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APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF CEMENT AND BUILDING MATERIALS

MECHANIZATION OF CONSTRUCTION AND CHOICE OF APPROPRIATE TECHNOLOGY IN CIVIL ENGINEERING

Background Paper

78-6932

MECHANIZATION OF CONSTRUCTION
AND
CHOICE OF APPROPRIATE TECHNOLOGY
IN CIVIL ENGINEERING

by

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CONTENTS

I. INTRODUCTION

Technology is the instrument by which labour, capital, land skills and other natural resources are used to produce goods and services to support the social and economic development of the society. Technology may be sophisticated and capital intensive on the one hand or labour intensive on the other hand and between these may be varying mixes of capital intensity and labour intensity.

To determine the appropriateness of a technology, it is necessary to have criteria. Since technologies are not ends in themselves but means of achieving social, political and economic development, the criteria for appropriateness must be found in the goals of development.

There are many different goals. Some of them are alternative and competitive rather than complementary. The development goals are established by politicans and economic planners who allocate priorities. These include: maximization of net national output and income; maximization of availability of consumption goods; maximization of rate of economic growth; reduction of unemployment; redistribution of income and wealth; regional development of specific areas; balance of payments relief (export promotion or import substitution); promotion of national political development; and, the improvement of the quality of life.

Each planning decision on allocation of priorities will have a consequential impact on technological decisions. When goals and criteria are consistent and complimentary, technological decisions are relatively straightforward; but when the goals of development and criteria for decision about appropriate technology are inconsistent and competing, a complex situation arise whose resolution presents difficulties. For example, economic growth and increase of consumption goods are rather competitive while income distribution and reducing unemployment are complimentary.

Conventional development strategies have hitherto tended to emphasize maximization of rate of economic growth. Thus, countries with high gross national product were considered to be developing satisfactorily. It is now realised that growth per se does not necessarily alleviate mass poverty and unemployment. This has happened in many developing countries where the fruits of growth have been concentrated in the hands of a small privileged minority and have not reached the bulk of the population. One of the factors which seems to have contributed to the perpetuation of poverty is that generally, rapid growth is allowed to occur in the small modern sector of the economy using inappropriate technologies imported from the industrialised countries. This growth is not spilled over into the rural traditional and urban informal sectors and quite often it takes place at the expense of these sectors.

Thus, increasing employment and its associated goal of income distribution are important set of criteria for the choice of technology in the developing countries endowed with abundant unskilled labour and having scarce capital resources. Another important determinant of a country's appropriate technology is its factor endowment - that is, the relative proportion in which labour, capital, land, skills and natural resources are available to the economy. In any country, the factor endowment varies from one sector to another; for example, as between rural and urban sectors, from one industry to another and from one project to another.

The choice of appropriate technology presumes that there exists a range of technologies available. When an industry has available to it a number of alternative technologies, it is considered to be technologically flexible. It is worthy of note that not all industries are technologically flexible. The availability of alternative technologies is a function of:

(i) effectiveness of technology transfer programmes
(ii) research facilities for selection, adaptation and development of technology.

Technological choices in developing countries are made by various types of decision makers and under a variety of sources of influence. They do not necessarily have the same objectives or conform to the same ideas of what is "appropriate". They include multinational enterprises whose main objective is to maximize global profits within the whole multinational complex; large-scale modern sector national producers who basically wish to maximise profits but who are also influenced by other considerations;

national governments who have specific development objeotives, possibly including up-to-date modern technology and other aspects of modernisation, as well as the reduction of poverty; family enterprises suoh as smaller farms or small production units in the informal sector whose objective is to maximise family consumption or output per unit of land. Within each of these groups, there is a further diversity of interests.

