcity of skills and spare parts have already been mentioned.

Cost estimate of power generated from diesel



Source: "Small scale power generation", *IAEA Bulletin*, Nos. 1/2, 1974.

Optimum mix of hydro and thermal plants

As can be seen from table 1, least developed countries have either 100 per cent thermal power plants (which are likely to be only oil-based plants, and thus exposed to the risk of a rise in the price of oil since there may be no other option), or 100 per cent hydropower plants, output of which may fluctuate from season to season substantially, making the supply to crucial industries unreliable. In 18 out of 23 countries such undesirable polarization (either hydro or thermal generation) occurs. In other words, many of the least developed countries are not in a position to plan a power system having a suitable hydro-thermal mix to minimize operating costs owing to oil use and the fluctuation in the electricity supply associated with hydropower plants.

These two difficulties—coupled with low GNP per capita and small prospects of high growth—make the prognosis discouraging for the least developed countries.

Investment comparisons of hydro and thermal plants

The purpose of this section is to illustrate the differences between hydro, steam and diesel plants in the following matters:

Impact of rising oil prices in costs per kWh in future

Differences in unit (kWh) costs under soft and hard conditions of financing for each of the three types of plant

Effects of economies of scale for each of the three types of plant.

The illustration chosen is from a typical country in the Sahel region using the information from a study made by Club du Sahel in 1978 [3].

For comparative purposes, it should be mentioned that in these least developed countries, not only are the investments high compared with those in the developed countries but are even higher compared with the average taken for developing countries. According to the study of the Club du Sahel, for a 30 MW plant, capital costs are $3,180 per kilowatt for hydro and $682 per kilowatt for thermal plants, which are higher than the World Bank figures for developing countries. The operating cost is approximately 6 cents per kilowatt hour even for a 200 MW hydro plant. Thus, eventual costs to the consumer could be two to three times higher.

A case of 200 MW hydro plant versus thermal plants in the Sahel region

Table 2 compares costs per kilowatt hour produced by large hydropower, steam power and diesel power plants. A large hydropower plant of a capacity of 200 MW with an annual production of 1,000 GWh is expected to last for 50 years, whereas a steam and a diesel plant of the same capacity and same production level are expected to last only for 25 years. However, steam and diesel plants have low line investment costs (transmission distance is small for them).

For a proper comparison the plants must be considered on equal terms. Assuming that a steam or a diesel plant is rebuilt at the end of 25 years and hence fresh investment costs towards this purpose will be incurred in year 26, a comparison between hydro plants and steam and diesel plants can be made. From the table it is clear that, even if the discount rate is assumed to be lower, steam and diesel plants will incur lower total investment costs than a hydro plant. The total investment costs incurred by a hydro plant are approximately four times those of a steam or a diesel plant, whereas the plant life of the former is only twice that of the latter.

The costs involved in debt service will vary according to the means of financing. Table 2 provides these details based on the terms of soft and commercial financing. The unit fixed costs for commercial (hard) financing terms are approximately 70 per cent higher than those with soft financing terms for hydro plants. The corresponding increase in the unit investment is approximately 32 per cent for steam plants and 20 per cent for diesel plants.

The debt-service component within the fixed costs is very high in all the cases. However, it is as high as 94 per cent for hydro plants financed on hard

Table 2. Comparison of costs per kWh produced by large hydroelectric power and thermal plants in the Sahel region

Item	*Hydropower*[a]		*Steam plant (heavy fuel oil)*		*Diesel plant (light fuel or diesel oil)*	
Total (thermal) capacity in one or several units (MW)	200		200		200	
Annual production (GWh)	1 000		1 000		1 000	
Transmission distance (km)	700					
Technical lifespan of plant (years)	50		25		25	
Technical lifespan of line (years)	50					
Investment costs of plant (CFAF/kW)	500 000 (700 000)		150 000		150 000	
Investment costs of line (CFAF/km)	25 000 million					
Plant investment (10^9 CFAF)	100 (140)		30		30	
Line investment (10^9 CFAF)	17.5					
Total (10^9 CFAF)	117.5 (157.5)		30		30	
	Financing (interest rates, maturity)					
	Soft terms (4%, 30 years)	*Commercial terms (8%, 20 years)*	*Soft terms (8%, 15 years)*	*Commercial terms (10%, 10 years)*	*Soft terms (8%, 10 years)*	*Commercial terms (10%, 8 years)*
Debt service (10^9 CFAF)	6.8 (9.1)	12.0 (16.0)	3.5	4.9	4.5	5.6
Operation and maintenance costs						
Plant (10^9 CFAF)	0.5 (0.5)	0.5 (0.5)	0.9	0.9	0.9	0.9
Line (10^9 CFAF)	0.3 (0.3)	0.3 (0.3)				
Total fixed costs (10^9 CFAF)	7.6 (9.9)	12.8 (16.8)	4.4	5.8	5.4	6.5
Cost per kWh (CFAF)						
Fixed	7.6 (9.9)	12.8 (16.8)	4.4	5.8	5.4	6.5
			1978 1990 2000	*1978 1990 2000*	*1978 1990 2000*	*1978 1990 2000*
Fuel			7 10 14	7 10 14	19 23 27	19 23 27
Total	7.6 (9.9)	12.8 (16.8)	11 15 18	13 16 20	24 28 32	26 30 34

Source: Club du Sahel, "Energy in the developing strategy of the Sahel" (London, FRIDA Investments, 1978).

Note: 220 CFAF = 1 dollar.

[a]Figures in parentheses refer to second investment assumption.

terms. For hydro plants financed on soft terms, this component works out to be around 89 per cent, which itself is higher than that for a diesel or steam plant financed on hard terms (around 85 per cent).

Owing to differences in debt-service assumptions for steam and diesel plants, their unit fixed costs are different although their plant investment costs are the same, which shows that not only the interest rates matter, but the maturity years also contribute differently in the eventual cost per kWh. Steam and diesel plants, however, have additional costs over the investment costs towards fuel purchases, which are almost nil for the hydro plants. Table 2 shows the estimated fuel costs per kWh in the years 1978, 1990 and 2000 for these two types of plant. Because of this additional expenditure on fuels by these two types of plant, the unit total costs for the hydro plants turn out to be less than those for the diesel or steam plants. The expenditure on fuels is proportionately so high, particularly for the diesel plants, that the following situation occurs:

(a) The unit fixed costs for the hydro plants are around twice those for the diesel plants financed on commercial terms (i.e. 12.8 vs. 5.8 CFAF/kWh in 1978);

(b) The unit total costs for the hydro plants are only about half those of the diesel plants—both financed on commercial terms (i.e. 12.8 vs. 25.5 CFAF/kWh in 1978 to 33.5 CFAF/kWh in 2000);

(c) Most important, the debt service alone amounts to 94 per cent, 84 per cent and 86 per cent of fixed costs of the hydro, steam and diesel plants, respectively, under hard conditions and 89 per cent, 79 per cent and 83 per cent under soft conditions—the rest being for operation and maintenance. Thus, reduction in investment during construction period due to efficient management and soft loans has a crucial role in reducing the cost of electricity.

Economies of scale, a case of 30 MW plants

The above-mentioned contrast in the relative cost structure is even more if economies of scale for hydroelectric power are taken into consideration. Table 3 provides details for comparing costs per kWh produced in medium-size hydropower plants (30 MW capacity and 120 GWh annual production). Tables 2 and 3 show that while there is absolutely no cost reduction per unit by shifting from a medium-size diesel plant to a large diesel plant, there is quite a significant cost reduction per unit by shifting from a medium-size hydro plant to a large hydro plant. This reduction in the hydro plants comes to about 40 per cent. However, even for medium-size plants the total costs per unit for hydro plants was only about 83 per cent of that for diesel plants, in 1978, a figure that was estimated would be even lower (only 64 per cent) by 2000.

Table 3 shows that for a medium-size 30 MW power plant, there is no gain in choosing a hydropower plant (over steam or diesel) under present conditions, unless it is financed under soft financing conditions. The cost per kWh works out to be 21.4 CFAF/kWh for all the alternatives under commercial terms but reduces to 12.7 CFAF/kWh for hydropower if financed under soft conditions. However, as one approaches the year 2000, even under

Table 3. Comparison of costs per kWh for medium-size (30 MW) hydro and thermal plants

Item	*Hydropower*	*Diesel plant (light fuel or diesel oil)*
Total (thermal) capacity in one or several units (MW)	30	30
Annual production (GWh)	120	150
Transmission distance (km)	150	
Technical lifespan of plant (years)	50	25
Technical lifespan of line (years)	50	
Investment costs of plant (CFAF/kW)	700 000	150 000
Investment costs of line (CFAF/km)	20 000 000	
Plant investment (10^9 CFAF)	21.0	4.5
Line investment (10^9 CFAF)	3.0	
Total (10^9 CFAF)	24.0	4.5

	Financing (interest rates, maturity)			
	Soft terms (4%, 30 years)	*Commercial terms (8%, 20 years)*	*Soft terms (8%, 10 years)*	*Commercial terms (10%, 8 years)*
Debt service (10^9 CFAF)	1.39	2.44	0.67	0.84
Operation and maintenance costs				
Plant (10^9 CFAF)	0.08	0.08	0.14	0.14
Line (10^9 CFAF)	0.05	0.05	—	—
Total fixed costs (10^9 CFAF)	1.52	2.57	0.81	0.98
Cost per kWh (CFAF)				
Fixed	12.7	21.4	5.4	6.5
			1978 1990 2000	*1978 1990 2000*
Fuel			19 23 27	19 23 27
Total	12.7	21.4	24 28 32	26 30 34

Source: Club du Sahel, "Energy in the developing strategy of the Sahel" (London, FRIDA Investments 1978).

Note: 220 CFAF = 1 dollar.

commercial conditions hydropower gives electricity at 30 per cent less unit costs and at 60 per cent less unit costs with soft financing.

Thus, economy of scale is especially relevant for hydro plants where the cost per kilowatt hour is 7.6 CFAF and 12.8 CFAF for 200 MW and 30 MW plants, respectively. Corresponding figures for hard financing conditions are as much as 12.8 and 21.4, respectively. However, oil-based plants do not have pronounced effects on economy of scale.

Future prospects for the least developed countries

As mentioned earlier, least developed countries face special disadvantages arising from geography, small demand and inability to create a hydro-thermal mix for power generation. Many of the difficulties could be overcome if several least developed countries joined a larger framework comprising several countries. This point is illustrated below from the example of several countries.

Thus, the least developed countries should pay special attention not only to obtaining financial aid but also to obtaining skilled manpower, equipment, spare parts etc. The most important contributions can come from bilateral, multilateral and regional co-operation.

Co-operation for hydro-power plants in Africa

Plants in Africa with a potential total capacity of 75 GW of hydropower are at the following stages: in operation, 11 GW; under construction, 4.6 GW; at the planning stage, 11 GW. The remaining potential (48 GW) consists of plants with a capacity of 9 GW in Angola, 5 GW in Mozambique and 32 GW in Zaire. This additional power could benefit several neighbouring countries, many of which are least developed countries. A scheme connecting many countries of South-West Africa extending up to South Africa was floated as an idea but never pursued.

Table 4 gives the hydropower potential for six countries in the Sahel zone of Africa, five of which are least developed countries. A look at geographical positions of the sites with respect to the demand zone shows that Mali, which has 800 MW hydropower potential, expects demand of only 200 MW by 2000, whereas Senegal, which has only 250 MW hydropower potential, expects demand of 700 MW by 2000. Both countries could benefit from mutual co-operation so that Mali's potential could be economically exploited and Senegal's development potential met.

Co-operation in the Indian subcontinent

Similarly, a large country could exploit its own large potential to accommodate the needs of a neighbouring least developed country with low demand and low hydroelectric potential. Examples of such collaboration could be:

(a) India and China could develop the hydropower potential of the Brahmaputra River to meet their own need for power and that of Bangladesh to mutual advantage;

(b) India and Nepal could collaborate on hydropower development of the Ganga River to mutual advantage;

(c) Pakistan and Afghanistan could co-operate through an exchange of equipment, manpower etc. for natural gas and coal development for both countries.

Thus, development in the least developed countries should be part of the development of larger neighbouring countries as far as possible. Moreover, the least developed countries should be assisted with a loan of skilled manpower and spare parts so that they could better utilize their existing and future power plant capacity.

Table 4. Hydro potential of the Sahel countries

Country	Site	Power potential (MW)	Guaranteed power (MV)	Expected annual output (GWh)
Gambia[a]	Yellitenda	14-28		
Senegal	Sambangalou dam	95-100		800
	Kékréti dam	40		250-300
	Courbassi dam (Falémé River)	113		
Mali[a]	Manantali dam	190	100	800
	Sélingué dam	46		184
	Galougo dam	300		
	Félou Falls	50		
	Petit Gouina	70		
	Koukoutamba	85		
	Mako	?		
	Tossaye dam	?	30	
	Labasan	80		
	Kénie	25-30		
Upper Volta[a]	Noumbiel dam (on the Black Volta)	70		303
	Pama dam (on the Kompienga River)	?		33
	Bagré dam (on the White Volta)	?		
Niger[a]	Kandadji dam (Niger river)	300		1 800
	Hydro plants on the Mékrou	26	13	83
	W dam (2 stages)	84		526
Chad[a]	Ganthiot Falls on the Mayo Kebbi	?		
Total		More than 1 700 MW		

Source: Club du Sahel, "Energy in the developing strategy of the Sahel" (London, FRIDA Investments, 1978).

[a]Least developed countries.

Recommendations

Least developed countries face special problems because their consumption of energy is less than a tenth of the average of developing countries. This means that they are restricted to small, uneconomic power plants with obsolete technology and therefore very expensive electricity. Moreover, they cannot choose an optimum mix of hydro and thermal plants as a protection against seasonal fluctuations and the high operation costs of using fossil fuels. From the data on capacity utilization it appears that power plants must break down frequently, which, taken together with a small number of plants serving entire countries, would imply serious disruptions in power supply. In addition, small demand does not make technological development and manpower training viable. The least developed countries, therefore, require special consideration such as soft loans and other forms of direct aid (skilled manpower, machinery and spare parts). In addition, co-operation with neighbouring countries could benefit not only the least developed countries but neighbouring countries as well. United Nations agencies could play an important role in opening such avenues of regional co-operation among developing countries.

References

1. "Small scale power generation", *IAEA Bulletin*, Nos. 1/2, 1974.
2. J. Parikh, *Energy Systems and Development* (New Delhi, India, Oxford University Press, 1980).
3. Club du Sahel, "Energy in the developing strategy of the Sahel" (London, FRIDA Investments, 1978).

Production and use of agricultural machinery in Kenya

*Gichuki Muchiri**

Background

The production and use of agricultural machinery in Kenya must be examined against the background of the country's basic problems. Furthermore, during the last 80 years attitudes towards development and a pattern of dealing with development problems have evolved that must be reckoned with. Unsuccessful past efforts can be attributed to a failure to address the basic problems. A change in the approach is essential, but to be successful that change must be gradual and smooth. The objectives must be clear from the outset.

The basic problem in Kenya is that in spite of a determined effort to modernize and industrialize through import substitution and development of export crops, only about 20 per cent of Kenyans have really benefited from this approach. To some extent, the export of cash crops has generated foreign exchange to be used for modernization, but the fruits of modernization, such as employment opportunities and equality of income (very noticeable in the developed countries) have not been shared; on the contrary, unemployment has worsened, income disparity has increased and inflation is rampant.[1] Because of the great emphasis on cash crops at the expense of food crops, the country has in recent years experienced severe food shortages. For instance, Meru District, which is the best coffee-growing region, has had to pay the highest price for the staple maize.

Modernization has generated development funds to provide education and health services at nominal cost, and these services have in turn contributed to political stability. However, long-term political stability can be sustained only by balanced development, which provides gainful employment and maintains a healthy degree of equality. Otherwise the dual society, whereby the modern (usually urban) worker earns 10-20 times more than his rural counterpart, will only perpetuate unemployment and the endless struggle between the haves and the have-nots. Better education and health services without gainful employment will only produce well-informed and healthy criminals, as is becoming increasingly obvious.

A more appropriate technology for the rural areas must be chosen to reduce heavy reliance on the urban sector, which in turn depends heavily on

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[1]More often than not imported items are cheaper and of higher quality than the locally manufactured alternatives. The local entrepreneur seems to have a free hand in setting the price of his labour.

imported technology. In addition to generating gainful employment, a degree of technological self-reliance will bring satisfaction and social security, the main foundation for a smooth cultural evolution that is so badly needed in Africa.

Since agriculture supports 90 per cent of the population and employs 85 per cent of rural labour, improved utilization of rural labour through an appropriate form of mechanization is bound to produce spectacular results. Locally made tools for field operations and local processing industries will generate gainful employment for rural skilled workers. Moreover, higher incomes from increased farm productivity and related activities will create a market for consumer goods and services.

Farming systems

As shown in table 1, Kenya has a total of 10 million hectares of arable land, consisting of 6.8 million hectares of high-potential land and 3.2 million hectares of medium-potential land.

The main emphasis in agricultural development has been on large-scale farming just as it was before independence in 1963. Thus, in predominantly high-potential areas the production of wheat, maize and barley in the large-farm sector is highly mechanized. To some extent the same thing is true in the large coffee, tea and sugar estates. If large farms can be maintained (there is a strong likelihood that they will be subdivided), large-scale tractor mechanization will be an essential farm input, although it will involve only a small number of workers. If mechanization is to be effective, this subsector will continue to absorb the major part of available agricultural credit and foreign exchange to acquire largely imported chemical fertilizers and other chemicals as well as heavy agricultural machinery (tables 2 and 3). This subsector will also control the marketing of these products. In some parts of Kenya, for instance, maize is sold in units of 9-ton lorry loads. Even after the costs of growing the crops have

Table 1. Categories of agricultural land

(Thousands of hectares)

Region	*High potential: 857 mm or over rainfall*	*Medium potential: 735-857 mm rainfall*	*Low potential: 612 mm or less rainfall*	*Total*	*All other land*	*Total land area*
Central Province	909	15	14	965	353	1 318
Coast Province	373	795	5 663	6 832	1 472	8 304
Eastern Province	503	2 189	11 453	14 145	1 431	15 576
Nairobi area	16	—	38	54	14	68
North-Eastern Province	—	—	12 690	12 690	—	12 690
Nyanza Province	1 218	34	—	1 252	—	1 252
Rift Valley Province	3 025	123	12 220	15 368	1 515	16 883
Western Province	741	—	—	741	82	83
Total	6 785	3 156	42 078	45 047	4 867	47 174

Source: Government of Kenya, *Statistical Abstracts, 1978*.

Table 2. New agricultural credit issued by type of farmer, 1974-1978

Type of farmer	1974/75 Amount (KSh million)	1974/75 Share (%)	1975/76 Amount (KSh million)	1975/76 Share (%)	1976/77 Amount (KSh million)	1976/77 Share (%)	1977/78 Amount (KSh million)	1977/78 Share (%)
Small-scale farmers	50.62	14.48	56.26	11.24	49.24	11.75	62.38	11.36
Large-scale farmers	78.36	22.42	139.88	27.94	173.02	41.27	273.80	49.85
Co-operative societies	193.02	55.22	304.56	60.83	196.98	46.99	211.86	38.58
Other farmers	27.54	7.88	—	—	—	—	0.14	0.025
Total	349.54		500.70		419.18		549.34	

Source: *Economic Survey, 1979* (Nairobi, Government of Kenya), table 8.9.

been met, approximately KSh 2,000 more must be spent to get one unit harvested, shelled, bagged, treated and transported to the depot, something most smallholder farmers would find extremely difficult.

Current practices in areas of small farms

Farming practices are mainly determined by climate, farm size, altitude, topography, soil type, crop and livestock systems, labour and input availability and tradition. On the basis of these factors, the following agroecological zones have been isolated and considered separately:

(a) *Zone A_1*. These are high-potential areas at high altitudes, usually over 1,800 metres. The farmers grow tea, coffee, wheat, pyrethrum, maize, potatoes and vegetables and keep dairy cattle. Typical areas are parts of Kericho, Elgeyo Marakwet, Uasin Gishu, Nandi, Kisii, upper parts of Meru, Murango and Kirinyaga, Embu and Nyeri. On small farms hand implements such as jembes and pangas are most commonly used, while tractors are used on larger holdings. These tractors are normally privately owned or provided by contractors. Animal power is not employed because of the high opportunity cost of land;

(b) *Zone A_2*. These are high-potential areas at lower altitudes, usually below 1,800 metres. Crops grown are mainly maize, beans, sugar-cane, with some coffee in the upper part of the zone. Dairy cattle are not common at lower altitudes. Typical areas for the crops are parts of Trans-Nzoia, Bungoma, Busia, Kakamega, Lower Kisii, South Nyanza. Oxen are used along with tractors and hand tools. Tractor services are usually lacking, especially during land preparation, since these farmers depend on private contractors;

(c) *Zone A_3*. These are high-potential areas on the coast. Here coconuts, cashew nuts and citrus fruits are grown. Dairy cattle are uncommon. Farmers rely mainly on hand labour or tractors. Oxen are rarely used;

(d) *Zone B_1*. These are medium-potential areas at high altitudes. Typical areas are parts of Uasin Gishu, Nanyuki, Timau and Nyandarua. Maize, beans and potatoes are the main food crops. These areas are not suited to tea or

Table 3. Import of agricultural machinery and equipment

A. Value of imported machinery and equipment, 1975-1978

	1975		1976		1977		1978	
Description of machinery	*Quantity*	*Value (KSh million)*	*Quantity*	*Value (KSh million)*	*Quantity*	*Value (KSh million)*	*Quantity*	*Value (KSh million)*
Jembes, hoes etc. (thousands)	14.9	0.18	0.1	0.01	1.5	0.01	9.1	0.13
Pangas (hundreds)	—	—	34	0.08	10	0.01	2 815	1.66
Other hand tools mainly used for agriculture (thousands)	421.5	2.25	768.1	4.35	603.5	8.74	271.7	3.53
Internal combustion engines for tractors (no.)	2 453	18.83	1 332	10.39	1 981	17.15	1 816	13.30
Machinery for preparing and cultivating (tons)	355.1	18.38	463.4	19.43	723.2	33.69	1 147.2	49.06
Machinery for threshing, harvesting and sorting (tons)	267.2	13.88	267.2	18.73	267.0	21.79	299.8	56.92
Cream separators (tons)	4.7	0.84	0.3	0.21	0.5	0.12	1.7	0.11
Tractors (no.)	1 389	62.06	1 267	81.74	2 737	204.32	2 659	226.03
Tractors—caterpillar type (no.)	52	14.73	15	8.73	28	15.22	106	29.18
Tractors—n.e.s. (no.)	12	0.68	37	8.28	13	8.56	50	9.15
Spare parts for tractors (tons)	213.1	17.13	268.5	23.21	191.0	14.18	224.6	28.46
Total		148.94		175.16		328.78		420.55

B. *Import of tractors by country, 1975-1978*

1975

Country or area	Quantity (tons)	Value (KSh million)
Canada	0.2	0.81
Germany, Federal Republic of	5.7	6.64
Italy	8.1	10.67
Spain	13.9	16.94
Sweden	2.0	2.78
Switzerland	14.5	2.76
United Kingdom	18.5	20.40
United States	0.6	1.25
Total	63.5	62.24

1976

Country or area	Quantity (tons)	Value (KSh million)
Australia	0.1	0.35
Denmark	0.3	0.29
France	1.5	2.44
Germany, Federal Republic of	4.6	7.12
Hong Kong	0.2	0.34
Italy	16.1	25.25
Netherlands	2.5	2.89
Romania	1.8	1.59
Spain	4.7	6.12
Switzerland	5.0	7.02
United Kingdom	19.6	25.90
United States	0.8	2.40
Yugoslavia	0.4	0.35
Total	57.6	82.06

1977

Country or area	Quantity (tons)	Value (KSh million)
Austria	4.9	10.36
Belgium	0.3	0.96
Brazil	0.5	0.17
Canada	0.1	0.58
France	2.1	7.81
Germany, Federal Republic of	19.8	32.82
India	0.1	0.02
Italy	33.6	52.63
Netherlands	1.3	2.08
Romania	0.2	1.57
United Kingdom	57.3	82.29
United States	3.2	14.05
Yugoslavia	0.2	0.27
Total	123.6	205.41

1978

Country or area	Quantity (tons)	Value (KSh million)
Austria	2.7	7.35
Belgium	6.5	12.96
Canada	0.1	0.62
Denmark	0.2	0.15
France	5.9	26.57
Germany, Federal Republic of	12.4	24.95
Italy	35.9	56.59
Netherlands	0.1	0.01
Romania	1.6	1.37
Swaziland	0.1	0.05
United Kingdom	53.2	91.17
United States	0.9	4.49
Yugoslavia	0.1	0.85
Total	119.7	227.13

coffee, but wheat and pyrethrum are grown. In these areas farms may be large or small depending on the population. Tractors and hand tools are used mainly for tilling. Oxen are less common;

(e) *Zone B*. These are medium-potential areas at lower altitudes. Typical areas include much of Eastern, Central, Western Machakos and Central Kitui, lower areas of Kirinyaga, Embu and Meru, South Nyanza, Misumu, Siaya and South Baringo. The coastal belt, which has lower rainfall, is included in this zone. Crops grown are mainly food crops such as pigeon peas, maize, beans, sorghum, while cotton and sunflowers are the only cash crops. Farms in these areas are large, and there is much common grazing, rendering ox cultivation very popular except on the coast. However, the timing of these farming operations is crucial owing to the unreliability of rainfall. Farmers who do rely on hiring oxen or tractor services are often late because of shortages during this critical period. Tractors and hand tools are also used;

(f) *Zone C*. These are low-potential areas with inadequate rainfall or poor soil conditions and hence frequent crop failure. Typical areas are Kibwezi, East Kitui, some parts of the Coast Province and lower parts of Baringo, Elgeyo Marakwet and West Pokot. Oxen are used together with hand tools on relatively large but unproductive holdings. The opportunity cost for land allocated to animals is negligible.

Small-scale farming in high-potential areas is mainly focused on development of cash crops—coffee, tea, etc. Consequently, the contribution of the small-farm sector to marketed cash crops has grown substantially since independence (table 4). Small-scale coffee and tea farming cannot be mechanized, and, except for harvesting, labour distribution over the year is fairly uniform.

Unfortunately, the development of cash crops has stifled development of food crops and nutrition has suffered. More often than not the income from cash crops is not used to buy goods to meet the basic needs of the family but is often siphoned off through alcoholism or through the purchase of imported consumable items.

In the medium-potential areas, growers of cash crops such as cotton and sunflowers are experiencing serious marketing problems. Food cropping is difficult because of limited rainfall and poor soil conditions. It is in these areas

Table 4. Gross marketed production from large and small farms, 1974-1978

Year	Large farms: Value (KSh million)	Large farms: Annual change (%)	Small farms: Value (KSh million)	Small farms: Annual change (%)	Total: Value (KSh million)	Total: Annual change (%)	Share of small farms (percentage)
1974	1 468	22.3	1 500	18.5	2 968	20.4	50.6
1975	1 436	−2.2	1 802	20.1	3 240	9.2	55.6
1976	2 442	70.1	2 560	42.1	5 000	54.3	51.2
1977	4 120	68.7	4 170	62.9	8 292	65.8	50.3
1978	2 876	−30.2	3 666	−12.1	6 544	−21.1	56.0

Source: Economic Survey, 1979 (Nairobi, Government of Kenya), table 8.5.

that famine relief efforts are usually directed Appropriate mechanization could help in preparing land when it is dry so as to enable planting at the proper time.

Efforts to provide tractor-hire service either through private contractors or a government tractor pool have suffered major setbacks in the last 15 years. To date only a very small proportion of farmers really depend on this service. Even if it were readily available, it cannot be controlled and managed by the farmer himself, which means that if something goes wrong with the system the farmer will have no feasible alternative to fall back on because he will have abandoned other alternatives such as ox cultivation. Any local manufacture of small equipment would also have been abandoned. Above all, it is questionable whether the country can afford the foreign exchange necessary to maintain the tractor-hire service.

Review of historical and current factors that have influenced current mechanization levels in the various zones

In Kenya, three levels of mechanization are found: hand tools, animal-drawn equipment and tractors and other power equipment. All three levels or a combination of any two may be used on the same farm, but the use of a particular tool normally depends on technical and socio-economic factors.

Hand tools are traditionally used in all small-scale farming areas, and especially in high-potential areas, where the opportunity cost of keeping draught animals is high (e.g. Nyeri and Kakamega districts). They are also used in other areas where the labour-land ratio is high. These hand tools include the jembe, the fork jembe, the panga, the mattock, the shovel and the axe. The jembe is used for tilling, while the panga is used for harvesting, but can also be used along with the axe for bush clearing. In many parts of Kenya, e.g. Machakos, the panga is also used for weeding, a practice not found either in Uganda or the United Republic of Tanzania. These tools used to be made locally by rural blacksmiths, and almost all farmers could afford them, since the farmers could pay for them either in cash or in kind. But now these local skills have been destroyed by modern techniques, on which the farmers are now wholly dependent. Moreover, the prices of these factory-made tools are too high for some farmers, which is the main reason why there are so few on some farms. A random survey in a few areas in Kenya revealed that on an average a household owned 1.5 jembes, 2-5 pangas, 1.25 digging sticks and only one in four had an axe [1]. These tools were locally made and easily available.

However, the problem with the current traditional tools is that they are made out of scrap metal that is not properly tempered, as is the case with tools made by rural blacksmiths in Nyanza and Western Province. Tools are forged out of metal scrap picked from local garages or from any other old metal instruments. They thus become dull soon, but farmers continue to use them until they are worn beyond efficient use. Therefore, the cost of the factory-made hand tools and the poor quality of the locally made ones are the major constraints on increased agricultural production among hand-tool users.

In medium-potential areas where the timing of operations is crucial, the inefficient traditional tools have not enabled farmers to carry out operations at the proper time, which has led to reduced or no yields at all in areas where the agricultural potential is already low.

Since these tools still have a role to play in small-scale agriculture, considerable improvements should be made to ensure their efficiency. Emphasis should be laid on the design of these tools and making them widely available to small-scale farmers.

Animal power is relatively new to most parts of tropical Africa; only in Ethiopia is there a long tradition of using oxen. In Kenya, cultivation with oxen was borrowed from South Africa 30-50 years ago. Before independence oxen were used on some European farms, where up to 16 animals were harnessed together. In Uganda on the other hand, ox cultivation is traditional mainly in the cotton-growing areas in the north.

Various pieces of equipment for use with oxen have been tested under local conditions to ascertain their suitability, and results have shown the use of such equipment has great potential for improving peasant agriculture. The items of equipment tested include those used for basic tillage, harrowing, planting, weeding, spraying and transportation. In Kenya, however, the Government has, in the past, given little support to the use of oxen; in fact there have been instances where local oxen were not even allowed in the settlement schemes that showed a potential for ox cultivation. Recently, though, the Government has initiated a UNDP/FAO agricultural improvement project at the Agricultural Machinery Testing Unit (AMTU) whose main concern is expanding the range of hand tools and animal-drawn equipment that might be available to small-scale farmers. Some efforts are being made to train young people as well as farmers to use oxen for farming.

Recently, some local manufacture of various pieces of ox-drawn equipment has been initiated. For instance, small factories supported by the Kenya industrial estates manufacture a wide range of ox ploughs, while rural industrial development centres in various places make copies of imported implements such as sine cultivators, wooden spike harrows and sledges. Also being developed by the FAO project is a pole type multipurpose tool bar with attachments for interrow cultivators. Sledges are also made for transportation where proper roads are lacking.

Current research in the Department of Agricultural Engineering on tillage and equipment systems for semi-arid areas has produced new equipment that can effectively replace the mould-board plough, which is considered unsuitable for semi-arid conditions.

Considerable progress has also been made at AMTU in identifying and testing a range of equipment and in devising evaluation procedures that include an assessment of the suitability of implements for local manufacture.

Today oxen are used in various parts of the country for such farming activities as preparing land, planting, weeding and transportation.[2] Ox cultivation is even more popular in semi-arid areas (zone B_2), where the average farm size is big and the opportunity cost of the land used for grazing working oxen is low. Thus, there is considerable scope for greater utilization of draught power in the lower altitude high-potential areas, and especially in medium-

[2]A survey conducted in May 1976 in 18 districts known to be using oxen revealed that there was a total of 91,833 working oxen and 27,983 ox ploughs (*World Bank Report, 1977* (Washington, D.C.)).

potential areas (zones A_2 and B_2), where livestock will continue to be included in the farming system. However, owing to the constraints on use of animal power, efforts should be made to remove these limitations through improved technology, for instance, through better breeding, training and maintaining of draught animals and better testing of designs and distribution of appropriate equipment innovations.

Tractor mechanization

In Kenya, but not in other East African countries, tractor mechanization, found in the large-farm sector, was originally associated with European settlements. In 1960, the large-farm sector comprised over 3 million hectares. In 1962, the 3 million hectares were divided into more than 3,000 holdings of an average size of somewhat less than 900 hectares. The farmed area was capital-intensive and wholly market oriented. Over time, this sector had become increasingly mechanized, the arable crops being both cultivated and harvested by mechanical means. By 1960, there were about 6,403 tractors (now over 10,000) and 1,000 combine harvesters employed in this sector. The scale of operation allowed fairly full use of equipment—for tractors well over 1,000 hours per season—which was clearly economic from the farmer's point of view. A high degree of mechanization was also encouraged by the Government's policy of fixing prices for arable products at a level highly favourable to farmers [2].

After independence, some of these large farms were subdivided and taken over by co-operatives or used for small-holder settlement schemes. Most of these farms continued to use tractors, although it is doubtful whether that was economic in view of the changes in the farming system and farm sizes.

Tractor mechanization in the small-farm sector in Uganda and the United Republic of Tanzania has proved to be uneconomic, and the sector has required a substantial degree of subsidization. Over the years mechanization has required rather large capital outlays and affected a tiny fraction of the population. Moreover, there is no indication that the introduction of tractors has raised agricultural or labour productivity.

In Kenya, experience with tractor mechanization in the small-farm sector has been a bit different for several reasons. Under the Swynnerton Plan, farms were consolidated and the use of tractors seemed to be feasible on such consolidated holdings. Consolidation first began in Kericho District and then spread to Central Province, and it was here that tractors were first used in the early 1950s.[3] In the early 1960s, the settlement of smallholders on the formerly European large-scale farms (the million-acre settlement scheme) also stimulated the use of tractors. In the first year of settlement, to ensure the planting of crops at the proper time, mechanized land preparation was undertaken either by the Department of Settlement or by private contractors. This caused a number of settlers who had previously employed either hand tools or animal power to rely on tractors. In fact, some settlers bought tractors for their own use and for hire to neighbouring farmers, and tractor cultivation became a

[3]Tractor services had been provided earlier by the Government for soil-conservation purposes.

popular feature of settlement farming. Some of the settlements were established in former wheat-growing areas, where tractor mechanization was economically justifiable. Tractors were also used economically in settlements in areas in which irrigation schemes had been highly successful; because of the increase in the yield of rice, the relatively high annual operating hours causing low acreage costs of tractor hire and the high price paid for rice, the use of tractors was economical. Thus, the success of tractor mechanization was associated with a cash crop. An International Labour Office (ILO) study [2] found that tractor cultivation was profitable on coffee and tea holdings and pyrethrum and tea holdings in Nyeri District, provided that the land-labour ratio was above 2.8 and 2.9, respectively.

However, the results of introducing tractor mechanization in the rest of the small-holder sector of agriculture have been no different from those in other East African countries. For instance, in its efforts to promote agricultural productivity, the Government encouraged smallholders to purchase tractors through the International Development Association under the tractor-purchase scheme. The scheme operated in 1967-1968 with 210 tractors and auxiliary equipment, but it proved to be a costly failure. The same fate befell similar schemes in Uganda and the United Republic of Tanzania.

In 1966, the tractor-hire service in the Ministry of Agriculture was started. It was the first government attempt to set up a national agency to engage in farm machinery contracting. Before this decision was made, the Government had recognized that certain areas in Kenya offered considerable scope for mechanization. Development of these areas was likely to be delayed for a long time because farmers lacked the necessary capital resources and technical know-how. Although the Government anticipated that the tractor-hire service would incur losses because of management problems, it went ahead with the scheme hoping that it would stimulate development and that ultimately a private ownership scheme would have a better chance of success.

As in several other African countries, these attempts to introduce tractor mechanization in small-holder agriculture have not been successful. The main reasons for the failure are:

(a) Short life of tractors and equipment owing to excessive wear and tear and poor maintenance;

(b) Lack of repair and service facilities;

(c) Farmers' inadequate knowledge of the nature of capital investment—some farmers buy tractors for prestige;

(d) Physical separation and small size of farms;

(e) Seasonal nature of tractor operation and hence a low degree of utilization;

(f) Equipment inappropriate for local conditions

Therefore the tractor-hire service has been running at a loss (table 5). The major question is thus why the tractor-hire service should be kept functioning when it is not an economic undertaking. Although the tractor-hire service has stimulated agricultural development in some areas, it may not be reasonable to continue with such a heavily subsidized service in view of the other needs of

Table 5. Analysis of use of tractors for six months, 1978/1979

Activity	Use (percentage)
Productive hours[a]	6.8
Workshop	44.5
Field preparation	15.8
Ploughing problems	1.9
No work	11.6
No diesel	0.6
Rain	1.2
Holidays	0.5
No reason	13.6
Other non-productive hours	3.5
Total	100.0

Source. *Tractor-Hire Service. Half-year Report. 1978/79.* Report 1 (Nairobi, Ministry of Agriculture, 1979).

[a]The percentage of productive hours in 1979/80 increased to 10 per cent (*Second Half-year Report*, January-June 1980).

agricultural development. There are, of course, areas where ox cultivation is not likely to be successful, and here tractors can play a major role. These are areas where:

(a) Farm size is small, and there is insufficient land to justify keeping oxen;

(b) The opportunity cost of keeping oxen is too high because of competing enterprises such as cash crops or dairy animals;

(c) Large farms have been subdivided, and oxen are unavailable or the tradition of using them has been lost;

(d) Oxen are prone to diseases (e.g. trypanosomiasis), the climate is too cold (Mt. Kenya) or too hot (the coastal belt).

The introduction of tractors needs careful planning because a hasty decision may do harm as has been the case in many instances. It is also important to look for other possible alternatives—for instance, obtaining equipment from private contractors and using equipment that does not involve the Government in day-to-day operation. The use of a simpler, rugged and less expensive small tractor such as the Tinkabi of Swaziland or the Eicher of India should be considered. Such a tractor can be owned and maintained by individual farmers, who can then provide a service to their neighbours. To a great extent the simpler tractor can be manufactured locally.