The choice of appropriate technology is therefore dependent on four major faetors:

(1) criteria for selection whioh are embodied in the goals of socio-economic development
(2) the resources available to the economy, that is, the factor endowment
(3) the availability of alternative teohnologies, that is, the technology shelf
(4) who is making the ohoice

It is clear that the choice of appropriate technology in developing oountries is rather a complex matter and is influenced by a variety of social, economic and technological measures. It is also clear that because of the oomplexity of the variables, it is almost impossible to evolve a methodology for selection of technology for the country as a whole. In order to make the discussion of the methodology for seleoting appropriate technology easy to grasp, it is intended to disouss it here within the framework of one sector of the eoonomy, namely, The Construction Sector.

II. SOCIAL, ECONOMIC AND POLITICAL CONDITIONS IN DEVELOPING COUNTRIES

The social, economic and political conditions in developing countries vary somewhat from country to country, but nevertheless, there are certain general characteristics which will influence the choice of technology. A large number of developing countries are experiencing a rapid growth of population associated with a high rate of urbanisation. Some of the developing countries with extensive mineral and oil resources have available capital and foreign exchange, but by far the greater number of developing countries are faced with scarcity of capital and with considerable pressure on their foreign exchange earnings. The developing countries with considerable mineral resources and large incomes are experiencing reasonable economic growth, but generally most developing countries are faced with very low economic growth.

The economy of most developing countries is essentially based on development of agriculture which is characterised by considerable unemployment and underemployment. There is generally a low level provision of social amenities. There is a preponderance of unskilled labour and with the exception of a few developing countries, there is also a shortage of high-level scientific, technological and managerial skills. There is a low-level scientific capability with generally, low-level industrial development. At the same time, there is a low level growth of research and development in related scientific activities.

The economy of developing countries which depend on income from the exploitation of agricultural and mineral resources is tied to world prices and world trade trends. Thus, a drop in, for example, cocoa price, timber or copper price, immediately affects the economy of producer countries.

Until recently, a large proportion of the export trading of raw materials from the developing countries were in the hands of foreigners. The situation has changed somewhat recently with the establishment of national marketing organisations for major raw materials export in many countries. Nevertheless, there still exist a substantial number of foreigners in import trading and some industrial production which rely on imported raw materials to a level that gives them considerable influence over the economy.

The political conditions in the developing countries today are varied. Political systems and philosophy vary from capitalist orientated systems to socialist orientated systems. The effect of social, economic and political instability, has resulted in the establishment of military dictatorships in a number of developing countries. There is no doubt that political conditions and political philosophy to be adopted by various countries will have an impact on the choice of technology in the future.

The post-independence period for a number of developing countries is not long. If we consider Africa for example, we can split the continent into:

(a) Southern Africa, where the majority is subjected to the will of a few whites
(b) Countries with military dictatorships
(c) One party states
(d) Multi-party states.

In Southern Africa it is considered that the basic needs of the majority of the people are determined by the minority who form the government. The situation is not very different from the military dictatorships where there are no avenues for expressing the wishes of the people on a systematic basis. Even though some one-party states are fairly socialistic in orientation, there is no doubt that in African countries, a large number of one party states have created situations where a dominant group who are in power determine and dictate what should be done. It is only in a few multi-party states that public participation in government is at a level of the people to make it possible for the views to be embodied in national developmental goals, and even in these cases, as it is generally known, there is a development of an elitist society who have access to the greater portion of the wealth and in fact control the political system. The general position in developing countries, particularly in Africa is one of general scarcity of resources, with increasing demand resulting from rapid population growth and urbanisation. At the same time, many countries are saddled with political systems which make it possible for the popular will and aspirations of the people to be controlled by a minority in power.

III. THE CONSTRUCTION INDUSTRY

The construction industry in developing countries is generally rather unorganised and unsuitable in character. It is generally characterised by a few, usually foreign contractors who execute most of the major infrastructural works as well as the very big buildings. There are also a number of medium-sized local contractors who generally carry out maintenance repairs and supervise generally the construction of small houses and dwellings.