Small farmers rely heavily on the services of private contractors. However, the service provided is often far from satisfactory. One problem is that the contractors may be over-committed and arrive late for a certain operation. A second problem is that the service offered is often only disc ploughing, and the disc plough is sometimes used where a mould-board plough, a tined cultivator or a disc harrow would be much more appropriate. A ploughing contest organized by the Agricultural Society of Kenya on a grass field at Sangalo near Bungoma illustrates the problem. All except one of the competitors arrived with a disc plough, which was clearly the wrong implement for the job.

The small farmer is sometimes forced to accept several ploughing operations with a disc plough to achieve an adequate seed-bed when use of the proper implements at the right time would give a better seed-bed at a fraction of the cost.

A project to improve the services of private agricultural contractors is thus justified. Such a project would examine:

Training facilities for owners and operators

Need for credit to purchase implements

Rates charged for various operations

Control of quality of work

Possibility of increasing the availability of private contractor services

The performance of the government tractor-hire service has been a total failure, since most of the time is wasted (table 5).

The co-operative ownership of tractors and equipment is generally much more difficult to organize. It is quite widely used in some countries and requires a fairly high level of managerial, financial and accounting skill, experience with machinery and problems of mechanization and the trust among the members that makes co-operation possible.

The large farmer co-operatives are unlikely to have the managerial capabilities for handling tractors and machinery, though at least one co-operative in Bungoma was said to be doing this successfully. The extent to which co-operatives do own tractors or could own tractors should be investigated further.

The feasibility of co-operative ownership of tractors and equipment by a few farmers—perhaps not more than 10—should also be investigated. Individual ownership may also be feasible if less expensive tractors are considered.

Local manufacture

The farming techniques used on large farms in Kenya compare very well with those in the developed countries. Thus, the modern form of mechanization that exists has created a demand for large tractors and other equipment for field operations, post-harvest crop processing and farm transport.

This is the main catalyst for the development of a substantial local manufacturing industry. Local manufacturing is aimed at reducing the import content of foreign-designed equipment. Thus, the locally made disc ploughs have imported discs, shafts and bearings but locally fabricated frames. The trailer bodies are also made locally while the wheels and brake systems are imported. Locally made equipment seldom emerges from local R and D. Some locally made hammermills and coffee machinery are notable exceptions. Because most of the local manufacturers have not developed their own design and development capacity, most of the locally made equipment reflects the image of imported counterparts and thus fails to take into account the unique characteristics of Kenyan agriculture.

Like tractors, the demand for farm implements for the large-farm sector is fairly static because of the static nature of that sector. Expanded production and sophistication reflect the degree of import substitution rather than local R and D. The imported components ensure a product of good quality.

With regard to the small-farm sector, there have been sufficient import restrictions to give the Government-financed Kenya Engineering Industries and Kenya industrial estates as well as others some control of the local market. At the moment almost all the hand tools are made locally without imported components. However, the protected local manufacturers produce low quality and more expensive equipment than the same imported items.

Ox equipment has existed in Kenya for over 50 years. For many years it has been produced by a local firm. However, owing to lack of extension service and supporting R and D, the demand for ox equipment remained static until only recently, when AMTU and the university started R and D to expand the range of animal-drawn equipment. Now the demand has increased. Thus, in addition to mould-board ploughs, cultivators, sine hoe tool bars and attachments, planters, weeders etc. have recently been made locally in the large urban centres of Kisumu, Nakuru and Nairobi.

No significant number of local manufacturers in rural areas seems to be developing in spite of concerted efforts to assist local blacksmiths through rural industrial development centres. Traditional metalworking skills seem to have been lost partly because hand and animal-drawn implements have been imported from foreign countries and recently from urban centres. Furthermore, there is no evidence that urban-based local manufacture stimulates rural manufacturing. In fact, the experience since independence proves the contrary. The urban dweller has easy access to knowledge and finance and may manufacture farm machinery as a sideline.

Urban-based manufacturing facilities are capital-intensive rather than labour-intensive and thus do not create badly needed jobs. Moreover, the farmer does not benefit from the support services such as provision of maintenance and spare parts.

Perhaps the greatest drawback with locally made hand tools and animal-drawn implements is the poor quality of these tools. The soil-working parts tend to wear out very fast; they may last only one week in very sandy soils. The plough-beam also bends, which makes ploughing difficult.

The problem seems to arise from lack of quality steel and the technical capacity for processes such as hardening and tempering, as well as a lack of understanding of the forces to which the parts are subjected in use. Without this knowledge, components are likely to be overdesigned and expensive and thus priced out of the market.

An interesting example can be drawn from a technical report by J. Bessell of the Department of Mechanical Engineering of the University of Nairobi [3]. After testing and finding that the plough-beam bent at 1,000 kg he concluded that it should be strengthened to withstand twice that force. Three alternatives were suggested, namely:

Increasing the cross-section of the beam

Using the cold-formed steel section of the same cross-section

Using the hot-formed steel section having a higher carbon content (0.5 per cent)

The report favoured the second solution, which is probably the most economical if the necessary equipment is available. However, just what causes the beam to bend is still not known. Since the plough-beam has been in use for years, it is important to determine why the earlier beam did not bend and the recent one does. A change in the hitching system might reduce the bending moment. Operating conditions require controlled field testing, done best by agricultural engineers.

The two prerequisites for a sustained local farm machinery industry are:

(a) Technical capacity to specify the requirements of a farm machine under various soil, crop and other environmental conditions, taking into account the relevant socio-economic factors;

(b) Technical capacity to translate machine specifications into design specifications for manufacture.

Demand for farm machinery

Until appropriate farm machinery for Kenyan farming has been identified, demonstrated and accepted by farmers the demand for it cannot be estimated. However, there is sufficient evidence to indicate that farmers suffer from severe shortages of currently available hand tools. In a random sample of 205 households in Mbere Division of Embu District, Diana Hunt [1] found that none of the farmers had oxen or ox-ploughs. On the average, each of the case-study households owned 1.5 jembes, 2.5 pangas, 1.25 digging sticks; and only one in four had an axe. This acute shortage of tools was confirmed in a similar survey in Lower Machakos District. Table 6 shows the frequency distribution of the farm tools available on the farms visited; 68 per cent of the farmers had two or fewer jembes and 80 per cent pangas. Since on the average there are three adults and three children in each family, even the most popular and the least expensive tools are in such short supply that about one third of the family labour force is rendered redundant at any one time. Furthermore, the tools are

Table 6. Ownership of farm tools and oxen

(Percentage of a sample of 106 farmers owning the number of tools or oxen indicated)

Item	*0*	*1*	*2*	*3*	*4*	*over 5*
Jembe	7	40	21	19	7	6
Panga	6	35	39	14	3	3
Shovel	27	53	12	4	0	4
Fork jembe	65	32	2	0	1	0
Mattock	79	20	1	0	0	0
Axe	64	33	3	0	0	0
Musululu	90	9	1	0	0	0
Ox-plough	30	65	4	1	0	0
Oxen	22	7	61	2	7	1

usually in a state of disrepair, with blunt or broken blades and missing or loose handles.

The currently available animal-drawn implements, however, are acceptable and by far superior to hand tools; but in those restricted areas where animal power has been introduced, 40-60 per cent of the farms depend on hiring equipment at the great risk of obtaining it late for planting.

Why tools are in short supply and badly maintained is not clear. However, the extreme poverty arising from both the diminishing farm productivity as well as changing life styles may be responsible.

With regard to tractor-drawn implements, a great demand for tractors exists on the one hand, but on the other hand tractors annually average 300 useful working hours, which is hardly sufficient to cover the variable costs. Here most of the problems have to do with the organization of work and the maintenance of tractors. The farmer's problem is related to the geographical location and size of farms that the tractor-hire scheme has to deal with; how efficient the scheme is depends on the calibre of the tractor-hire management and staff.

While it is true that considerable improvements can be made in the quality, quantity and the range of hand tools and animal-drawn implements, a big question arises as to whether the current farming system—which has failed to take advantage of the available equipment—will be able to take advantage of innovations in equipment. Only solvent farming enterprises will be ready to accept equipment innovations; and thus mechanization must be accompanied with other inputs necessary to make farming profitable—improved seed, chemical fertilizer or manure, crop protection and plant population. Furthermore a market outlet for surplus crop must exist or be developed.

The successful application of tractor mechanization to the large-farm sector has proved the need to combine mechanization with a complete package of farm inputs. In this sector it is assumed that in a well-managed farm machinery scheme one tractor and accessory equipment can serve 100 hectares for mixed farming. For the 600,000 hectares currently being cultivated as large farms, at least 6,000 tractors would be required. This figure agrees with the current tractor strength of 6,013 wheel and 436 crawler tractors recorded in 1978 (table 7). This demand has been fairly static since 1970. Increased demand will result either from expansion of cultivated land or a tractor more appropriate for small and medium-size farmers.

Table 7. Large farms—mechanical equipment, 1970-1978

Item	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*1978*
Wheel tractors	6 607	5 336	5 501	5 235	5 709	5 501	5 503	5 728	6 013
Crawler tractors	710	645	555	527	486	512	479	458	436
Combine harvester									
Self-propelled	462	405	407	337	318	289	322	260	253
Tractor-drawn	177	153	141	143	144	144	147	119	113

Source: Government of Kenya, *Statistical Abstract 1978*, table 100

Application of four-wheel tractors to small and medium-size farms has been a success in areas adjacent to large farms, especially in the settlement schemes. The long-term success of tractor cultivation in these areas will depend on the availability of an inexpensive tractor that is simple to operate and maintain. A few farmers, or even one, could buy such a tractor and then share it with neighbours. This type of mechanization would serve up to 1 million hectares already allocated or likely to be allocated to settlement schemes. It is estimated that a small (20-30 hp) wheel tractor would be able to serve up to 50 hectares per annum; the demand would be about 4,000 tractors per annum assuming an economic life of five years.

It is far more difficult to estimate the demand for agricultural machinery for small farmers than for large farmers. In fact, the current demand is far from the potential demand because the current land use is much lower than the potential land use. To arrive at reasonable estimates, rational land use must be worked out. The large-scale farm sector (less forest land) occupies a total of 2.5 million hectares of predominantly high-potential land in the Rift Valley and Central Province, of which 1.9 million hectares, or 76 per cent, is classified as uncultivated meadows and pastures. The area of small-scale holdings amounts to 3.5 million hectares. Only 1.3 million hectares, or 37 per cent of this area, is cultivated. The balance of 4 million hectares is unaccounted for, but includes most of the unutilized land, especially in the medium-potential areas. The total cultivated land currently amounting to 1.54 million hectares could be more than doubled without infringing on grazing land. The mechanization requirements are based on increased cultivated land in both the large- and medium-potential areas.

However, expanding cultivated land in predominantly high-potential areas that are densely populated and where farms are small will be very difficult. The average farm size of between 1-1.9 hectares per household would be expanded if possibilities existed. One of the ways more land could be cultivated is by resettling people on the unused land in the high-potential and in the medium-potential areas. To some extent this has already happened in the last 15 years.

Some surveys in typical medium-potential areas show that the average farm holding in Lower Kirinyagah is 3.6 hectares and between 2.5-3.0 hectares in Lower Machakos [4].

An analysis of labour utilization also indicates that 2.0 hectares is the largest size of farm that can be managed using hand tools. With animals, up to 4 hectares can be productively managed [4], [5].

A logical land-use policy in small-scale farm development would therefore be to maintain cultivated land per holding at 2.0 hectares and 3.5 hectares in high- and medium-potential areas, respectively.

For an estimated 1.5 million holdings averaging 6.5 persons per holding, there are 10 million workers in the small-scale farm sector currently cultivating 1.3 million hectares. The population distribution between the high- and the medium-potential areas is estimated at 8 and 2 million, respectively. In the same proportion, about 1.2 and 0.3 holdings are estimated in the high- and medium-potential areas, respectively.

A survey by the Ministry of Agriculture shows that this land is cultivated as follows:

	Area (1,000 hectares)	*Share (percentage)*
Hand tools	1 039	84
Ox cultivation	150	12
Tractor cultivation	42	4
Total	1 231	100

Cultivated land could be expanded by 3.6 million hectares—2.2 million in the high-potential areas and 1.4 million hectares in the medium-potential areas. The total is about equal to the land currently held by small farmers. The additional land required then would be for grazing and could be of poorer quality, or on slopes or on poorly drained land. In short, cultivated land could be doubled without a major movement of population.

To avoid further fragmentation, the new generation of farmers or the currently landless population should be settled elsewhere in underutilized high- or medium-potential areas. It is estimated that 1 million hectares may be available for such settlement.

The main questions that must now be addressed are:

What mechanization methods would be appropriate?

What is the demand for various types of equipment?

How can the equipment be provided?

What supporting R and D is necessary?

It can be assumed that farmers in the high-potential areas will use hand tools. Hand-tool cultivation is feasible for cash crops such as coffee, tea and pyrethrum and for dairy farming. Assuming that each holding has 3 pangas and 3 jembes and that the tools have a useful life of three years, then the requirement in the high-potential areas would be 1 million pangas and jembes per year.

Hand tools would be required in the medium-potential areas to supplement ox cultivation in planting and weeding. The additional requirement would be similarly proportional to the number of holdings as follows: 400,000 pangas and 400,000 hoes per year. In addition, each household would require a hand-operated sprayer for pest control on crops and animals.

With regard to ox-drawn equipment, the author has developed a package of equipment suited to dry-land farming in the medium-potential areas. When accepted by farmers this package would replace the traditional mould board plough. The main operations recommended include chisel ploughing before the rains, opening planting furrow, hand planting and mechanical weeding from 2 to 3 weeks after emergence. Each of the individual attachments is mounted on a modified sine hoe tool bar originally developed in France.

Assuming that ultimately each 3.5 hectare holding should have one set, the demand would be 400,000, or 80,000 units per year for an economic life of five years. Each farm set would consist of a sine hoe tool bar, chisel share, desi plough with standard and 3 × A-shares with standards.

The currently available animal-drawn mould-board plough is a suitable alternative to either the hand tool or small tractor for small-scale farmers having more than 4 hectares in high-potential areas, where beef and dairy animals are kept. The percentage of farmers having 4 or more hectares of land ranges between 14 in Nyanza Province and 25 in the Rift Valley. Assuming that about half of the small-farm population in the high-potential areas, especially in Western Nyanza and Coast Province, cannot grow high valued perennial cash crops and may keep dairy or beef cattle as an alternative, about 8 per cent of 1.1 million, or 88,000 farmers, may be able to use the animal-drawn mould-board plough. Assuming a life of 5 years, 17,600 ploughs would be needed per year.

Table 8 summarizes the tools and equipment that would be required if an appropriate agricultural mechanization policy is adopted.

Table 8. Estimated utilization of farm equipment

Item	*Sets required per year*	*Estimated area of cultivated land (thousand hectares)*
Hand tools (jembe, panga, sprayer)	1 500 000	3 600[a]
Animal-drawn, dry-land equipment—sine hoe, desi plough attachments	80 000	1 400[b]
Mould-board plough	17 000	2 000[c]
Small tractors and accessories	4 000	1 000[d]
Large tractors and accessories	1 200	600[e]

[a]A small-scale farm land.

[b]Cultivated land in the medium-potential areas. The other 1.8 million hectares of the total 3.2 million hectares is used for grazing.

[c]8 per cent of small-scale farm land having more than 4 hectares and keeping cattle.

[d]One million hectares land for settlement drawn from unutilized land in the high-potential areas.

[e]Land currently cultivated by the large-scale sector.

The expanded cultivated land would be mechanized as follows:

	Size of farm (million hectares)	*Form of mechanization*
Small	2	Hand tools
	0.2	Animal-drawn
	1.4	Animal-drawn, sine hoe or desi plough attachments
	3.6	
Large and medium	1.0	Small tractors
	0.6	Large tractors
Total	5.2	(1.9 million hectares are currently under cultivation)

Table 9 gives the capital outlay for the annual equipment requirements estimated from table 8.

In contrast, KSh 420 million was used in 1978 for importing farm machinery (table 3) of which KSh 410 million, or 97 per cent, was used for large-farm equipment. Tractor and tractor parts alone accounted for 227 million. The problem of obtaining spare parts and maintenance is accentuated by the diversity of makes from various countries.

Table 9. Capital outlay for equipment required annually

Item	*Quantity per annum (thousands)*	*Cost of complete set (KSh)*	*Total value (million KSh)*	*Estimated population benefiting directly (millions)*
Hand tools[a]	1 500.0	300	450	11.0
Ox equipment	97.6	1 500	120	3.0
Small tractors and equipment	4.0	60 000	240	0.60
Large tractors and equipment	6.0	120 000	144	0.024
Total			344	14.6

[a]Used by all small-scale farmers, including those who use ox equipment and tractors. However, the estimate is based on the current 1.5 million small-farm holdings.

Agricultural mechanization policy

The recent history of mechanization in Kenya reflects an implicit policy. While its neighbours Uganda and the United Republic of Tanzania had tested small-scale animal-drawn implements over the last 20 years, only four years ago small-scale machinery testing started at the 26-year old Kenyan AMTU located at Nakuru.

In the last 17 years of independence, considerable efforts have been concentrated on tractor-hire schemes through attractive credit facilities offered by the Agricultural Finance Corporation.[4] As mentioned earlier, up to now only a small fraction (4 per cent of small-scale farms) is cultivated by tractors. One of the most reputed agricultural colleges in Kenya, which initiated an agricultural engineering diploma nearly 20 years ago, has concentrated on training for large-scale mechanization and only given lip service to small-scale animal-drawn implements. All these developments have taken place under the supervision of the Ministry of Agriculture.

These developments clearly show that the implicit policy has been to support large-scale mechanization based on the imported tractor. This policy was never seriously questioned until 1975, when a workshop was held to discuss farm equipment for agricultural development and rural industrialization. Without debating the highly controversial subject of the effects of tractor mechanization on production and employment, the workshop concluded that animal-drawn implements and hand tools could play an important role in agricultural development and rural industrialization. To a great extent the workshop proceedings became a document that has guided the policy decisions in the last six years. Consequently, AMTU is now almost fully dedicated to small-scale mechanization based on the testing and development of animal-drawn and small-tractor equipment. At the same time the Department of Agricultural Engineering of the University has biased mechanization training in favour of the small-scale farmer.

[4]In 1977/78, KSh 549 million worth of agricultural credit was disbursed, 87 per cent of which went to large farmers and co-operative societies.

Because of low demand, low prices and marketing problems connected with hand tools and animal-drawn implements, the commercial and industrial sector has not invested in local R and D for these tools. Farm machinery has been produced for clearly identified demand. Because the follow-up repair and maintenance service has been inadequate, demand has not grown, and the farm machinery manufacturers compete for a small and static market.

The problem at the moment is that as equipment innovations are tried out and found to be successful, there is no way to translate the prototypes into design specifications for the manufacturers. The product is therefore usually poor in quality and expensive.

Because of lack of properly organized mechanization extension institutions, AMTU is often requested to do extension work, including the training of farmers and controlled testing. Furthermore, because of lack of agricultural engineering research capacity at the Kenya Agricultural Research Institute, AMTU is also drawn into problem areas that demand research attention. At the moment it is covering too wide a spectrum of work to be effective. It also suffers from staffing problems, being largely dependent on FAO staff who may not stay for long periods.

One problem that is not being dealt with at all is lack of agricultural power. As it is now, 1.1 households with less than 2 hectares of farm land in the high-potential areas have no access to any power source except human power. Macinery is more effective for heavy cultivation, weeding, spraying, transportation, water pumping and many post-harvest processes such as crop handling, drying, size reduction, cleaning and grading. There is an urgent need for an internal combustion engine of about 10 kW mounted on a simple chassis that farmers could carry from one part of the farm to another. Under easy soil conditions a form of walking tractor would be appropriate for many of the functions listed above. The Tinkabi system of Swaziland might be appropriate, but as a riding tractor it is bound to be expensive and probably beyond the means of the owner of a 2-hectare farm. The Groom system developed at the Institute of Tropical Agriculture at Ibadan, Nigeria, based on zero tillage is appropriate for areas where zero tillage is feasible.

Whatever form of mechanization is adopted, it will require energy readily available to farmers at reasonable prices. The only commercial energy currently being supplied to rural areas, kerosene, is now not readily available, a good indication that rural areas will be the first to experience a shortage of commercial energy. Future plans can therefore not be based on conventional sources. Alternatives such as biogas, vegetable oils and alcohol should be explored.

Although photo-voltaics may become economically feasible in the long run, in the medium term, great reliance must be placed on biomass sources. Biomass production and agricultural development in general go hand in hand. A close-knit relationship between the two must be established.

Of paramount importance is domestic energy for cooking and lighting. While due respect must be given to current efforts to plant trees, these efforts will be misdirected unless the land-use problems connected with them are recognized. At the moment most land is being used for cash crops such as tea, coffee and sugar-cane, with food production given second priority. The balance of the land, if any, is allocated to livestock. Inevitably forests will have to be planted in the low-potential areas usually far removed from villages. The attendant transport costs will make wood and charcoal too expensive for the rural poor. Like agriculture, domestic energy will have to be obtained from biogas and vegetable oil alternatives.

To address the basic problems of the rural population, the agricultural mechanization policy must encompass agricultural production, biomass energy production and rural industrial production, which is primarily related to agricultural machinery production, the prime mover for agricultural production using available human, animal and mechanical power. Without it agricultural and biomass energy production is not possible. Failure to adopt a three-prong approach is the cause of the limited success in the past.

The agricultural mechanization policy must also recognize the need for self-reliance in technology, which is vital to cultural development. The current socially disruptive migration to the cities arises from lack of gainful employment in the rural areas. Rural methods of production offer no opportunities to educated young people. Employment in the rural areas will have to be locally generated and will to a great extent be self-employment. The rural industrial development centres are doing an excellent job of helping individual entrepreneurs who lack capital and other facilities. What is needed is an integrated approach encompassing the identification of equipment needed by the farmers; research and development of mechanization systems and equipment, design and manufacture; extension services and training of farmers; and improved machinery distribution and maintenance. All these aspects must be co-ordinated if results are to be achieved within a reasonable period.

Given the currently available cropping innovations coupled with efficient management, including use of improved seed, chemical fertilizer and plant protection, a farm in a semi-arid area can achieve an average yield of 2 tons of grain per hectare (or 7 tons per household cultivating 3.5 hectares) if the crop is planted and weeded on time and maximum water is conserved in the soil. This would amount to doubling the current yield level of 1 ton per hectare. To achieve correct and maximum water conservation, a farmer needs new kinds of equipment, including chisel and desi ploughs and weeding attachments mounted on a sine hoe tool bar. Operations carried out at the proper time would increase the production of legumes in the short rainy period. This development would ensure stable production of food crops. A surplus of cereals or grain legumes would provide a good cash income.

Production of grain at the rate of 2 tons per hectare brings with it biomass production at the rate of 18 tons per hectare. For a farmer cultivating 3.5 hectares, the total biomass would be 63 tons of dry matter. At an estimated rate of 0.22 m^3 biogas per kilo of dry matter the total biogas produced from half of the dry matter would be $0.5 \times 63{,}000 \times 0.22 = 6{,}930\ m^3$, of which 4,712 m^3 (68 per cent) would be methane. This amount would be sufficient for the following requirements per household per annum (m^3):

Cooking	1 029
Lighting	80
Small engine (for 500 hrs)	2 000
Total	3 109

The corresponding biomass production from high-potential areas averaging twice the biomass production per hectare would produce even more biogas, but the power requirement without oxen would be about twice as much.

It should be noted that use of biogas energy ensures a good recirculation of plant nutrients and may reduce reliance on chemical fertilizer.

If biogas presents insurmountable technical problems, especially in medium-potential areas lacking abundant water, then oil crops such as sunflowers or castor beans may be grown and the vegetable oil used for domestic consumption as well as in a diesel engine. Biogas energy is likely to be successful in high-potential areas, where green vegetation and water are abundant. China's experience in this connection is worth examining.

If all the required hand tools and animal-drawn implements are produced in the rural areas using steel produced in the urban areas, the value added in the rural areas would be 40-50 per cent. Assuming that 50 per cent of the value of the equipment would be in the form of skilled labour, the income generated would be (millions of KSh):

Ox equipment	410
Hand tools	450
Total	860
50 per cent value added	= 430

Assuming that the average rural skilled worker will earn the minimum urban wage of KSh 350 per month, or KSh 4,200 per annum, 100,000 jobs would be created. This increase would support a population of 700,000. In addition, increased production of food and biomass energy would provide skilled employment through management of the wastes of related primary crop processing and other agro-service industries. In turn, increased rural income from agriculture and rural industry would create a demand for consumer goods and services.

Structural and institutional changes

Experience indicates that training institutes in agriculture, education and industry are geared to the modern sector of the economy. Thus, engineering graduates are usually employed in urban centres or in the public service institutions such as the Kenya railways, Ministries of Works and Water and Transport and Communications and the East African Power and Lighting Company. There are no graduates dealing with rural housing or rural and farm transport. The mud houses, latrines, ox-carts, water supply etc. remain as they have been for ages.

Some of the best training programmes for rural manpower exist in the Faculty of Agriculture, Egerton College, and many agricultural institutions. However, the agriculturalist goes out with a fixed idea that he must modernize traditional agriculture rather than develop and improve it. Having little understanding of the factors that have determined the traditional system, he is quick to suggest pure stands rather than the traditional intercropping, planting and weeding on time without understanding the reasons why farmers fall behind schedule. In the same way suggestions for afforestation, biogas units etc. are beginning to be presented without due consideration being given to the underlying constraints. Thus, time and efforts are wasted and may even achieve negative results.

Kenya is at present facing a serious food crisis. At the same time the proportion of land under cultivation is relatively low, as shown below:

Category of farm	*Total farm land (million hectares)*	*Cultivated (million hectares)*	*Percentage cultivated*
Large	2.5	0.6	24
Small	3.5	1.3	37

Much of the small-farm land is not cultivated because its yield would be low. In the semi-arid areas, where much of the idle land is situated, it is not profitable to expand cultivation with the current equipment. Using more land and even more labour is not profitable until equipment innovations have been adopted. This is probably the reason why farmers have not responded to credit facilities for fertilizers etc.

Why large-scale farmers cultivate only 24 per cent of the land is not obvious because they have easy access to tractors. One most likely reason is that grain production (except wheat) involves complex management of labour, especially at harvest time. It is easier to manage livestock, and that activity is preferred, although per hectare output is low. Thus, a case can be made for sub-division into smaller and more manageable units. The Kenyan land settlement programme has proved its worth and should continue until at least 1 million hectares of the 2.5 million hectares in the hands of large-scale farmers, mainly in the high-potential areas, has been subdivided.

Much of the land in the medium- and low-potential areas can be productive if an appropriate technology is developed.

The following stages of farm machinery development have been suggested [8]:

Comprehensive analysis of needs of farmers and constraints under which they work

World-wide search for equipment

Evaluation and testing of equipment under field-controlled conditions

Determination of the extent to which equipment performance under controlled conditions can be transferred to meet the identified needs of farmers subject to constraints, including other inputs

Trials of package innovations, including farm equipment and other necessary inputs

Limited local manufacture and extension programme

Widespread local manufacture and extension programme

Once the equipment has been selected, a decision can be made as to whether to carry out controlled field tests. If there are no obvious problems, these time-consuming and expensive tests can be omitted.

To implement such a broad-based programme a wide range of disciplines is needed. To co-ordinate an analysis of farmers' needs, R and D, design and local manufacture and extension programmes is not likely to be easy. In fact, it is the lack of an institution framework for co-ordination that is the crux of the problem.

Virtually every government ministry offers some kind of service to the rural areas. However, rural development requires close co-ordination of at least three ministries, namely, Agriculture, Industry and Energy. Within each ministry there are technical divisions of departments charged with specific tasks. In addition, semi-autonomous institutions for R and D are charged with specific responsibilities that are not easy to carry out within the normal government structure.

Because they lack a sufficiently broad mandate, none of the existing institutions has been able to address the basic problems of rural development such as the energy shortage and lack of jobs. Thus, the Kenya Agricultural Research Institute in the Ministry of Agriculture is concerned with basic agricultural research, water-catchment studies, farming systems etc. However, it is weak in farm machinery R and D and agricultural engineering in general. Farm machinery R and D is partly being done at AMTU, which was set up in the Land Development Division to test tractors and equipment before they are released to farmers. However, the tested equipment is prematurely taken up by manufacturers before proper design specifications have been developed. Although some entrepreneurs are being encouraged to develop production capacity, there is little evidence to show that farmers will buy and use an equipment innovation to maximum advantage. Pre-extension studies are necessary to identify problems farmers have with an innovation before the adoption of the innovation is encouraged.

There has been some talk about setting up a Kenya Energy Institute, although the Kenya Power Company and the East African Power and Lighting Company have been charged with the responsibility of developing large hydro and geothermal electricity. Obviously, the larger power stations will meet only part of the power requirement of the modern sector. The proposed rural energy centre would be expected to concentrate on alternative sources such as biomass or solar energy. However, energy R and D must be closely related to the production and use of energy in agriculture and rural industry if they are to be effective.

Owing to lack of proper co-ordination in rural development programmes, it is proposed that a Kenya institute of technology for rural development be established. The institute would have five centres focusing on common problems of agricultural development and rural industrialization.

Conclusions and recommendations

1. Past efforts to mechanize have apparently been misdirected, and the real need for tools and agricultural power has not been met. The main reason is that the effect of mechanization on production and employment has not been well understood. It is recommended that *(a)* the needs of farmers be analysed and then *(b)* appropriate equipment based on world-wide experience be chosen. The equipment should be evaluated and, if necessary, further tested under controlled field conditions before it is introduced to farmers. A multidisciplinary team should carry out the analysis of needs and put together the package of inputs.

2. Once the necessary equipment and other inputs have been identified, they should then be subjected to trials to learn farmers' opinions and to determine any socio-economic or technical problems that might arise when the inputs are used.

3. The next stage is to manufacture a limited number of pieces of equipment and use them to expand the number of farmers who have agreed to try them out. At this time local entrepreneurs who can manufacture and provide maintenance and repair service should be identified and involved. The necessary credit schemes and market opportunities for the increased output expected must be organized.

4. If the first and second steps recommended are successfully implemented then widespread local manufacture and use should be promoted.

5. Normally an imported piece of equipment will be found to be unsuitable for use. Experience has shown that conditions vary so much that modification and even redesigning are often necessary. A supporting R and D centre is therefore necessary. AMTU should be strengthened to assume this role. The R and D system must be able to respond to the observations made on farms of an interdisciplinary team of agronomists, socio-economists and agricultural engineers.

6. The function of the R and D centre would be to establish the interaction between the machine and its physical environment of soil, crops etc. It would be concerned with the functional design rather than a design for manufacture *per se*. Thus, for tillage the functional design would be based on the force applied on the soil by the tool, power required, rate of wear and the required field capacity (rate of work). Once a prototype had been designed, produced and fully tested by agricultural engineers it would be handed over to production engineers to determine the most appropriate design for local manufacture. It is therefore recommended that a design and development centre be established. The production engineers should also be made aware of the limited income of farmers, limited skills in operating and maintaining machinery and lack of supporting facilities.

7. The number of rural industrial development centres should be increased and strengthened to enable them to promote local manufacture by providing capital equipment, credit facilities and technical service to rural entrepreneurs.

8. To ensure an adequate supply of energy in the long run, the possibilities of using biogas, vegetable oils and solar energy should be studied. A rural energy centre is therefore necessary.

9. The analysis of needs of farmers, development of a package of inputs and monitoring of subsequent performance require the continuous attention of a multidisciplinary team. Therefore it is recommended that a farm level studies centre be established to provide a link between the farmer and all the other centres.

10. All these centres, some of which already exist, will need to be closely co-ordinated to ensure the common objective of increased agricultural, biomass energy and rural industrial production. It is therefore recommended that all these centres be established under the Kenya Institute for Rural Development Technology (KIRDT). The Institute will have to adapt and implement many

scientific and technological findings of other agricultural, industrial and energy research institutes. Lack of such a body to assemble diverse scientific knowledge and put it in a usable form for rural development has been a severe constraint on rural development.

11. Once complete packages of inputs acceptable to both the farmer and the entrepreneur are available, sustained development of the rural economy will depend on having stable manufacturers in rural areas. In addition, the distribution and maintenance of the equipment are critical. Appropriate physical infrastructure and the necessary credit facilities should be developed.

12. The whole purpose will be defeated if the increased surplus of farm produce cannot be marketed at a good profit. Facilities for processing crops at or near the farming community and efficient methods of storing, transporting and marketing produce must be developed.

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Jute spinning in Bangladesh: technological change in light and heavy yarn production

*M. G. Kibria and C. A. Tisdell**

Background to technological change in jute manufacturing

The purpose of this paper is to examine changes in production functions in jute spinning in Bangladesh that arise from technological change, learning by doing and related factors.

There are two distinct phases in jute manufacturing: *(a)* spinning of jute (from batching to winding) and *(b)* weaving of jute yarn (from beaming to finishing). Those mills engaged in spinning are mostly involved in weaving.[1] However, weaving operations are completely separated from spinning operations. Spinning results in the production of yarn, and weaving (using yarn as an input) results in the output of fabric. Both yarn and fabric are marketable products.

The jute manufacturing industry and, therefore jute yarn production, has existed in Bangladesh for just over twenty years. Previously, practically all jute had been exported for manufacture. Two types of jute yarn are produced in Bangladesh: heavy yarn (with an end-use as sacking weft) and light yarn (used for sacking warp and also for warp and weft in hessian and in carpet backing). Most spinning mills in Bangladesh are nationalized. Yarn from the nationalized mills is all used by the jute weaving industry in Bangladesh, whereas the privately owned mills concentrate on the production of light yarn for export.

The jute spinning industry in Bangladesh depends almost entirely on imported capital equipment embodying imported technology. The average length of life of spinning equipment is at least 30 to 40 years, a very high duration. Consequently, since no spinning mill in Bangladesh is much more than 20 years old, each still has its orginal equipment incorporating the available technology at the time of its establishment. Furthermore, expansion in the industry has occurred by adding mills rather than by expanding the existing mills. It can be assumed that once a mill has been established there has not been any change in the composition of capital equipment in that particular mill. Thus, machine-determined technological change is only an inter-mill phenomenon, not an intra-mill one.

In this study the impact of technological change in spinning in Bangladesh is divided into two components: *(a)* machine-determined technological change due to the installation of machinery of newer vintage in new mills; and

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[1] The wage structure is different in spinning and weaving. Time-rates prevail in spinning (except for winding) whereas piece-rates prevail in weaving.

(b) alterations in productivity due to learning by doing, that is, gains in productivity resulting from greater experience in production using new machines, and due to other time-related factors.

By way of background, the history of the adoption of spinning frames in the Bangladesh jute spinning industry may be considered. This study concentrates on the 25-year period 1954/55 to 1979/80. Only one mill was established before this period.[2]

During the period 1954/55-1961/62, the "old slip-draft" type of spinning frames was adopted for the production of both heavy and light yarns. Mostly heavy yarn was produced in the period for sacking.[3] All heavy yarn slip-drafts were made by one firm which also produced most of the light yarn slip-drafts with smaller shares being supplied by three other firms. However, even though the makers were different, all machines were of the same slip-draft type.

After 1962, mills had the choice of technologically more advanced spinning frames. The modern slip-draft and apron-draft type of spinning frames became available.

Modern slip-drafts are similar to old slip-drafts but are more flexible, being able to produce either heavy or light yarns.[4] The heavy yarn spindles of the modern slip-drafts can easily be converted into light yarn spindles and vice versa. It was found during the survey, on which the main results of this paper are based, that the administration of many of the jute mills in Bangladesh very much appreciated this ease of adaptability of modern slip-drafts in view of the constantly changing demand for jute goods. Modern slip-drafts have a far greater flyer speed (in rev/min) than the old slip-drafts. This makes them more efficient, and they also can produce finer and better-quality yarn than the old slip-draft type.

Apron-draft spinning frames are more specific than modern slip-drafts and are suitable only for light yarn production. But in that regard they are especially suitable for the production of finer and lighter yarns, the demand for which has expanded greatly from the mid-1960s on. They also have higher flyer speeds than modern slip-drafts[5] and are capable of higher productivity.

The use of apron-draft frames was encouraged by the rising demand for light yarn to satisfy increased demand for hessian relative to sacking and to meet the rising demand for carpet-backing cloth (CBC) during the 1960s.[3] The rising output of hessian peaked in 1968/69, but demand for CBC, especially from North America and Western Europe continued to expand. Some

[2]This was established in 1952 using second-hand machinery (old Mackie type) purchased from India.

[3]G. Mustafa, "An analysis of the world jute economy and its implication for Bangladesh", unpublished Ph.D. thesis, University of Exeter, 1978.

[4]Each frame for heavy yarn consists of 80 spindles and for light yarn 100 spindles.

[5]The comparative flyer speed of the different types of spindles used in Bangladesh are as follows:

Type	*Period introduced*	*Speed (Rev/min)*
Old slip-draft	1	3 000-3 200
Modern slip-draft	2	3 600-3 800
Modern apron-draft	3	4 200-4 600
Modern apron-draft	4	4 800-5 000
More modern apron-draft	5	5 500-6 000

broadloom weaving was established in Bangladesh (the first mill was established in 1964) to help meet the rising demand for CBC.

Of the frames adopted during the period 1962/63-1969/70, most were modern slip-drafts, but a significant number of apron-draft frames were also installed.

The demand for light jute yarn continued to expand during the next period 1970/71-1977/78, owing to continuing expansion in demand for yarn for carpet backing. Consequently, several weaving mills were established in Bangladesh to produce CBC, and spinning mills were also added to increase the supply of carpet-backing yarn, mainly to provide yarn for these weaving mills. Most of the frames imported during this period were of the apron-draft type, but some modern slip-drafts continued to be imported. The normal flyer speed of these machines was higher than the speed of those introduced in the 1960s.

From 1978 on there were further technological developments. The continuing relative rise in demand for CBC and the emergence of direct foreign demand for light yarn led the new private entrepreneurs in the Bangladesh spinning industry[6] to import the most modern light yarn spinning[6] frames. They imported apron-draft frames suitable for making yarn for either hessian or CBC. Most of the frames imported by Bangladesh since 1978 are of this type. The flyer speed of these machines is much higher than that of any of the previously introduced frames.

Analysis

This study focuses on three questions. To what extent has capital change been capital-intensive? How have economies of scale altered? Of what significance, if any, is learning by doing in this context?

To resolve these questions data were collected (as explained in the next section) from spinning mills in Bangladesh in 1981 and used to make estimates of Cobb-Douglas production functions of the type

$$Q = AL^{\alpha} K^{\beta} \tag{1}$$

where Q = quantity of yarn output, K = quantity of capital, L = quantity of labour, A is a positive constant and α and β represent the elasticity of production in relation to labour and capital, respectively.