They generally form about 30 per cent of the contractors in the industry. There is, then, a larger number number of artisans and private builders who are either individual supervisors executing private contracts such as plumbers, electricians or else general artisans carrying out individual contracting jobs. They constitute the majority of contractors, and generally they are of the order of 50 to 60 per cent of the contractors in this sector.

The Construction industry may therefore be divided into formal or monetary sector and the informa' sector. The formal sector is the modern sector; this is more or less industrial, in that, it consists of the firms applying a specific technology in operating under some form of management. They undertake infrastructure such as the major highways, dams, buildings, et cetera. These generally involve the use of heavy machinery, and cranes at times. Because of the better management and the use of better paid and highly productive labour force, labour cost may be generally low in relation to output. However, such infrastructural projects have costs with rather high foreign exchange component in the form of foreign exchange requirements for the equipment as well as for the materials, as a result of which generally the provision of infrastructural in most developing countries is frightfully inadequate. This sector would be susceptible to the adoption of new materials, advanced concrete technology, pre-stressed concrete, steel framework structure, mass production of building component and at some time heavy prefabrication.

The informal sector comprises the popular housing and building effort including the 'do-it-yourself' projects. This sector covers work still carried out by housing with traditional techniques which to a great extent incorporate poor management, and productivity. The sector will cover the construction of a substantial part of a total volume of housing in rural and peri-urban areas in developing countries.

The technology in this sector is essentially non-monetary in character and tends to rely on utilisation of indigenous skill and locally available materials such as earth, natural stone, mud, wood and bamboo.

In between these extreme sectors may be found the sector which tends to incorporate the adoption of conventional technology involving different degrees of capital intensity and labour intensity. The type of technology here is generally based upon old established crafts such as stone and brick masonry and carpentry, and it is somehow intermediate between the traditional and modern industrialised technologies.

In some developing countries technologies which relate to these different sectors exist and are applied side by side, for example, in so far as building construction is concerned, the more sophisticated technologies may be adopted in the design and construction of such structures as hotels and big public offices. Similar mechanised construction techniques may be adopted in major road construction projects like concrete pavements or in major airport runways or in the provision of sizeable water and electricity projects. These same techniques could exist side by side with projects which incorporate the application of the more traditional technologies, particularly in the rural sector for housing and at times for rural feeder roads. The actual allocation of priority of funds will depend to a great extent on the developmental objectives, the level of development in the country, and the availability of funds, skills and materials resources.

In the construction industry, the government is generally the major client, taking decisions on the projects to be undertaken and this in itself, at times becomes a constraint on the proper selection of appropriate technology. A large number of countries undertake major construction projects more as prestige projects, many at times not subjected to detailed project analysis and appraisal to permit the adoption of the most appropriate technology.

Many countries have established national technical institutions which were expected to permit the productive and efficient use of scarce technical manpower. Some of the institutions include a national consultancy agency for undertaking designs for all government projects, a national construction organisation for undertaking construction of government projects. However, because these organisations have not adequately provided incentives to the staff, the organisations have mostly not achieved high degrees of efficiency and productivity. In fact most of such organisations incur losses when similar private organisations are making profits.

Availability of Skills

The technology available in the construction industry may be divided into two:

(1) Soft-ware which covers design, planning and analysis techniques, research management of information and control, and construction methods.

(2) Hardware which covers materials and equipment.

In most developing countries, the availability of trained personnel to provide these necessary software technologies is limited. Even though in a number of countries, engineering institutions have been established, the production of engineers is far below the requirements.

Secondly, the training of such personnel has not been given the necessary broad scope in order to enable the graduates to acquire the skills which will facilitate the adoption of the appropriate technology. The software technology applied in the developing countries are for projects planned, designed and executed by personnel from the developed countries, or where they are undertaken by local staff, these are people who have been trained, using techniques which are similar to those available in the developing countries.