In competitive equilibrium the firm equates its marginal rate of technical substitution of the factors to the price ratio of the factors. Thus, equation (1) implies that, for a perfectly competitive firm, capital and labour are combined so that

$$\frac{w_L}{w_K} = \frac{\alpha K}{\beta L} \tag{2}$$

where w_L represents the price of labour and w_K that of capital.[7] It follows from equation (2) that the optimal value of K/L varies inversely with α/β if the ratio

[6] In 1977/78, the Government of Bangladesh allowed private enterprise in jute manufacturing for the first time after the emergence of the State of Bangladesh.

[7] See, for example, A. C. Chiang, *Fundamental Methods of Mathematical Economics* (New York, McGraw-Hill, 1967), pp. 373-374.

of the prices of the factors is constant. Other things being equal, the more a capital-intensive technology tends to be optimal for the firm, the higher is β/α.

Variations of α/β or β/α can be used to help measure the degree of capital-intensiveness of technological change. An upward movement in β/α indicates technological change with a capital-using bias, whereas a fall in this ratio indicates a change with a labour-using bias.

Variations in the ratio $\alpha/(\alpha + \beta)$, the proportion of total output attributed to labour divided by the proportion of total output attributed to labour and capital, can also be used (as has been done by Brown and Popkin)[8] as a measure of alterations in the relative importance of capital in contributing to output. Changes in the relative importance of capital in contributing to production may arise because of embodied technological change. Alternatively, one can use the ratio $\beta/(\alpha + \beta)$, the contribution of capital to total factor productivity, as an indicator of technological change. Alterations in α/β and in both of these ratios will be estimated for the Bangladesh jute spinning industry.

In addition, trends in returns to scale of operations, defined as the proportional change in output resulting from an equi-proportional change in the quantity of the factors used, can also be a useful indicator of the nature of technological change in an industry. Returns to scale given the Cobb-Douglas function in equation (1) are indicated by $(\alpha + \beta)$, the sum of the output elasticities of labour and capital.

To consider the possibilities of productivity changes due to learning by doing, particular attention will be paid to alterations in parameter A, the autonomous multiplicative factor in equation (1). The higher the value of A, other things being equal, the greater is the productivity of inputs. Given the same techniques, an upward trend in A over time could indicate the presence of learning by doing.[9] An increase in A leads to a parallel upward shift in the isoquant corresponding to any level of output if α and β are constant, and the logarithm form, shown in equation (3), is used.

To estimate equation (1) for Bangladesh jute spinning mills, the practice has been followed of using the natural logarithmic form of the equation, namely,

$$\ln Q = \ln A + \alpha \ln L + \beta \ln K \qquad (3)$$

The collected data were fitted to this equation by the least squares regression method, thereby enabling A, α and β to be estimated.

The source of the data (a survey) and data used

The data for this estimation were obtained for 57 out of the 84 spinning mills (77 nationalized and 7 privately owned) in Bangladesh through direct interviews by one of the authors, M. G. Kibria, during March-July, 1981. The

[8] M. Brown and J. Popkin, "Measure of technological change and returns to scale", *The Review of Economics and Statistics*, vol. 11, 1962, pp. 402-411.

[9] But A may also alter for other reasons as discussed in this paper. For further information and references on learning by doing in production, see, for example, D. A. Hay and D. J. Morris, *Industrial Economics: Theory and Evidence* (Oxford, Oxford University Press, 1979), pp. 48-50.

survey included 22 mills in the Dacca zone, 14 in the Chittagong area and 21 in the Khulna zone. Care was taken to ensure that the sample, a large one, was representative: mills of all sizes and from all zones were represented in it. The mills surveyed accounted for just under two thirds of all the spindles in the Bangladesh jute spinning industry. Together the surveyed mills accounted for 230,580 spindles (37,680 for heavy yarn and 192,900 for light yarn manufacture) out of the industry's total of 385,140 spindles (55,840 for the manufacture of heavy yarn and 329,300 for light yarn manufacture).

Data were collected mostly by direct examination of the records of individual mills and from interviews with key personnel. Individuals interviewed in the mills included project heads, production managers, quality control officers, accounting officers, statisticians, shift supervisors, spinning sardars (foremen) and some spinners.

Data were also provided by the Ministry of Jute, the Bangladesh Jute Mills Corporation, and the Jute Research Institute.

For each mill surveyed the following data were assembled for each year since its foundation: its annual output of yarn measured in tons (weight), the number of spindles used each year, and the annual total number of hours for which all spinners were employed. These data were used to make various estimates of production functions of the type indicated in equation (1). Q was represented by annual jute yarn output in tons, K by the number of operating spindles in a year and L by thousands of labour hours used in spinning. The rationale for using these measures is discussed in the next section.

Organizing the data for estimation purposes

Physical data were collected because of their ready availability and to avoid indexation problems inherent in monetary data,[10] a not unreasonable approach because of the homogeneity within the jute spinning industry. Spinning mills established in similar periods have adopted almost identical machinery so that the number of spindles employed by a mill is a useful index of the amount of capital employed by it. The quantity of all capital employed is assumed to vary proportionately with the total number of spindles used. Only the annual hours of labour (in thousands) of spinners are used to measure labour input. This is reasonable if the quantity of all other labour employed varies proportionately or almost so with the number of hours worked by spinners. The use of any other variable inputs such as raw jute input is implicitly assumed to vary proportionately with the total output of yarn.

Even the cursory outline of technological change in the jute spinning industry given above indicates that input-output relationships are heavily influenced by the vintage[11] of the type of technology embodied in spinning frames. The production functions corresponding to different spinning technologies need to be estimated separately.

[10] For a full discussion and justification of the use of physical data in production functions, see M. D. Intriligator, *Econometric Models, Techniques and Applications* (Amsterdam, North-Holland Publishing Company, 1978), section 8.3.

[11] For some discussion of vintages, see W. E. G. Salter, *Productivity and Technical Change* (Cambridge, Cambridge University Press, 1969).

As outlined in the first section, different types of spinning frames were adopted in Bangladesh in four distinct periods: 1954/55-1961/62, 1962/63-1969/70, 1970/71-1977/78 and 1978/79-1979/80, which are identified as periods A, B, C and D, respectively. Depending upon when it was established, each mill is assigned to A, B, C or D, which indicates the vintage of its spinning frames. The periods below refer to the financial years (July to June).

Production functions were estimated for vintage A mills for 1954/55-1961/62 using cross-sectional data, namely, the average annual output of each mill in this period (for the time it operated), its average number of operating spindles and its average hours of labour used in spinning. This exercise was then repeated for these A group mills for the periods 1962/63-1969/70, 1970/71-1977/78 and 1978/79-1979/80. A similar exercise was undertaken for group B mills for the periods 1962/63-1969/70, 1970/71-1977/78 and 1978/79-1979/80; for group C mills for 1970/71-1977/78 and 1978/79-1979/80; and group D mills for 1978/79-1979/80. Table 1 identifies the 10 possibilities. The first script identifies the vintage of the plant and the second script the period for which the production function is being estimated.

Table 1. Classification of spinning mills by period in which established (vintage A, B, C, D) and period in which operated (0, 1, 2, 3)

	Vintage			
Period of operation	*(A)*	*(B)*	*(C)*	*(D)*
1954/55-1961/62 (0)	A0			
1962/63-1969/70 (1)	A1	B0		
1970/71-1977/78 (2)	A2	B1	C0	
1978/79-1979/80 (3)	A3	B2	C1	D0

Production realtionships for heavy yarn were also separated from those for light yarn so that distinct production functions could be estimated for light and heavy yarn.

Changes in production functions between groups A, B, C and D may be ascribable to the adoption of new spinning machines incorporating changed technology, whereas changes in production functions that occur within groups (for example, from A0 to A1, to A2 and A2 to A3) may be ascribed to learning by doing or similar time-dependent influences.

The estimates

Estimates for the production function for the vintages and periods set out in table 1 are given in table 2 for heavy yarn and in table 3 for light yarn. As mentioned earlier, least squares linear regression was used to estimate the parameters in equation (3). However, no estimates have been given for heavy yarn production for vintages C or D because the sample for 1970/71-1977/78 and 1978/79-1979/80 is too small. Only two of the mills established in the period 1970/71-1977/78 produced heavy yarn (most of those established produced light yarn) and in the period 1978/79-1979/80 no mills were established to produce heavy yarn.

Interpretation of the estimates

The estimates need in part to be interpreted against political changes in Bangladesh that have affected the jute industry. The period 1954/55-1961/62 was relatively stable from a political viewpoint, and the second period, 1962/63-1969/70 was very stable. However, the period 1970/71-1977/78 saw a great amount of political instability. Political unrest occurred in 1971 and was followed by the war of liberation from Pakistan. In 1972, with the emergence of the new State of Bangladesh, the whole of the jute manufacturing industry was nationalized. Nationalization led to initial problems in organizing the industry

Table 2. Regression results: heavy yarn

Group	A	α	β	$\alpha+\beta$	β/α	$\frac{\alpha}{\alpha+\beta}$	$\frac{\beta}{\alpha+\beta}$	R^2	F-ratio
A0	1.798	0.273	0.651	0.924	2.385	0.295	0.705	0.986	516.514[a]
		(0.059)	(0.066)						
		4.635[a]	9.852[a]						
A1	1.895	0.223	0.681	0.904	3.054	0.247	0.753	0.970	238.782[a]
		(0.084)	(0.093)						
		2.65[b]	7.335[a]						
A2	1.833	0.293	0.626	0.919	2.137	0.319	0.681	0.978	338.621[a]
		(0.084)	(0.094)						
		3.484[a]	6.634[a]						
A3	1.871	0.273	0.672	0.945	2.462	0.289	0.711	0.976	303.998[a]
		(0.078)	(0.086)						
		3.49[a]	7.793[a]						
B0	1.914	0.195	0.739	0.934	3.79	0.209	0.791	0.938	121.025[a]
		(0.082)	(0.108)						
		2.394[b]	6.859[a]						
B1	1.818	0.236	0.665	0.901	2.818	0.262	0.738	0.889	64.19[a]
		(0.108)	(0.145)						
		2.186[b]	4.594[a]						
B2	1.858	0.211	0.714	0.925	3.384	0.228	0.772	0.943	131.442[a]
		(0.074)	(0.098)						
		2.864[b]	7.291[a]						

Note: The figures in parentheses are the standard errors, below which appear the corresponding *t*-values.

[a] 1 per cent level of significance.

[b] 5 per cent level of significance.

because many managers and skilled workers left the country (to Pakistan), new and not infrequently inexperienced administrators were appointed to some mills, and trade unionism grew in strength and disrupted jute manufacture.[12] By 1978/79-1979/80 there appears to have been a return to (political) stability from the viewpoint of the industry.

Table 3. Regression results: light yarn

Group	A	α	β	$\alpha+\beta$	β/α	$\frac{\alpha}{\alpha+\beta}$	$\frac{\beta}{\alpha+\beta}$	R^2	F-ratio
A0	0.777	0.324 (0.075) 4.338[a]	0.641 (0.093) 6.915[a]	0.965	1.978	0.336	0.664	0.967	221.195[a]
A1	0.879	0.292 (0.088) 3.339[a]	0.673 (0.109) 6.198[a]	0.965	2.305	0.303	0.697	0.955	160.73[a]
A2	0.772	0.351 (0.067) 5.269[a]	0.606 (0.083) 7.34[a]	0.957	1.726	0.367	0.633	0.974	279.133[a]
A3	0.841	0.335 (0.067) 5.009[a]	0.629 (0.083) 7.613[a]	0.964	1.878	0.348	0.652	0.974	278.854[a]
B0	0.891	0.197 (0.073) 2.709[b]	0.764 (0.065) 11.799[a]	0.961	3.878	0.205	0.795	0.948	173.608[a]
B1	0.814	0.244 (0.101) 2.406[b]	0.71 (0.077) 9.256[a]	0.954	2.91	0.256	0.744	0.909	95.12[a]
B2	0.865	0.215 (0.11) 1.951	0.782 (0.083) 9.377[a]	0.997	3.637	0.216	0.784	0.908	93.626[a]
C0	0.923	0.164 (0.181) 0.908	0.825 (0.258) 3.2[b]	0.989	5.03	0.166	0.834	0.821	20.647[a]
C1	0.976	0.114 (0.098) 1.167	0.846 (0.137) 6.182[a]	0.960	7.421	0.119	0.881	0.937	66.905[a]
D0	1.062	0.094 (0.059) 1.591	0.858 (0.164) 5.225[b]	0.952	9.128	0.099	0.901	0.969	30.914[b]

Note: The figures in parentheses are the standard errors, below which appear the corresponding *t*-values.

[a] 1 per cent level of significance.

[b] 5 per cent level of significance.

[12] For further background on historical developments, see Q. K. Ahmad, *The Jute Manufacturing Industry of Bangladesh, 1947-74*, unpublished Ph.D. thesis, University of London, 1976; and International Bank for Reconstruction and Development, *Production in Bangladesh*. The World Jute Economy (Washington, D.C., International Development Agency, 1973), vol. 2.

It would obviously be incorrect to compare the performance figures for 1962/63-1969/70 and 1970/71-1977/78 at face value. Group A2 and its chronological equivalents, B1 and C0, might be expected to show lower productivity (for 1970/71-1977/78) because of political instability and independently of any changes arising from the adoption of new technology, or learning by doing that might have otherwise continued during the period. Thus, the results need to be interpreted with that in mind.

It may be noted that equation (3) provides a good fit to the data in terms of R^2. All the R^2-values are high. The F-ratios enable us to reject the null hypothesis at either the 1 and 5 per cent significance level, and the t-values indicate that we can have a high degree of confidence in the parameter estimates.

Variations in coefficient A and learning by doing

The multiplicative factor A in the Cobb-Douglas production function tended to rise in the selected period following the introduction of new vintage machines, except when the period coincided with the liberation war, nationalization and managerial dislocation. Take heavy yarn: the A-value corresponding to vintage A machines or mills is 1.798 in period 0, rises to 1.895 in period 1, but falls to 1.833 in period 2 (which coincides with the war of liberation and other disruptions), rises slightly again in period 3 to 1.871 but does not return to its highest level achieved in period 1. In the case of vintage B mills, the A-value is 1.914 in the initial period, falls in period 2 to 1.818 and recovers to 1.858 in the next period but does not reach its initial maximum value.

Similar trends in A-values can be observed for light yarn manufacture. However, now there is also some evidence for A-vintage mills or machines. In the initial period, the A-value for A-vintage mills is 0.777 and rises to 0.879 in the subsequent period.

Taking account of the period of the liberation war and associated distubances, the results are consistent with an A-value that rises at first and then declines. In the absence of disturbing factors, the A-value appears to peak in the period following the initial introduction of a new vintage and then to decline. It appears to be a unimodal function of the time for which a vintage or set of machines has been used.

The initial rise in A may reflect the contribution to output that comes as a result of learning by doing. The subsequent decline in A may reflect the fact that the machines are losing efficiency due to wear and tear and/or that some skilled management is being attracted to newer mills with more modern machines.

Changes in capital-intensity and the contribution of capital to production

The capital-intensity of both heavy and light yarn production as indicated by β/α has tended to rise in time. So also has the share of capital in total production due to labour and capital (as determined on a marginal productivity basis), that is $\beta/(\alpha + \beta)$. This is so if trends in the production functions based on new vintages of spinning frames are considered.

In heavy yarn production, β/a is higher for the initial use of vintage B machines compared with the initial use of vintage A machines. In the former case the ratio is 3.799 compared with 2.385 in the latter case. This comparative position, however, is not maintained for the second period of use of these machines, something it may be appropriate to ignore because of the disturbing influence of the war of liberation. The third period of use once again indicates that vintage B is the more capital-intensive technique.

For light yarn production, during the initial phase of production using a new technique, β/a is greater the later the vintage of the spinning frame is. Thus, it is 1.978 for A-vintage, 3.878 for B-vintage, 5.03 for C-vintage and 9.128 for D-vintage. Capital-intensity rises with the adoption of later techniques. Comparisons of later phases of use of the same techniques tend to confirm this if allowance is made for the disruptive period containing the war of liberation.

Capital's proportionate contribution to the share of total output (explained by the marginal productivity of labour and capital) has tended to rise with the adoption of machines of later vintage. For heavy yarn and for A-vintage machines, $\beta/(a+\beta) = 0.705$ for the initial period, whereas for B-vintage machines the corresponding value is 0.791. Comparison of the other phases is complicated by the war of liberation. As for light yarn, the proportionate share contributed by capital in the initial period of its use rises consistently with the vintage of machines. The ratio $\beta/(a+\beta)$ for A, B, C and D vintage mills is, respectively, 0.664, 0.795, 0.834 and 0.901. Allowing for the implications of disruption caused by the war of liberation, an upward trend in $\beta/(a+\beta)$ is also present for later techniques when other phases of use are compared between vintages.

Within vintages there seems to be a tendency for $\beta/(a+\beta)$ first to rise with time and then to fall. In the absence of political disruption, this ratio tends to be higher for each vintage in the second period than in the first period of use and then appears to decline. The pattern is therefore somewhat similar to that observed for coefficient A. The proportion of total output attributable to capital seems to rise at first with the installation of new machines and then decline. This implies that the proportion of output attributable to labour at first falls after a new machine is installed but that after a time the share due to labour begins to rise.

While this may reflect learning-by-doing relationships, it is also possible that machinery reaches its greatest efficiency in terms of reliability of operation in the second phase. In later phases of operation, much more care may need to be taken of machinery and more labour used to compensate for the declining technical efficiency of capital. Consequently, labour's share in production may rise once more.

A-vintage mills can be used to illustrate the tendency. In the case of heavy yarn, the proportion of output attributed to capital in the initial period is 0.705, rises to 0.753 in the next period, falls to 0.681 (a result influenced by the liberation war) and then goes to 0.711, and so it does not return to its peak. In light yarn the pattern is the same with the respective ratios being 0.664, 0.697, 0.633 and 0.652.

Economies of scale

For all the production functions estimated, $\alpha + \beta < 1$, so decreasing returns to scale prevail. However, decreasing returns to scale are not marked because although $\alpha + \beta < 1$, it is not greatly less than unity. Decreasing returns to scale are more marked in heavy than light yarn production. For heavy yarn production $\alpha + \beta$ tends to be in the range from 0.9 to 0.95, whereas in light yarn production it exceeds 0.95. There does not appear to have been marked changes in economies of scale in the jute spinning industry in Bangladesh during the period of the study.

Conclusions

There is evidence that the multiplicative contribution to jute output (indicated by coefficient A in the Cobb-Douglas function) rises for a new jute spinning mill (using new techniques) for some time after its establishment and then falls. This pattern may be explained by the combined influences of learning by doing, the eventually reduced efficiency of older machines and the possibility that some of the experienced managers may leave older mills to manage newer ones.

With the introduction of spinning frames incorporating newer techniques, the capital-intensity involved in the spinning of both heavy and light yarn in Bangladesh has tended to increase. Consequently, the labour-intensity of jute yarn production has tended to decline. This trend may be of concern to those who believe that labour-intensive techniques are more appropriate to developing countries than capital-intensive ones.

Furthermore, taking that level of total output attributable to labour and capital, the share attributable to capital has tended to rise in Bangladesh with the introduction of new spinning frames embodying new technology. By contrast, the share attributable to labour has tended to fall.

Economies of scale in the Bangladesh jute spinning industry appear to have altered little as a result of technological change. Although decreasing returns to scale occur, returns to scale are in fact close to constant.

Dualism and technological harmony for balanced development

*Gerard K. Boon**

Introduction

The objective of this paper is to explore the possibility of creating a two-tier industrial development pattern in the third world and the role technology should play in it. Such a development is aimed at reducing the dualism of these societies and therewith improving the fate of the vast majority of the population living outside the modern sector. Somewhat more in particular the possibility of a semi-urban, semi-modern industrialization in textiles is explored.