Some of the latest techniques of information processing are not available in the developing countries; in any case, a large number of developing countries have not established the necessary research organisations to undertake the compilation of available technology and their cost implications. This is particularly important since in these countries, the weather changes as well as such factors as diet will influence the productivity in labour intensive technologies.

In so far as materials are concerned, whereas materials adopted in informal sectors are particularly indigenous, a large number of developing countries have sought to adopt the use of imported materials in construction, particularly in the formal sector. Thus, materials resources in most developing countries have not been exploited to the maximum. There have been cases where a few materials production facilities have been established which depend on imported raw materials and this has created a situation where the products are quite expensive.

In so far as equipment is concerned, developing countries have not given adequate attention to the development of essential tools and equipment in construction. All the major construction equipment, particularly, those for prefabrication have been imported.

IV. CONSTRUCTION MATERIALS DEVELOPMENT AND USE

The availability of indigenous building materials generally places considerable limitations on the choice of technology for construction. Whether there is a wide choice available in terms of appropriate technology to be adopted depends to a great extent on the resources of the country in question and in some cases also on the locality of the construction operations. Before arriving at the choice of appropriate technology for construction, it is necessary to, first, look at the availability of material resources in the country in relation to the specific location in question. However, the choice of appropriate technology must not be limited solely to the availability of material resources in the locality. It is possible that there may be materials available in other parts of the country or else in another part of the region or even overseas where the utilisation from strict detailed economic and social considerations might lead to a better choice of appropriate technology even though this is generally not the case.

Construction materials can be improved and changed for better performance and therefore even though the materials available at a location may not have the necessary or requisite properties, consideration must be given to the extent to which such materials must be improved for use and the cost implications.

In all developing countries, the low level production, manufacture and use of indigenous building materials and therefore the greater reliance on imported materials is not attributable to the fact that the local raw materials are not available but that there is a lack of the general basic requirements for establishing such industries, namely, lack of capital, lack of technical as well as managerial skill, and inadequate information on the extent and scope of availability of these raw materials.

There is a need to establish building materials industries with production rates sufficient to support the rate of housing construction desired and needed. Unless this is done, the housing situation in a large number of these developing countries will continue to deteriorate.

Selection of an Appropriate Technology

The selection of an appropriate technology for a materials industry is a difficult proposition since the raw materials and utilities positions as well as the capital resources and manpower availability have to be considered.

Production of materials can be done at different levels:

(a) Large scale production using advanced technology. Such manufacture is highly capital intensive and is heavily dependent on foreign capital and know-how. Production of steel, aluminium, cement, glass and ceramic products are examples.

(b) Small to medium scale industrial or semi-industrial manufacture of materials like brick, cement, lime, pozzlana, paints, aggregates, etc. Production is usually labour intensive, involving less capital. Equipment may have to be imported but on a smaller scale.

(c) Cottage type production; operated mainly in rural areas for the production of materials like lime, clay tiles, products from bamboo, reeds, straw and agricultural wastes.

There may be several technologies available for production of a materials at the same or different levels of production. The problem is to select an appropriate technology. The cost of manufacture of the product is the accepted criterion for the selection of an appropriate technology. The cost of manufacture comprises both the financial or market cost as well as national economic cost. The technology which yields the largest net benefit, (difference between gross benefit and costs, using economic cost) is to be selected.

Some materials (cement, brick and tiles, lime and pozzolana) can be produced on a large, medium or small scale to suit demand. Technologies are available to suit each level of production, depending on the raw materials and utilities position.

Equipment and Labour for the exploitation of Indigenous building materials:

The building materials industry in developing countries is characterised by scarcity of equipment and machinery as well as high level of unemployment amongst unskilled and semi-skilled workers. For the processes of exploitation of indigenous building materials which are technologically flexible, the choioe of the equipment and machinery depends to a great extent on the tasks which cannot be performed easily and efficiently by labour. It is essential that these tasks are clearly identified before any decision regarding the use of equipment is taken.