Although many scholars have examined various aspects of dualism (see bibliography) very few scholars have approached the question from the point of view of technology.

Economic, technological dualism

Third-world dualism

The term "dualism" was first coined by J. H. Boeke in writings before 1914, referring to the Dutch East Indies. Dualism in this paper refers to the generally observed fact that in developing countries at least two sectors can be observed: one using modern technology and organization and the other using simple labour-intensive technology and a more traditional organization.

In their desire to develop the expertise of the developed market economy countries, developing countries have welcomed experts and technology and various types of capital transfers from these countries, with the result that pockets of economic and industrial development have been established that may have more linkages with the developed world than with the country in which they are located. This dualism between a small modern sector, usually concentrated in and around a number of big cities, and the large remaining part of the country, which is virtually unaffected by this type of development, creates several undesirable imbalances.

One of the fundamental causes of this type of development is the lack of third-world mechanisms for internal development. The easiest and quickest way to develop, it was felt, was to use the human, physical and technological resources from those areas in the world that were developed. Since a clear

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conception of the development process was lacking initially, firms in the developed market economy countries had an opportunity to establish themselves in developing countries, and gradually economically and industrially developed islands were created which in those aspects were copies of the developed market economy countries. Although the developed islands expanded, they did not become a nucleus for a balanced development throughout the country. A trickle-down effect did not occur to any extent. One important reason is that technology from the developed market economy countries had to be chosen because there was no other source of supply. This technology, designed to serve those countries, was transferred to the third world by agents from those countries, for the use and control of companies in those countries operating in the third world, usually on the invitation or with the consent of the third-world authorities.

The capacity of the third world to absorb financial and human resources of this developed market economy development pattern is restricted. The cumulative effect of these investments in generating employment and a surplus is also limited. Therefore, the economic spin-off, the direct, the indirect, the cumulative and the external effects are too restricted to create the momentum for a dynamic development process. Such a process should have, little by little, affected the entire economy. However, most of the population has remained in a more traditional socio-economic structure, which stands in sharp contrast in almost every respect to the so-called modern, usually mostly urban part, of the economy. This imbalance creates tensions and may lead to social and political conflicts.

The "glamour" of the cities exerts a strong impulse on the poor, landless, rural workers to migrate, but they usually find their fate has worsened by doing so. Clearly, the third world has to reduce this internal dualism to a more acceptable level, and technology has an important role to play in this respect.

Potential dualism in the developed market economy countries

If countries in the third world have realized that the development strategy followed has not yielded the desired effects, the developed market economy countries also have some doubts about their strategy. Economic growth in the developed world is sharply lower than it used to be and even negative. It is not certain that a return to substantial higher economic growth is possible or even desirable. Therefore, developed countries have problems in realizing adequate employment levels. Further, labour wants satisfying employment.

To realize an acceptable level of employment, it may be necessary to stimulate the growth of a certain dualistic structure in the economy and in society at large. The latest, most efficient technology would be applied in a high-growth, surplus-generating sector, encompassing industry, services and agriculture. This sector would offer employment to only a few highly skilled workers and professionals. A decentralized, semi-formal type of sector would absorb the bulk of the working population. In this sector, the focus would be on human creativity and not on productivity. As a matter of fact, the national income and product generated by the modern sector should be such that, by means of transfer payments, a base income could be provided to all. This base income could be supplemented by additional income, earned either in the formal sector or in the semi-formal and informal sectors.

The developed and the developing worlds are interlinked in many ways. Most third-world countries before 1950 were subordinated to the developed world, politically and economically. Although these countries are politically independent now, a considerable economic dependence, but therefore also political, still exists. At the same time the developed world is dependent on the third world, and surely interdependence always gives a better base for a relationship on mutual advantageous terms than dependence. In the field of technology, however, mainly a one-way avenue prevails, and the dependence of the third world in technological matters is very strong. This implies largely that the available technology in the world is developed-market economy technology, while in certain technology types, the centrally planned economy countries are international suppliers. Little by little the newly industrializing countries, the industrially most advanced countries of the third world, have also become producers and exporters of the less complex and sophisticated types of technology. In other words, for the modern sector there is, speaking in general and global terms, only one technology in the world, and it originates in the economically and techologically dominant area of the developed market economy countries. If the acquisition of this technology is one of the important causes of a type of development in the third world judged to be highly undesirable because it creates economic, social and political problems for the large majority of the population, a few fundamental questions are in place. These are:

> Can a technology be conceived that is better able to ensure that the development aims and needs of the third world shall be fulfilled?
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> Does this technology have the potential to reduce the pronounced dualism characteristic of the economies of the third world?
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> Is it necessary to split technology in the world, that is, to create a third-world technology distinct from the technology originating in the developed market economy countries?

In the course of this paper, an attempt will be made to answer these questions. But one must be realistic. One cannot strike away the industrial development that has already taken place in the third world and which in certain countries stretches over a period of 30-40 years. In other words, the modern industrial sector in developing countries is a reality. This sector is mainly dependent on developed market economy technology, and in the future this dependence will largely continue, although it is not in all cases a necessity but a policy option. By the time production installations have to be replaced in the modern sector, one may choose a domestically manufactured technology, although such technologies are often produced under licence and therefore foreign in origin also. In any case it is safe to assume that, directly or indirectly, developed market economy technology will be dominant in most of the modern sectors in the third world for many years to come.

Trade in technology

The developed market economies have among other things, a comparative advantage in producing equipment and machinery with a high-technology content, a complex and special type of output. They can hardly produce the more simple alternative techniques any more on a profitable basis because it is too costly, and therefore they lose their comparative production advantage. The interesting point, however, is that these countries are not losing their comparative production advantage to third-world competitors, but to their own superior technological alternatives, in which they do have a comparative production advantage. The main reason is that manufacturing machinery of good quality, even if it is simple, needs highly skilled labour for its production. Therefore, relative to the price of equipment with a high-technology content, which is mainly set by the technology and not by the labour and capital inputs, it is too costly to produce the machinery. By continuing to use the more simple production techniques in the developed market economy countries, costs and prices increase, which means that the economic difference between the simple and sophisticated alternative techniques may largely fade away. The simple technological version is pushed into obsolescence prematurely and ceases to be an economically viable alternative.

In the context of this discussion it is worthwhile to introduce the concept of "geo-technology". A geo-technology is defined as a technology in the production of which an area has a comparative advantage and is also the most appropriate technology to apply in that area. In general terms, the equipment and machinery with a high-technology content is the geo-technology of the developed market economies; the more simple lower-technology machinery and equipment is the geo-technology of the third world. The latter technology, although technologically speaking simple, more labour-intensive, less capital-intensive in its use, nevertheless is not necessarily a simple technology to produce because it often requires high-precision production and accurate assemblying. Often these prerequisites are the result of a long tradition of precision mechanical engineering and skill accumulation, and therefore reality shows that although, theoretically speaking, on the basis of its simplicity and labour-intensity in production it ought to be the geo-technology of the third world, so far that has not materialized on a sufficient scale.

Nevertheless, little by little, the third world is going to produce its geo-technology. Certain specialized inputs, particularly related to skills, are not sufficiently available and therefore have blocked the materialization of a logical division of labour in technology production. Other inputs and their relative prices, however, do make this third-world technology production economically highly attractive, and for political reasons almost a necessity. On the basis of well-planned technical assistance the bottle-neck in this development may be gradually lifted, and the third world's geo-technology production will become a fact.

A third-world-designed-and-produced semi-urban and rural technology intended to start up the development of the stagnant areas in the third world may, possibly, have meaning for the informal labour-absorbing sector of the developed market economy countries also. If in these countries a small-scale, decentralized dual industrial pattern and informal, creative activities where excess labour can be engaged meaningfully are considered desirable, it needs a technology close to the geo-technology of the third world. Thus, in addition to supplying its own geo-technological needs, the third world could in the future well find that its technology is a desirable product in the developed world also.

In this view of global technology three classes of production techniques and know-how are found: the sophisticated and high-technology techniques, low-to-medium technology techniques and the manual techniques. The first class is the geo-technology of the developed market economy countries and therefore they will be the major supply source for this technology; the second and third classes of technology can be considered the third-world geo-technology classes, with the second category particularly suitable for the newly industrializing countries. Therefore these countries will become the major supply source of this class of technology. For the third category, the other third-world countries will become the suppliers, or at least a source of inspiration. Hence, international trade in technology could develop, and to some extent is already developing, on the basis of comparative production costs of these major classes of technology. This vision is based on a future global technological harmony in contrast to the alternative possibility of conflict and confrontation in technological matters. It also implies international trade in technology and in that sense integration, on the basis of interdependency, reducing a previous basic but dangerous situation of technological dependence for the third world.

To make the picture complete, final-commodity trade must be examined. In theory, final-output trade is an alternative to the movement of the production factors. One may well argue that from a purely economic viewpoint the final output of the high-technology content sectors ought to be produced by the area having a comparative advantage in its production and if tradeable be internationally traded for the final output produced by the low-technology content sectors. This solution, however, is for economic and political reasons less acceptable to the third world. Many countries in this group want to establish a certain capability in the final-output production of the high-technology sectors for economic, strategic and political reasons. Therefore, the movement of production factors, which may substitute for international trade of final outputs, particularly in this context of technology, which ought to be conceived as a production factor, is more acceptable. This implies a certain continuing technological dependence, but in the vision presented here essentially in the future, little by little, it will concern interdependence in technology.

Besides, the theory is not based on absolute production advantages, but rather on relative ones. Nevertheless, also in the production of high-technology-content equipment, the newly industrializing countries will try to establish a certain production capability, not for economic and trade reasons but rather for strategic reasons.

Reality differs, of course, considerably from theory. This reality creates all kinds of imperfections; and therefore the theoretical optimum in the international division of labour in the production and trade of final outputs, including technology, will never be reached. This, however, is rather an advantage as it may imply a greater trade diversity in the sense of a combination of international commodity and technology trade.

Choice of technology and economic sector

Classifications of technology

In the previous section, technology was roughly divided into three classes—sophisticated technology, simple mechanized technology and manual technology. Is such a division indeed meaningful? Concentrating mainly on the first two classes, there are obviously many more possibilities of classifying technology. Another classification distinguishes between monopolized technology and freely available technology, in which as a criterion the accessibility and the market or tradeability of the technology is used. Monopolized technology, monopolized in various degrees, is the technology offered by the transnational companies. A third technology, meaningful to this discussion, is flow, or continuous, process technology and discrete, or discontinuous, process technology, which is based on the nature of the production process. The outputs in the continuous-process technology concern liquids, gases or currents; the input, the throughput and the output are carefully controlled by hardware and now microelectronics, but are not physically discrete. These industrial processes are highly capital-intensive and characterized by economies of scale. The discrete, or discontinuous, production processes yield concrete outputs, parts, often produced by individual machines or groups of machines, which are assembled into larger units, subassemblies, which in turn may again be assembled to end-products. Examples are metal products, including the machinery industry, but also the manufacture of most household durable goods, woodworking, the confection industry and several other industrial activities. Certain industries are partly flow, partly discrete in several gradations.

There are other possibilities of classifying technology, but for the present discussion the three classifications introduced are sufficient. These use the following criteria: the degree of technological sophistication, the accessibility or marketability of the technology, and the nature of the production process.

The economy in the developing countries is divided into the modern sector, the semi-urban, or semi-modern, and the rural, or semi-traditional sector. Clearly, for the semi-urban and semi-traditional sectors, a more simple technology would be applicable. However, the fundamental question is, which sectors are or should be modern and which can be semi-modern and semi-traditional? To answer this question, other questions must be asked—which industrial activities can be, from an economic viewpoint, fruitfully decentralized and which are the relevant criteria in this decision? As far as the development of the rural areas is concerned, various options exist. One may think of huge agricultural communes or co-operatives, which have complementary industrial activities, to process the agricultural products and to produce certain commodities for consumption and investment for these, to a certain extent, self-contained units. Such a development pattern also affects the interrelation with the modern and semi-modern sector, and the criterion of economic efficiency does not have to adhere to private economic considerations.

A very important criterion for decentralization is whether the unit cost price is affected by producing on a smaller scale. This depends largely on whether the technology available has scale effects. Scale effects may be distinguished for capital, labour and overhead. Scale effects happen if by applying larger productive indivisibilities and hence investments, e.g., the capital requirements per unit of output, decline more than proportional to the relative investment requirements. Generally, one may state that in all industrial processes where important economies of scale occur, decentralization is from a private-economic point of view less attractive. Also a well known constraint to decentralization is the transport costs of outputs, inputs or both.

The scale phenomenon is believed to be a central consideration in determining whether an economic sector can be decentralized. Therefore, another classification is introduced, based on the scale effect potential of the production technology of economic sectors. Consequently, economic sectors are classified as capacity-choice sectors and technology-choice sectors.[1]

In the capacity-choice sectors, a technology is applied that is available in various output capacities all applying essentially an identical technology. Therefore, the choice concerns the productive capacity of identical technologies and identical production processes. Normally, economies of scale are involved; and higher capacities yield, when fully utilized, lower cost per unit of output than smaller capacities. Given this characteristic of these sectors, they qualify generally for centralization, although there is a trade-off between the increased transport costs of inputs and outputs and the reduction of unit production costs caused by the centralization of production. Even when transport costs are heavy, a certain centralization in the capacity-choice sectors is still possible. The technology used in the capacity-choice sectors is of the continuous process, flow type; usually it concerns the more capital-intensive technologies that often are produced, supplied and controlled by transnational companies.

In the technology-choice sectors, a choice among alternative production techniques, each with distinct factor proportions, exists. Therefore, these sectors particularly qualify for decentralization. Further aspects should be mentioned. In the technology-choice sectors, which apply a discrete, discontinuous type of technology, production indivisibilities do play a role also, and therefore the scale phenomenon, although less pronounced, happens here, too. Further, complementary considerations may be involved in the choice of technique such as the quality of the output, which among the various alternatives may differ, and the skill and interface input requirements, which usually differ also. The interface requirements refer to the dependence of the normal functioning of the technology on precise standards, for the complementary conditions and inputs such as raw materials, the humidity and heat conditioning of the air, the internal product routing and the general planning of the internal production process.

In these technology-choice sectors, the available discrete technology can be classified into the two groups mentioned earlier: the sophisticated and the relatively simple, or conventional, technology. The sophisticated technology, as a general rule, is used less in the third world; not only is it capital-intensive and labour-saving, but it also is demanding on human skills, particularly for repair, maintenance, internal planning and management and on other conditions. However, in the simple, conventional technology also a choice remains to be

[1]G. K. Boon, "Small-scale industry its appropriate place in the industrial framework", World Symposium on Industrialization, Athens, 1967; summarized in *Industrialization and Productivity*, Bulletin No. 14 (United Nations publication), 1969.

made. Economically important criteria in this choice then are the capital-labour substitution possibilities, the relevance of economies of scale and the quality-output differences among the production techniques. Also in this case the transport costs of inputs and outputs may limit decentralization. The relevant economic sectors that apply discrete, discontinuous technologies in which an ample choice exists and that definitively belong to the technology-choice sectors are the following: woodworking, metalworking, leather-working, footwear manufacturing, spinning, weaving, apparel and construction materials, to mention a few important ones. It concerns the economic sectors where industrialization started, where human transformation processes have happened for thousands of years and which all are related to consumer durables for basic needs.

Evaluation of technology

So far, some qualitative criteria have been mentioned to choose sectors and technologies that may foster centralized or decentralized industrialization. Naturally, a discussion of further quantitative methods and analyses to assess the various technological and sectoral alternatives is helpful. In this paper, it cannot be done in any detail. As far as technological evaluation is concerned, in addition to the methods commonly known and applied, a simple quantitative method can be applied to data aggregation at various levels: production tasks, products, factories and projects.[2] The method determines the least-cost technique for key parameter variations, for example, in physical characteristics of the output; in scale of production; in utilization levels; in capital, labour and technology prices; in labour efficiencies; in skill differences; or in any other quantifiable parameter. For all such parameters, sensitivity (S) analyses are run.

By applying an economic efficiency criterion, the preferred technology among the alternatives introduced shows up. The economic preference in the next stage can be enlarged to an appropriateness criterion. Finally, by means of a decomposition (D) method, it may be established which of the parameters introduced is most instrumental or decisive in the shift in technological preferences. This enables the classification of technologies according to their sensitivity to major parameters, considered crucial in the evaluation. Systematic information on alternative technologies and their sensitivity to key parameters would be extremely helpful in the decision on the suitability of the technological alternatives for decentralized application. An advantage of this method is that it can be centrally applied, say, in one place in the world. The method provides the relevant information on which choices of centralized or decentralized industrial application can be based. Besides, the information obtained is instrumental in determining the preferred technology for varying parameter combinations for all countries, i.e., for wherever such decisions have to be made. The only necessity is to include a complete range of alternative techniques and the relevant discrete parameter values on which the sensitivity analyses have to be run.

[2]G. K. Boon, *Technology and Sector Choice in Economic Development* (the Hague, Martinus Nijhoff, 1978).

The general validity is further enhanced by the fact that the method, although static in nature, becomes essentially dynamic, owing to the multiplicity of production circumstances, based on whatever parameter value combination one desires to know, which the model simulates. Because of this feature of the method, present as well as likely future production circumstances can be simulated in order to be able to make a deliberate choice of technique. Such a choice can be based on present or future exogenously determined market or accounting prices.

Obviously, the model can consider only the existing technology, but as soon as new technology becomes available, it may be fed into the computer model as well. Besides, the results of the method are helpful in evaluating product and technology adaptations both, while they also provide some insight when the design of an "alternative technology" would be desirable to make the choice spectrum more complete.

So far, all the aspects mentioned concern those that are quantifiable. Clearly, there are considerations in the choice of technology that are not quantifiable but nevertheless may have to be considered. Examples of these qualitative aspects are the contribution to the domestic technological capability that may differ from one technique to another, the contribution to the aims of self-reliance or to satisfying the basic needs of the populace. Although often these more qualitative considerations are hard to quantify, that does not mean that no quantitative methods can be applied in their assessment. It is quite possible to attach to these various considerations ranking numbers according to their importance. Such a numbering can be accomplished, for example, by a group of wise men on the basis of objective judgement. By means of the ranking numbers again a quantitative element is introduced, which therefore makes these aspects also subject to quantitative treatment.

Evaluation of economic sectors

In deciding which economic sectors are suitable for decentralization, evaluation methods based on input-output analyses are particularly helpful. The input-output tables make it possible to establish the forward and backward linkage effects by sector. Certain sectors have more linkages than other sectors, hence the forward and backward linkage effect of sectors among each other differs. The forward linkage effect can be measured as the ratio of the interindustry output of a sector to total output; the backward linkage effect is measured by expressing the sum of the intermediate inputs for each sector as a percentage of the total sectoral inputs. Hence, sectors can be ranked according to the importance of their forward and backward linkage effect. The five most important receiving or delivering sectors can be ranked further on the basis of the other criteria introduced. Particularly by applying the one of capacity-choice and technology-choice sectors, a further deepening of insight can be obtained in the decentralization potential of those sectors with a high linkage effect.

Indeed, if among the development aims is the reduction in the dualism of the economy, a strong interlinkage of the modern and rural part of the economy may be preferred. More important than the linkage effects based on the direct effects are the indirect effects. The indirect effects are caused by the interdependent relations in the economy. Although it is important to be informed about the direct increase in, for example, employment by means of a unit increase in final demand, it is of great interest to know also the indirect employment effect and its distribution among the various sectors. The indirect effect and the cumulated effect, the sum of the direct and indirect effects, can be obtained by inverting the matrix of technical coefficients, which is deducted from the identity matrix. The most important sectors according to their indirect effects can again be further ordered according to their decentralization potential. This combined insight is informative for the assessments of the indirect effects in case of decentralized industrialization. In case of planned semi-urban and rural industrial development, one has to be informed about these effects. A similar method, as described in the case of the evaluation of the qualitative aspects of a decision on technology, may be used to assess the qualitative sectoral considerations. Clearly, if one wants to fill in the concept of appropriate technology, the qualitative aspects in the technological and sectoral assessment may become more important.

A two-tier development strategy

Some vital questions

So far, it has been assumed that the available technology is a datum. The question of whether the technology available is appropriate to further the aim of semi-urban and rural development has not yet been discussed. It has been implied in the discussion that, given the objective of reducing the economic dualism in the economy, the emphasis must be on developing the less developed part of the economy rather than stopping the growth of the modern sector. One of the most important instruments in realizing this objective is the infusion of an appropriate technology. This semi-urban and rural technology is a third-world geo-technology that ought to be produced in the third world. A very important aspect that has so far not been illuminated is how this semi-urban and rural industrial development programme can be implemented, a crucial question.

So far, some classifications of sectors and technologies have been provided mainly according to their potential for decentralization. Further, an assessment procedure for technology and for sectors has been briefly described. However, an answer is needed to the question of whether a two-tier development design, as much as possible interlinked, is at all feasible. Hence, the following questions need to be reviewed:

(a) Is a two- or multiple-tier development of the economy at all possible?

(b) If such a possibility is believed to exist, what should this development design look like and how can it be implemented?

(c) Will appropriate technology for the semi-urban and rural sector have to be designed, or is it already available?

A two-level industrial development seems possible, but it is not automatically forthcoming. Only a few aspects of the first question will be briefly reviewed. If the starting point of the discussion is kept in mind, that is, a kind of capitalistic, free-market economy functions for final outputs and for the production factors, some type of balance between the sub-economies must exist. If wage and labour costs are substantially higher in the modern sector of the economy than in the traditional sectors, a constant incentive will exist to migrate from the rural areas to the modern centres.

Not only migration can be avoided by having a reasonable balance between income and living costs, practice shows that great discrepancies in educational, recreational and cultural facilities between urban and rural areas are a sufficient incentive for migration. Also, to induce the use of more simple, alternative techniques that are more labour-intensive, the cost of labour definitely has to be lower. If the Government has a system of minimum wages, distinct differences in the minimum wage level are needed, and the social legislation in force in the modern part of the economy, initially, cannot be made applicable to the rural areas without modifications. In other words, to pursue two-level economic development, two-level economic, social, institutional legislation may be needed. Such a double legislative structure may imply legal and organizational complications that cannot be fully judged by this author.

Also, the Government will have to supply a certain infrastructure. If indeed linkages between both the country's sub-economies are desired, there ought to be railroads or truck roads and not too many internal toll barriers, as sometimes is a common practice in developing countries. Educational facilities for the primary and secondary school, and in particular for vocational training, are necessary. In many developing countries, no vocational training facilities exist, not even in the modern sector.

Concepts and implementation

How the two-tier economic development design should be conceived and implemented is a big question. It is assumed throughout this paper that a market economy is in force in which the profit motive is a basic consideration. Therefore, the Government would like to bring the two-tier development scheme into motion by using this market mechanism and profit motive, by making certain signals stronger. By means of direct or indirect subsidies the attractiveness of organizing some type of production in a certain place can be greatly increased. If this is done, the opportunity may be taken up by local, that is, semi-urban or rural entrepreneurial talent, or by experienced and strong urban entrepreneurs. The urban entrepreneurial initiative may be purely domestic, but it may also be affiliated with transnational companies. Whatever the urban, entrepreneurial affiliation, it is used to order production around the technology of the developed market economy countries. Moreover, it is economically and financially strong and, speaking in general terms, has highly experienced personnel.

The interrelation and basic dependence between the modern and the semi-traditional sector within developing countries is similar to the relationship between the third world and the developed countries. In certain aspects, the internal dualistic differences are even more pronounced. This implies that urban, economic, financial and technological resources may easily dominate any industrial development in the semi-traditional sector, a dominance that may lead to dependence and to an imperialistic type of development. Since no political frontiers exist and the urban political élite also dominates the countryside politically and often is close to the business élite, it is almost unavoidable that rural development will be at the mercy of the urban centres.

Under such conditions the availability of a semi-urban, rural technology may hardly change the picture because it may not be applied. The problem is to implement an appropriate technology, which is essentially a political issue and therefore subject to the power realities between classes or groups in the country concerned.

In the capacity-choice sectors a basic capital-intensity prevails; the productivity of capital is positively correlated with the scale of output, the higher the latter the higher the former. This type of sector demands not only vast amounts of investments, but also technology, R and D and know-how in general. For these reasons, the capacity-choice sectors are more dominated by the big and powerful enterprises and therefore also more by transnational companies. Almost logically, the capacity-choice sectors are technology-dependent, centralized, modern sectors. However, since their potential for decentralization on the basis of the existing available technology is limited, these sectors, the enterprises operating in these sectors and the often strong affiliation of the economic powerful élite from these sectors with the political élite are no fundamental danger for the second-tier industrialization drive. The relevant economic sectors in this drive are the technology-choice sectors.

As the name suggests, in the technology-choice sectors a choice of technology is possible. Two sub-groups may be distinguished. In some sectors a rather wide difference in the capital-intensity among alternative techniques may be observed. In another group of sectors, the technical options vary less widely; all are labour-intensive. One may state that the degree of control in an economic-urban sense is higher the higher the potential capital-intensity of the technology-choice sectors is. For example, the economic control in the sense specified is higher for metalworking than for woodworking industries, higher for textile spinning than for apparel manufacturing, higher for plastic footwear than for leather footwear manufacturing. Therefore, in those technology-choice sectors with a wider spectrum of alternative techniques, the modern-sector powers have a stronger foothold and therefore will be greater competitors than in those sectors with a more limited variation in technology, all labour-intensive.

One may observe in certain developing countries that textile, apparel, wood and sometimes even metalworking and leather footwear manufacturing are all more dispersed economic activities, and, although some of these sectors certainly use developed-world technology and could be qualified as modern sectors, they are not located in the largest cities. In Mexico, for example, the big modern industrial centres are Mexico City, Monterrey and Guadalajara. However, textile manufacturing is strongly concentrated in Puebla, metalworking industries such as motorcar manufacturing in Queretero and Puebla, leather footwear manufacturing principally in Leon and Guanajuato. Although

Puebla, Queretero and Leon are urban centres, they are considerably smaller than Mexico's three big urban centres. There are few developing countries where the centralizing force of the big urban centres will be stronger than it is in Mexico. Nevertheless, the technology-choice sectors mentioned operate successfully in a more decentralized way.

National, international and transnational economic control does occur in the technology-choice sectors also, particularly in those sectors with a greater diversity in capital-intensity of the technology. In all developing countries motorcar manufacturing is dominated by automobile manufacturing, carried on by transnational companies; but also textile, woodworking and even apparel and footwear may be controlled by transnational companies. The need for transnational economic control in the technology-choice sectors differs greatly between sectors. In the manufacture of automobiles, a complex product, the need is by far greater than in apparel and footwear. Besides, third-world car manufacturing companies, fully or partly subordinated to foreign companies, often subcontract manufacturing activities to much smaller local firms, which are, legally at least, fully independent and domestic. Apparel and footwear are very much less complex products and the economic justification for foreign economic control is much less. There are, however, a few aspects that may explain why foreign economic control may exist in these sectors. Three important ones are exports, fashion and quality, all of which are interrelated. To export, more initiative is demanded of the entrepreneur, and a third-world entrepreneur may also lack familiarity with the appropriate channels. Exports may require different, not necessarily higher, qualities, different sizes, colours and packings. To be informed about fashion in time and of its change over time is essential when exporting apparel and footwear to developed countries.

Obviously, transnational companies have an enormous advantage in these aspects; and if they become established in these sectors in developing countries, they may become so dominant that local entrepreneurial initiative is suffocated. Such a situation may frustrate the second-tier economic development design. Still, it may be helpful to use the know-how of transnational companies to overcome export, quality and fashion barriers in case the country wants to compete in the international market. However, established alternative sources of such know-how may exist; if so, the transfer of technology from such sources must be carefully negotiated. The acquisition of know-how from sources other than transnational companies may be preferred. If one wants, however, to export by making use of particular trade marks, an affiliation with the transnational company bringing these trade marks is almost always a necessity.

However, for the domestic market the situation differs, and transnational companies are not essential in these manufacturing branches. Still, in developing economies there is demand by the affluent class of consumers for products with foreign specifications and qualities. Clearly, the income distribution influences the quality and quantity of the output mix and therefore of the technology mix. If a two-tier development is possible, the desire of the well-off group of the population to imitate the consumption pattern of the developed market economy countries should be checked. Such a desire, if not controlled, brings in all the famous trade marks of the developed countries in the output mix of the technology-choice sectors.

The physical characteristics of the output are a major determinant of the technological efficiency of the various alternative techniques. Thus, the choice of alternative products influences the choice of alternative techniques. Transnational companies, responsible for specific output mixes, fix the production technique further. Such a development, as is typical for several Latin American countries, diminishes severely the possibility of an industrial development outside the modern sector. Hence, the problem is that firms of the developed market economy countries bringing consumer products and qualities to be produced with techniques used in their countries and applying consumption-technology principles with which they are familiar become dominant also in sectors that are suitable economically and technologically for decentralization. The greater the dominance of the firms affiliated with the developed market economy countries the less the chances are for balanced two-tier industrial development.

One may argue that domestic firms, defined as firms without any type of foreign affiliation, have a chance to compete also. For example, by producing products for the population in both the modern and traditional sectors, they are free to locate their production in the rural areas. Indeed, this possibility exists and also can be observed in practice. However, two points should be mentioned:

(a) The consumption demonstration effect between groups of the population in one country also is strong;

(b) The competitive strength of domestic firms vis-à-vis firms with a foreign affiliation is stronger the more the domestic firms have received a chance to develop.

If foreign firms in the consumption-goods sector are allowed to enter the market, the danger of domination by these firms becomes less if the time of entrance is duly chosen with regard to the degree of development of the domestic firms. By means of a differentiated domestic policy relative to foreign affiliations, these latter can be made conducive to certain development objectives such as exports, efficiency in production and increased domestic technological capability. Further, if the foreign affiliated firms are permitted to produce only for export, these firms can exert little or no influence on the domestic market. Even in bond, manufacturing may occur, that is, technology and raw or intermediate products may enter free of tax, under the condition that the output produced is exported.

However, the ability of third-world countries to implement such a flexible and diversified policy in the face of powerful and experienced foreign firms requires already a certain level of economic and political independence. Such a level is usually the result of at least a generation, say, 30 years, of development, and therefore it is unrealistic to assume such an ability at the outset. Countries in the earlier stages of development may therefore be better off by rejecting applications for residence of firms with a foreign affiliation in the consumption-goods sectors. Instead, domestic firms should be upgraded by using the services of independent experts, which may also be requested through the United Nations system.

To sum up: basic to the success of a two-tier industrial development design is, first, selectivity in granting permission to firms of the developed market economy countries to enter the consumption-goods sector and in the technology-choice sectors, in general. Selectivity as to product type and to time of entrance may be required to give the semi-urban and rural development design a fair chance. Secondly, the minimum wage must differ substantially between the modern and the traditional sectors and the complementary labour and social legislation must also differ, which means that total labour costs between the two sectors should differ significantly. In the present discussion, modern and semi-traditional sectors are conceived as being geographically separated, which in reality is not always the case. Thirdly, infrastructural facilities, particularly educational, transport and recreational ones, are also a prerequisite. Part of the needed infrastructure is credit and extension facilities. To stimulate local initiative, certain incentives may be needed, which in the last instance affect the profitability. Although all these kinds of facilities are basic conditions, they do not yet explicitly determine the design of this type of rural industrial development. However, again as the market continues to have a major function, and the industrialization is largely confined to the technology-choice sectors, with restricted indivisibilities and scale effects, the most important step is to create the preconditions for two-tier development.

Further conditioning factors

Little by little, industrialization may start; again, it may not. In any case, a thorough understanding of the economic, sociological, anthropological and political local conditions is needed in the areas where it is hoped this type of industrialization will occur. What incentives do the people have? What is the economic power and income structure? Which classes, sub-classes, dominating families and, if relevant, racial differences can be distinguished? If no understanding of these facts and relations exists, no plan to induce some form of industrial takeoff can be formulated. Industrial development in the semi-traditional sector should fully consider existing realities so that new types of destructive dualism in that area will be avoided.

By studying carefully the structure of the traditional society one may conclude that the market as a principal allocation mechanism is, for some time, inappropriate. However, it is difficult to discuss in detail the design for the industrialization in the semi-urban and rural areas for the third world in general. As far as this author may judge, a market mechanism is normally feasible because it already exists for those products that this area produces and does not need introduction, but only widening.

Third-world technology: necessity and availability

Is there a need for a specifically designed third-world industrial technology? This question still needs to be discussed. As mentioned earlier, the technology-choice sectors are believed to be the suitable sectors for decentralization. The technical efficiency of the alternative techniques of this sector determines their appropriateness under certain conditions. The developed market economy countries have a technology available, but the more simple alternative techniques have become less and less profitable to produce. Production of these technologies by the third world is only slowly materializing, owing to some structural third-world obstacles.

Although Japan, the centrally planned economy countries and some developing countries with a substantial internal market have become production sources, there is a real danger that some quite useful, simple technologies may disappear from the market. If this happens, the choice of technology in the lower labour-intensive part of the spectrum is narrowed down. Therefore, the chance that an appropriate technology for the two-tier industrialization of the third world is obtainable is reduced. The question of which technology actually is available will be discussed next.

In most of the sectors mentioned, simple, small-capacity industrial equipment is available. Another category of simple equipment produced in the developed market economy countries has more recently become available. In these countries, because of the decreased work hours, the desire for creative, manual work in leisure time and the high cost of having things made by skilled workers, simple, electrically driven, sometimes even electronically controlled hand tools and small machinery are now mass-produced and consequently cheap. The difference between this type of equipment and the simple, semi-industrial and industrial equipment is often not large. Some intermediate design, the one for the non-professional hobbyist and the other for the small professional workshop, could possibly yield an appropriate production technique for the third-world second-layer industrialization drive. The equipment is not complex and not particularly skill-demanding. It can still be profitably produced in great quantities in the developed market economy countries, but could equally well be produced in the modern sector of the third world for application in the semi-modern sector. This would be true for simple woodworking and metalworking machinery.

In earthenware, tanning, footwear and simple textile processing, the traditional sector in many developing countries has been using indigenous techniques for a long time. Sometimes, experts are able, by relatively minor changes in this traditional technology, to introduce significant improvements in the efficiency of these production processes and in the quality of the output. Also, in fashioning copper, silver and gold ornaments and jewelery, a high level of craftmanship and know-how usually exists in the semi-modern and semi-traditional sectors, not to speak of handicrafts in wood, metal, stone, earthenware, textile and other raw materials. The very labour-intensive, handicraft cottage industry is a major source of creative work in many developing countries, which by all means should be stimulated and improved. Close to this activity is the manufacturing of toys, of labour-intensive apparel and textile specialities, which indeed are frequently occurring. The introduction of certain simple tools and machinery may enable rural cottage industry to grow into something more.

Essential to the healthy growth of these semi-urban and rural manufacturing activities is access to small amounts of credit on reasonable terms and the establishment of an intermediary system free of exploitation and abuse. The economic power of the cottage industry and of the small-scale manufacturing units is very weak; unfortunately, exploitation is common, which may be one of the principal reasons why further industrial growth on the basis of the existing facilities and structures has not been happening more than it has.

Indeed, all energy and talent in developing countries have been directed towards enlarging the modern sector. No sufficient effort has gone into the development of the major part of the country, which has usually been a powerless satellite, exploited by the modern sector.

Hence, simple low-technology-content hand tools and light equipment usually seem to be available, although a specific effort to design, on the basis of the latest know-how, a certain class of heavier equipment specifically to be used in the semi-urban industrialization drive would be useful. In the next section this question is further explored for textile technology in particular.

A point so far not explored in this paper is whether new technology particularly designed for and possibly by the third world can break through the various technology and sector classifications presented in this section. How likely is it that a technology for a capacity-choice sector can be designed that is not high technology or capital-intensive, that is not characterized by scale effects and that, therefore, would make this economic activity also suitable for semi-urban industrialization? Such possibilities exist, but they require much more research and development time and cost than the design of a specific semi-urban technology for those industrial activities that on the basis of the know-how are suitable for decentralized application.

New techniques in energy generation, in water generation and purification are suitable for decentralized application. Similar possibilities exist in synthetic fibre production and other chemical process industries. Most likely, research will show that possibilities for a technology suitable for decentralization exist in most production activities. However, the distance between a potentiality and reality can be so wide that it may be virtually impossible to bridge.

Semi-urban technology: textiles

To make the argumentation somewhat more concrete, in this section technological and policy aspects for a semi-urban textile industry in developing countries are explored. The basic question clearly is whether a semi-urban textile industry is needed and if it is economically justified. The answer depends very much on the local conditions in a country.

Available technology

The desired technology for a semi-urban textile industry should be modern; should be easy to operate, to maintain and to repair; and should be labour-intensive in all these aspects. The skills required in these operations should be easy to master. These features make the equipment suitable for decentralized application in areas where no textile production tradition exists.

The equipment should be of a somewhat intermediate quality; its overall technical lifetime could still be long if maintenance and repair services were carried out at the proper time. The equipment should have a restricted output versatility; specialization in output would be per firm. Reducing the output versatility simplifies the machinery; therefore output can be more cheaply produced. Automatic greasing and other automatic maintenance options should be eliminated. Although the equipment should have about the same level of mechanization and automation in its basic performance as the technology for the modern sector, all other automatic features should be eliminated. Optional choices, of reed width, for example, should be strictly limited. Even more simplified versions of the technology in certain areas of the world would be more appropriate to apply in the semi-urban sector. The reason is that the degree of development among third-world countries differs significantly, and certainly not just one type of production technique could be proclaimed the most appropriate one throughout this part of the world.

Once an idea of what the equipment should be has been arrived at, the available textile technology in the world should be reviewed to determine whether a semi-urban textile technology already exists or whether it has to be designed, manufactured and supplied. If it has to be designed, then the next question to be discussed is how this can be done.

As has already been pointed out, the manufacture of a semi-urban textile technology is not a profitable proposition for the technology suppliers of the developed market economy countries. Nevertheless, in this area some relatively simple modern equipment is supplied, which is excellent for application in the modern textile sector of the third world. Other supply sources are from the centrally planned economy countries and from China, India, Japan and more recently Brazil. In these areas textile technology of the developed market-economy countries is produced under licence, but technology is also manufactured indigenously. The technology produced under licence usually concerns "frozen" technology, that is, technology that is no longer produced in the developed market economy countries and has been replaced by a version with a higher technology content. For this reason, this technology is closer to a semi-urban textile technology than most of the technology produced in the developed market economy countries. The quality of this technology may be somewhat compromised, and it is produced in areas having lower labour costs. Although the price of this equipment is attractive, the equipment has some disadvantages; in particular, the after-sales service is often poor, but that is also true for indigenously produced equipment.

Not only is there a problem with the after-sales service but the diffusion of this equipment is hampered by inadequate marketing by the suppliers; although it is presumably available, in fact in most third-world areas it cannot be acquired.