It has not been possible to compile a list of the cost implications of the adoption of different combinations of equipment and labour for the exploitation of indigenous building materials. Such information will be valuable in the future selection of equipment and labour. This is an area for future researoh studies. It is clear, however, that most of the processes for the exploitation of indigenour building materials are technologioally flexible.

Distribution of materials industries

The location of industrial units should take into account the distribution of raw materials and utility services as well as the market. Whenever there are long distances between the market and the manufacturing installations, costs are likely to be quite high for the user. Transportation costs in manufacture and distribution should be reduced to the minimum.

V. TOOLS AND SIMPLE EQUIPMENT FOR CONSTRUCTION

Various types of tools, equipments and plants can be developed for use in construction in the developing countries if some thought were given to the requirements of the industry. These can be substitutes for costly, imported equipment and at the same time provide increased speed and quality in the construction operations. Some research institutes in developing countries, like the Central Building Research Institutes of India have been engaged in such development works, but there is need for further development work in this area by other research institutes.

The proper selection of tools for construction depend on the following factors:-

(a) Relationship between capital cost and labour on one hand and the organisation of the production process on the other.

(b) the employment situation.

(c) the construction operation and the methods to be used.

(d) the degree and type of skill of the labourers to be employed.

(e) the extent to which tools are produced locally, and,

(f) the extent to which tools have to be imported.

Simple and hand-manipulated machines of earthmoving works, foundations and construction of public utility services.

The achievement of efficiency as well as increased productivity in construction operations necessitates the appropriate use of labour and equipment. In many of the highly industrialised countries as well as developed countries because of the level of technology, the availability of capital, the shortage of labour as well as availability of highly skilled labour, availability of the housing market increased efficiency and productivity has been achieved with increased mechanisation. With time, the machines that have been used in various construction operations have become more and more sophisticated.

In most of the developing countries however, because of a surplus of manual labour a number of factors have to be considered before the choice is made as between manual or mechanised earthmoving operations or some combination of both. These factors include the target requirements of theproject and technical considerations, availability of foreign exchange, availability of spare parts, availability of skill for maintenance, economic and social conditions and political and other considerations. The key issues relate to the means of achieving a more effective use of manual labour through improvement in implements, labour incentives, welfare facilities and also to the establishment of the criteria for determining how far manual labour alone or in combination with machines should be adopted.

Data on the efficiency and productivity of manual labour in earthmoving operations in comparison with the use of mechanised equipment for these developing countries are rather scarce.

The United Nations Economic Commission for Asia and the Far East has compiled some material on "Earthmoving by manual labour and machines". The Building and Road Research Institute of the Council for Scientific and Industrial Research (CSIR) in Ghana has carried out studies on opportunities for cost reduction in construction based upon which some information on the use of labour in some construction operations have been obtained.

The conclusions from the UNECAFE Report give a definite pointer towards ways of achieving fuller utilisation of manual labour for earthwork operations in the countries of the region which may be applicable to other developing countries. These are:

(1) for excavation and loading to heights of less than 1.2 metres, manual labour is economical in low wage countries.

(2) excavation and movement of earth are cheapest by bulldozers up to 25 metres load. For loads up to 50 metres, manual labour costs compare favourably with tractor-drawn scrapers.

(3) Motor Scrapers work out cheapest in India for leads from 200 to 1,500 metres, excluding the charges for pusher. If the pusher charges are added, the cost may still compare favourably with that of manual labour and narrow gauge truck.

(4) In general, manual labour and petrol trucks are economical for leads of over 2,000 metres on good roads.

(5) Shovels and dumpers are economical on bad roads and for leads of more than 2,000 metres.

(6) Manual labour with narrow gauge truck animal-drawn, compares favourably with tractor-drawn and motor scrapers in Japan for leads of 250 to 750 metres.

(7) For the performance of shovels, dumpers and motor scrapers, one south-east Asian country compares favourably with India.

The type of earthwork being carried out will influence the decision on mechanisation (i.e. whether canals, highways, dams, railways, tunnels, open cost mines, etc.). There is evidence that manual labour can be employed more effectively for earthwork operations if use is made of animals for transport. In general, in developing countries, it is accepted that mechanisation can go in hand with manual labour operations and earthworks if account is taken of limitations imposed by technical and target considerations. The combination of labour and mechanised techniques leads to better utilisation of existing resources and will generally help to improve economic conditions.

Simple implements to be used in manual operations of earthmoving must be designed carefully and improved through trial and error methods in order to suit local soil conditions as well as the physical characteristics of labour which will vary with climate and standards of living. Some of the simple tools which are being used in earthmoving operations include shovels, wheelbarrow, bullock carts, pick-axes and handpans. The heavier equipments include bulldozers, scrapers and dumpers.

Simple and Hand Manipulated machines of materials preparation

There are a number of simple machines for material preparation that are currently in use in developing countries that can be easily manufactured.

For large scale concrete mixing, the use of concrete mixer is inevitable. However, for relatively small scale concrete mixing, manual methods of mixing, using shovels are adopted in a number of developing countries. However, a simple mixer has been developed somewhere in Paris and this is being tried out at the Building and Road Research Institute, Kumasi. This simple mixer operates as a roller without a motor. It is built entirely out of wood. The cement and aggregate is put in a wooden box in the middle forming the centre of the roller and simply pushed around the ground. After a distance, concrete is mixed. The process is very cheap.

The mixing of mortars is largely undertaken manually. There is a wide range of machines for the fabrication of sandcrete or concrete blocks, from very simple wooden moulds which use essentially manual techniques, to the highly mechanised and almost authomatic system of moulding in the factory.

Some of the equipment used for conveying fresh concrete are trucks, conveyors, trawlers and cranes. For casting concrete wood, forms are generally used but metals and concrete may also be used in some circumstances.

For moulding soil cement blocks, simple equipment like the simple cinva or ram or slight modifications of it have been found useful and easy to manipulate. Laterite lime blocks or sand lime blocks however need more pressure and there is need for simple presses to mould such materials. The processes that have been developed so far and are in the market are meant for large scale operations and are relatively expensive. Similar presses are being used in some developed countries for compressing various agricultural wastes into blocks of various dimensions for use in wall construction.

Devices, Scaffolding, Shutterings and Simple Housing Equipment necessary for the Construction of Vertioal Support

Generally, scaffolding is made of timber and bamboo in developing countries. There is a growing use of steel tubes as well. Manually operated devices which can be used in the construction of one storey detached houses include block and tackle which can be easily manufactured from timber. The standing derrick consists of a round or square timber of the required length stuck into the ground in a vertioal position or slightly including towards its area of operation. A block is mounted at the top of which a rope tackle is attached. A chain taokle or rope tackle nails have been used. Weights up to about 250 kg. may be lifted manually using tackle fitted with hemp rope.

When greater weights are to be lifted the rope should be heaved in with manually operated winch. The top and the foot of the standard derrick may be equipped with rope pulleys; lifting is then done with manually operated winches.

Derrick cranes can also be easily assembled from timber but possibly from metal sections. The post and the jibs are fixed to transoms placed at right angles and revolving round a pin. The post and the transoms are connected by legs. A counter-weight to ensure the stability of the structure may be placed at the end of the transoms or anchoring should be provided. The post together with the jib can be slewed across 220 to 250 degrees. The slewing is done with spliced rope laid around a large diameter pulley fixed to the post and operated by a hand winch. Hoists may be used at all the building sites where the weight of the individual precast units to be installed does not exceed the load which two workmen can handle manually. The required lifting capacity of the hoist may range from 150 to 1000 kilograms depending on the size of the building and the amount of materials needed for its construction. The framework of hoist may be made of timber or steel sections. An example of an up-to-date construction is the easily assembled or self-erecting hoist with a steel frame. These mobile hoists have a base section which can be lowered into a horizontal position and moved, on pneumatic wheels to another location within a very short time.