R and D aspects

The conclusion must be that the developed market economy countries are not suppliers of simple modern equipment. The more simple models usually become a frozen technology that is licensed to the centrally planned economy countries, and third-world suppliers are not yet capable of operating an efficient world-wide dealer and service network. Another important factor is that the suppliers in the developed market economy countries enjoy such an excellent reputation that usually customers in the third world prefer this technology over the cheaper alternatives produced elsewhere. That is why other suppliers have difficulties in building up their marketing organizations. However, even if third-world-produced technology were an effective alternative, this technology may not be the appropriate type to use in the semi-urban sector. Older-vintage technology is not necessarily the best technology for developing areas. Conceivably, a technology making use of the latest know-how, but basically simple and labour-intensive and not complicated in its production, could be designed that might suit the semi-urban textile industrialization drive in developing countries much better.

No doubt, the third world has sufficient talent and expertise in textile technology to formulate design principles, to work out a blueprint of the various production techniques and to build the prototypes. To put such an idea into effect, one could organize public, regional research institutes or make use of existing ones. The R and D work on new technologies could be financed by a third-world research and development bank, to which each country, according to a certain formula, would contribute. This bank should be advised by a third-world appropriate technology unit that received R and D proposals from the various R and D institutes that could be organized around principal technology areas: textiles, metalworking, woodworking and so on. The appropriate technology unit should be combined with a technological data bank, which could evaluate the available technology in the way mentioned before. In this way also, insight would be obtained on the technology's usefulness for a semi-urban industrialization drive. Such an authentic, international institutional framework in the third world is entirely lacking.

Another avenue leading to the design of a semi-urban technology exists. This road should not necessarily be seen as a substitute but preferably as a complementary route; both roads may unite for part of the way.

Some noted technology designers and suppliers in the developed market-economy countries are, in principle, interested in designing a semi-urban textile technology, using their considerable reservoir of know-how and experience. They are, in principle, willing to assist in establishing local manufacturing facilities that could be situated at several geographically dispersed places in the third world.

Obviously, these technology producers, whose business is to design, manufacture and sell technology, have to be rewarded for this work on the basis of private, commercial practice. Their R and D work could be done on contract for a third party, but, although this is subject to negotiation, they would preferably hold title to any patents that would result. Also, in establishing manufacturing facilities in the third world, their services could be obtained through a technical assistance contract based on a consultancy fee. This possibility has some attractive aspects. Use is made of the best, most experienced, practical know-how available in the world. If the name of a well-known first-world technology producer in the developed market economy countries is linked to a certain machine design, it will be of great help in selling this technology, particularly in the third-world market economies.

Production, supply, application

On the basis of the geo-technology concept, technology to be designed or existing adapted technology should be produced in the third world. Although there are economies of scale in the production of machinery and therefore some decentralization is possible, certainly not every third-world country can produce its own textile technology.

The semi-urban textile technology should be commercially supplied by third-world manufacturers to neighbouring third-world countries and, possibly, on the basis of a common export promotion plan, be marketed in the developed market economy countries also.

At present, there is an enormous trade in textile goods, particularly from the developing countries and the centrally planned economy countries to the developed market economy countries, while technology flows almost exclusively from the developed market economy countries to the developing countries. The urban, modern textile industry in the developed market economy countries has a difficult time competing with third-world textile imports. Therefore, it is hard to see how a semi-urban technology, imported from the third world and applied in the sub-industrial sector in the developed market economy countries, could compete. Seemingly it is out of the question that wages in the sub-industrial sector would drastically be reduced; nevertheless, such possibilities exist. Also by means of product specification design, colour variety, quality and general speciality, such a sub-industrial textile and apparel activity may have a chance in the developed market economy countries in a semi-formal sector.

Certain measures influencing cost are conceivable, although at present non-existing. One can imagine a situation in which workers are willing to work a part of the day for a lower salary than is customary and also are willing to forgo the social security benefits. Unemployed and underemployed male and female workers could be allowed to receive supplementary social security income, for example, if they accept a lower wage rate. As the work is different from normal industrial work, implying a lower labour productivity, the remuneration may differ also. The output produced should have different characteristics and specifications and therefore not be a substitute for the output of the modern textile sector.

In this way labour costs could be reduced by 60-70 per cent. As was mentioned earlier in relation to the implementation and application of a semi-urban industrial technology in the third world, the condition that social security and labour legislation could not apply or at least should be differentiated is also valid for the two-tier industrial development of the developed market economy countries.

Although in this way employment in the developed market economy countries may increase, third-world textile exports may suffer and unemployment may increase. This possible increase in third-world textile unemployment may not be compensated for sufficiently by increased employment in the third-world textile machinery building industry. Besides, the third world is very large, and increases and decreases in employment in machinery building and textiles may happen in quite distinct places. Nevertheless, it is not yet fully certain that a development as discussed here may lead to a substantial decline in third-world textile imports to the developed market economy countries, since output specifications would be quite different. Certainly, some shifts in output mixes would occur, and possibly textiles would be less feasible for semi-modern production in the developed market economy countries than some other products, which, although labour-intensive, are less suitable for international trade, owing to their bulkiness, for example.

Concluding remarks and recommendations

A third-world institutional framework would help a two- and multiple-tier industrialization scheme to materialize. Such a framework at present is entirely lacking. The design of a semi-urban technology needs a common third-world research effort. Since such research is very expensive, a third-world research and development bank whose primary aim is to finance R and D relevant to the third world should be created. Such a bank should be independent of the existing international institutional framework. In general, a third-world international institutional framework is needed, independent of any other existing global framework. Third-world institutions can obviously collaborate with other international institutions but it is extremely important for third world countries to learn to work together, to try to formulate a common viewpoint, and to reach a consensus on major issues.

The appropriate technology unit mentioned earlier should handle the negotiations with the technology suppliers in the developed market economy countries. In textile technology, as in all freely available technology, the transfer may concern embodied and disembodied technology. The embodied technology concerns the machinery to produce the final output; the disembodied technology concerns know-how for operating, maintaining and repairing the machinery, but also for designing and building it. Suppliers are in an especially strong bargaining position regarding disembodied technology. The transfer of such technology usually takes place by means of a licence, a legal contract with a flexible content. Negotiating such licence agreements on technology by an agent acting on the behalf of the entire third world greatly improves the possibility for the third world to obtain favourable terms. The agent acting for the third world can then, according to some agreed-upon procedure, co-ordinate the manufacturing of this technology at various places in the third world. Although the suppliers in the developed market economy countries will resent somewhat their loss in power in negotiating with a strong, central agent instead of a weak individual customer, they will like the higher sales volume to which their royalty is related.

Before the technology is used, it has to be acquired. If a market mechanism operates, something, including technology, will be bought if it is attractive. At a semi-urban level, a certain technology may be attractive if it is supplied on favourable terms, particularly regarding price and credit for its purchase. A more fundamental requirement in a market-regulated sub-economy, however, is the economic efficiency of the technology. The semi-urban technology will be simple, labour-intensive and therefore, to make its application technically efficient, the labour costs in the areas where it is intended to be used, have to be lower than in the modern sector, where technology from the developed market economy countries is applied.

The labour cost is composed of two elements—wage costs and social security and other related implied costs. A realistic, but politically difficult, solution would be to have no minimum wage, social security and labour law regulations in force outside the modern sector. The cost of labour in this part of the economy would be set completely by supply and demand. In the beginning of the industrialization, owing to labour's weak position, workers would be exploited. Nevertheless, their position would improve, since they at least would find employment and receive an income, while previously they were not employed and received no income. The lack of any binding minimum wage would make a semi-urban industrialization feasible under a market mechanism. This exploitation of labour is not unfair or even inhuman, although it may be [illegible] as such from the point of view of the developed market economy countries and from labour employed in the modern sector of developing countries. If, indeed, workers were able to find employment in the semi-urban industrial sector the economic situation of labour would be considerably better than its position before. Therefore, labour would not be discontent. Moreover, this situation would be only temporary, for, as soon as that part of the economy could afford it, the prevailing socio-economic legislation would apply there also.

For political and practical reasons, it might not be possible to have, for some time, a two-track socio-economic legislation, that is, one track for the modern sector, with an official minimum wage, labour and social security laws in force, and another with more rudimentary laws, or no laws at all, on those matters for that part of the economy where the second-tier industrial and agricultural development effort was launched. If two distinct economics in this sense are not feasible, one could officially have in force one set of socio-economic laws for the whole country. However, outside the modern sector the socio-economic legislation would be ineffective and not enforceable.

Another possibility would be to have one set of socio-economic laws and to subsidize the cost of labour to the entrepreneur. In this case, indeed, labour might receive a higher wage than the market wage in labour-abundant developing countries. The market wages in the semi-urban areas would be below the minimum wage of the modern sector and even below the minimum wage in the semi-urban areas if that one were fixed. However, the market wage would be above the so-called accounting price of labour in the semi-urban areas. (The accounting price is the theoretical price of labour, which brings demand and supply into balance, assuming that complete market information is available and labour is mobile.)

Two points, however, have to be considered. The subsidy mechanism would be complicated and costly. Besides, a new dualism would be created outside the modern sector. Although, even in the case of an absence of any legislation on labour and its social security, some dualism by a semi-urban industrialization would be created between those employed in it and those not. This difference would be more pronounced if those workers received a wage substantially higher than the market rate. The funds that could have been used for wage subsidies could be better used for building up the needed infrastructure in the semi-urban sector and for educational purposes in that area.

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The paragraph numbered 2 *should read*

2. The English version will appear first, followed as soon as practicable by the French and Spanish versions. However, summaries of the text in all three languages will be provided.

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Préface

Comme pour le numéro précédent, le présent numéro d'*Industrie et développement* porte essentiellement sur les pays les moins avancés et les pays en développement d'Afrique, et en particulier sur trois activités industrielles — la production d'électricité, le machinisme agricole et les textiles.

Les trois articles consacrés à des industries particulières sont tous liés en particulier à la question du choix de la technologie appropriée. Dans l'article rédigé par Parikh sur la production d'électricité dans les pays les moins avancés, l'auteur compare les coûts de cette production dans la région du Sahel selon qu'il s'agit de centrales hydrauliques, de centrales à vapeur ou de centrales à diesel. Parikh étudie également la situation en ce qui concerne la production d'électricité, dans les pays les moins avancés, définit divers problèmes qui se posent et étudie les perspectives d'avenir, spécialement en ce qui concerne la coopération régionale et les autres formes de coopération pour la production d'énergie électrique. L'article s'inspire d'une étude plus étoffée établie par Parikh pour l'ONUDI[1].

L'article que Muchiri consacre à la production et à l'utilisation de machines agricoles au Kenya porte tout particulièrement sur la question de savoir quelle est la technologie agricole adaptée qu'il convient de retenir, suivant qu'il s'agit d'outillage manuel, de matériel à traction animale ou de tracteurs. L'auteur montre que les programmes de "tractorisation" au Kenya, comme dans la plupart des pays d'Afrique tropicale, ont été coûteux et que les résultats en ont été médiocres. Par exemple, l'auteur présente des statistiques qui montrent que dans le cadre du programme de location-bail de tracteurs, les opérations véritablement productives n'ont absorbé que 10 % maximum du temps disponible pour ces opérations pendant la période 1978-1980; la plupart du temps, les tracteurs étaient soit en panne soit à l'atelier. L'article confirme, dans un contexte particulier, un bon nombre des observations et des idées formulées dans un rapport récent de la Banque mondiale[2], y compris la nécessité de privilégier les petits exploitants en leur fournissant un meilleur outillage manuel et d'autre matériel peu coûteux, et en transformant le cadre institutionnel et la politique générale, c'est-à-dire en développant les facilités d'emprunt et en relevant les prix des produits agricoles là où ces prix sont maintenus artificiellement à un taux particulièrement faible au moyen de la politique commerciale, du contrôle des prix, etc. Il est impossible, faute de place, d'évoquer les nombreuses autres questions que Muchiri étudie. L'article est l'abrégé d'un document établi avec 14 autres études de pays pour servir de documentation générale aux fins d'une réunion de consultation de l'ONUDI

[1]"Investment requirements of developing power industries for the industrialization of developing countries" (UNIDO/IS.359, 1982).

[2]*Accelerated Development in Sub-Saharan Africa : An agenda for Action* (Washington, D.C., 1981).

qui s'est tenue en 1982 sur l'industrie du machinisme agricole en Afrique. Ces études parmi d'autres qui ont été établies tout spécialement pour cette réunion constituent l'analyse la plus détaillée dont on puisse actuellement disposer sur l'industrie du machinisme agricole en Afrique, industrie qui établit un lien d'une importance majeure entre le développement agricole et le développement des biens de capital[3].

Kibria et Tisdell étudient l'évolution technologique du filage et du tissage du jute au Bangladesh à l'aide d'une analyse économétrique de données réunies auprès d'un échantillon de 57 ateliers. Leur conclusion est que l'intensité de capital de l'industrie du jute dans ce pays augmente et que la part de la production imputable à la main-d'œuvre décroît; tendance qui, dans un pays où l'offre de main-d'œuvre est forte et le capital disponible réduit, semble contredire les idées reçues qui ont généralement cours sur la technologie appropriée. Les auteurs constatent par ailleurs que les économies d'échelle n'ont guère été modifiées par l'évolution technique et demeurent quasi constantes. Les auteurs étudient en outre certains aspects de l'apprentissage empirique.

L'article de Boon, qui reprend plusieurs de ses précédents articles, propose une évaluation de caractère plus général des rapports entre la technologie et le développement économique, et du dualisme technique en particulier. Ce dualisme, qui se traduit par l'existence d'un secteur moderne où sont utilisées des technologies empruntées parfois sous une forme légèrement modifiée à des pays plus avancés, à côté d'un secteur plus traditionnel ou moins structuré, est un phénomène qui se constate frequemmment dans les pays en développement.

L'article de Boon se demande comment on pourrait réduire ce dualisme, susciter un équilibre technologique en encourageant le développement du secteur le moins moderne quand l'analyse permet de penser que cette solution serait appropriée. L'auteur propose un cadre pour cette analyse. Il n'empêche qu'un système de développement économique à deux niveaux se justifie parfois, si aux deux niveaux la progression respecte un plus grand équilibre entre eux que ce n'est actuellement le cas. L'auteur étudie les possibilités qui s'offrent d'appliquer un tel système, y compris plusieurs mécanismes institutionnels. Il développe sa thèse générale en prenant l'exemple concret de l'industrie textile.

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[3]Ces études font l'objet d'une synthèse dans deux documents intitulés "Diagnostic sur la situation présente et les tendances de la production et de l'utilisation des machines agricoles dans les pays africains" (UNIDO/IS.288); "Situation présente, perspectives et choix stratégique pour le développement du machinisme agricole dans les pays africains dans le cadre du plan d'action de Lagos". (UNIDO/ID/WG.365/1); *et dans une publication destinée à la vente qui paraîtra* prochainement.

Prefacio

Al igual que en el número anterior, el presente número de *Industria y Desarrollo* se centra en los países menos adelantados y en el Africa en desarrollo, particularmente en tres actividades industriales: producción de energía eléctrica, maquinaria agrícola y textiles.

Los tres artículos sobre industrias específicas están relacionados entre sí, entre otras cosas, porque se refieren a la cuestión de elegir la tecnología apropiada. En el artículo de Parikh sobre la generación de energía eléctrica en los países menos adelantados, el autor compara los costos que probablemente tendrá la producción de energía eléctrica en la zona africana del Sahel según se trate de centrales hidroeléctricas, térmicas de vapor y diesel. Parikh examina también la situación de la energía eléctrica existente en los países menos adelantados, y señala varios problemas y trata las perspectivas futuras, especialmente por lo que respecta a la cooperación regional y de otra índole en la generación de energía eléctrica. El artículo se basa en un estudio más amplio preparado por Parikh para la ONUDI[1].

El artículo de Muchiri sobre producción y utilización de maquinaria agrícola en Kenya se centra particularmente en la cuestión de la tecnología agrícola apropiada en forma de aperos manuales, equipo de tracción animal y tractores. El autor demuestra que los programas de tractorización de Kenya, al igual que en la mayor parte del Africa tropical, han sido caros y en gran medida no han tenido éxito. Por ejemplo, presenta estadísticas en las que se demuestra que las operaciones productivas del plan de alquiler de tractores no pasaron del 10% del tiempo posible de operación en el período de 1978-1980; la mayor parte del tiempo, los tractores estaban averiados o en el taller. El artículo confirma, en un contexto específico, muchas de las observaciones e ideas contenidas en un reciente informe del Banco Mundial[2], incluida la necesidad de alentar a los pequeños agricultores suministrándoles mejores aperos manuales y otro equipo de bajo costo, y también mediante cambios institucionales y políticos tales como mejores facilidades de crédito y mejores precios para los productos agrícolas cuando esos precios se mantienen artificialmente bajos a consecuencia de políticas comerciales, controles de precios, etc. El espacio no permite exponer otras muchas de las cuestiones que examina Muchiri. El artículo es un resumen de un documento preparado, junto con otros 14 estudios de países, como información para una reunión de consulta de la ONUDI celebrada en 1982 sobre la industria de la maquinaria agrícola africana. Estos y otros estudios preparados especialmente para esa reunión constituyen el análisis más amplio existente hasta ahora de la industria

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[1] "Investment requirements of developing power industries for the industrialization of developing countries" (UNIDO/IS.359, 1982).

[2] *Accelerated Development in Sub-Saharan Africa : An agenda for Action* (Washington, D.C., 1981).

de la maquinaria agrícola africana, vínculo fundamental entre el desarrollo agrícola y el de los bienes de capital[3].

Kibria y Tisdell examinan los cambios tecnológicos en la industria del yute de Bangladesh utilizando análisis econométricos de datos recogidos de una muestra de 57 fábricas. Llegan a la conclusión de que la densidad de capital en la industria del yute de aquel país ha estado aumentando, en tanto que disminuía la participación en la producción atribuible a la mano de obra, tendencia que, en un país con una gran oferta de mano de obra y pequeñas reservas de capital, parece contradecir conceptos aceptados de tecnología apropiada. Descubren también que el cambio tecnológico ha alterado escasamente las economías de escala, que se mantienen casi constantes. Se examinan asimismo aspectos del aprendizaje por la práctica.

El artículo de Boon, basado en gran medida en trabajos suyos anteriores, proporciona una evaluación más general de la relación de la tecnología con el desarrollo económico y del dualismo técnico en particular. El dualismo, es decir, la existencia de un sector moderno que utiliza tecnologías transferidas, quizá con alguna modificación, desde países más avanzados, junto con un sector más tradicional o informal, es un fenómeno que se observa corrientemente en países en desarrollo. El artículo de Boon se refiere a la posibilidad de reducir ese dualismo para crear armonía tecnológica mediante el fomento del desarrollo del sector menos moderno siempre que se demuestre la conveniencia de hacerlo mediante análisis. El autor sugiere un marco para la realización de ese análisis. No obstante, en algunos casos puede ser adecuado un sistema de *desarrollo económico en dos planos*, si los dos planos pueden desarrollarse en condiciones más iguales que en la actualidad. Se examinan las posibilidades de llevar a la práctica un sistema de esa naturaleza, inclusive varios mecanismos institucionales. Los argumentos de carácter general se centran más específicamente en el caso de la industria textil.

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[3]Estos estudios se condensan en "Diagnostic study of the present situation and trends in the production and utilization of agricultural machinery in Africa countries" (UNIDO/IS.288); "Present situation, prospects and strategical choices for development of agricultural machinery in Africa" (UNIDO/ID/WG.365/1); y en una próxima publicación para la venta.

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