Devices, Support and Shuttering Constructions necessary for Horizontal Load Bearing Structures.

Shuttering is generally made of wooden boards with posts or bamboo as supports. There are cases where metal plates are used in conjunction with steel tubes. Cranes are also used not only to lift the materials as well as precast units but also move them horizontally right to the point of installation on various housing projects.

Hand Manipulated and Simple Machines for Rendering

Rendering is normally undertaken manually using trowel. However, in the construction of low cost houses there is need to reduce the cost of rendering and plastering to the minimum. This is done by leaving the block work with a fair face finish. A simple tool for rendering low cost walls is the tyrocan machine.

Hand Manipulated and Simple Machines for Floor Finish

These include frictioner polisher, power hand sander and Terrazzo machine.

Hand Manipulated Devices and Simple Machines of Material Movement and Transportation

Hand manipulated devices and simple machines used for material movement during construction depends to a great extent on the type of work being undertaken and the rate at which the work is being under taken. The simple machine to be selected must be in such numbers that transportation does not create a bottleneck in the movement of material. Generally, there is a greater scope for labour when such use is made of mechanical means of transportati n particularly for longer distances. For transporting soil or cement or such material on very short distances, in some developing countries, head pans have been used. The use of wheelbarrows, handcarts which have two or four wheels with steel rails or pneumatic tyres and also small dumpers have been found useful. The latter ones are also useful for the transportation of precast units, in blocks. For the transportation of bricks, brick barrow can be designed and used effectively.

For vertical transportation of materials, some of the simple equipments, which can be used include loaders, block and tankle, and simple lifts which can be designed and simple cranes.

Optimal Use of Hand-Manipulated Devices and Simple Machines for the above-mentioned Operations.

To determine the optimal use of hand-manipulated devices and simple machines for construction operations, it is necessary to establish the combination of simple-machines and labour which will achieve maximum efficiency and adequate speed in the construction operations. Before adequate information can be collected which will be used as scientific basis for selecting this combination of simple machines and labour for optimal performance in construction operations, detailed study must be carried out in many countries covering different climatic as well as socio-economic conditions and also the different characteristics of labour from one country to another.

In order to identify the relationship between capital and labour costs some of the factors which have to be taken into account in the study include:

(1) the availability of foreign exchange for the purchase of simple tools and equipment.
(2) availability of local skills and energy to operate the mechanical equipment.
(3) the need to import skills and spareparts for the maintenance of mechanical equipment.
(4) the characteristics of labour productivity on the susceptibility of labour training in the use of equipment.
(5) the effect of good organisation on productivity.

Information so far available on the influence of these factors on the relationship between capital and labour costs for the combination are rather scarce. The approach to be undertaken will necessarily involve the application of trial and error methods in various countries, for different types of construction operations.

It is not possible to determine accurately the extent to which the rational use of equipment influences building productivity as measured in man hours per square meters of construction. Some of the information on the increases in productivity for some of the building operations through the use of simple machines has been compiled by the Central Building Research Institute of India which might be used to compare with similar data elsewhere (Table 1)

Some of the information on the extent to which some of the more capital intensive machines replace labourers is available (Table 2). This is also a subject on which national andinternational co-operative research should be undertaken, the data from which can be used to establish the choice of labour in relation to machines.

It must be expected, however, that in many developing countries, the growth of mechanisation will be to some extent inevitable. This is because of the increasing cost of labour, the general level of productivity andthe general increase in the level of technology. However, the type and extent of mechanisation must be carefully selected to correspond to the aspects of construction operation for which it is required, and also to relate to the availability of national and in some cases regional resources.

TABLE I

INCREASE IN PRODUCTIVITY WITH MECHANISATION (CBRI)

OPERATION	INCREASE IN PRODUCTIVITY
1. Mixing concrete using concrete mixer	0.7 times
2. Transportation mixed concrete in skip hoist	9.0 times
3. Compacting concrete using vibrators	3 to 4 times
4. Tamping lime concrete terracing using tamping machine	20 times
5. Floor grinding using FLOOR polishing machine	0.6 times
6. Providing chases in brick work for Electrical wiring using Electric chaser	15 times
7. White/Colour washing using spraying pump	10 times.

TABLE II

REPLACEMENT OF HUMAN LABOUR BY MACHINES

TYPE OF MACHINE	NUMBER OF LABOURERS REPLACED
Excavators, 0.15-3 m^3	20 - 160
Motor-scrapers, from 6 m^3	50 - 120
Dozers, from 80 HP	70 - 90
Motor-grauers, 60 - 120	30 - 50
Machines for earth compaction 4-25 metric tons	20 - 50
Building cranes, 30 - 80 metric tons	30 - 40
Dump-cars, 3-5 m^3	20 - 30
Motor-cranes, 5 metric tons	10 - 20
Mixers, 250 - 750 litres	5 - 20
Conveyors, 4-15 metres	3 - 5

Source: Stevebni vyxkum cis. 2-3 vyxkummy ustavebni vyroby, Praha, 1963

VI. INDUSTRIALIZATION AND MECHANIZATION IN CONSTRUCTION OPERATIONS

With any developing economy, the factor endowment will change with time. Labour costs will increase with increasing scientific and technological capacity. There will therefore be a definite trend towards mechanization and industrialization. The essential point is that to the introduction of mechanization andi industrialization in construction must be carried out gradually and carefully. If the applic tion of such mechanised method is too much out of context with the factor endowment the result and effect is unemployment and its associated social consequences. However, a gradual and methodical industrialization and mechanization programme will lessen disastrous effects. This can be done if consideration is given to all the salient factors which have a bearing on the possible effect of adopting such methods. These factors include the following:

(1) The requirements for capital, particularly the foreign exchange component.
(2) The extent to which demand for housing and building is planned and will be continuous.
(3) Whether the plants to be used will be imported or manufactured in the country.
(4) The standard of technical personnel and operators available and the extent to which there might be need to bring in foreign personnel.
(5) The shortage or excess of manpower (unemployment).
(6) Availability of materials and the extent to which some of it have to be imported.
(7) Whether building activities are sufficiently concentrated to allow further development of the building industry.
(8) The state of the transport network.

In addition to all these, there is need to take into account the broad socio-economic as well as political considerations.

A large number of developing countries in Africa today, have adopted the philosophy of self-reliance which in itself is not against the introduction of industrialised methods of construction but has a bearing on the rate at which such industrialised methods can be introduced. The philosophy emphasises the need to take account of the circumstances of the situation in any developing country before adopting industrialised methods in the solution of various problems including building.

In most developing countries particularly in Africa, capital, especially the foreign exchange component is rather scarce, and the little there is, being competed for by all the various sectors of the economy. A disproportionate expenditure of this scarce foreign exchange on investments in establishing industrial plants for building activity, when other less capital intensive methods could be adopted, will obviously affect the broad socio-economic development of the country and therefore finally the housing environment itself. As a result the availability of capital places constraints on the level of industrialization of building in various developing countries.

In many developing countries, building activities have not been sufficiently planned to ensure continuity which is necessary to justify capital intensive techniques in building industry. This is mainly because of the distribution of population in a large number of the developing countries, particularly in Africa.

The level of technology in all branches of industry is such that the introduction of industrialised methods in construction, in these countries, will invariably require the need to import machinery which of course means there will be need not only for foreign exchange but also for bringing in personnel to set it up and maintain it. This lack of high level technology makes the use of complicated machinery rather expensive in developing countries.

The developing countries in Africa which have adopted the philosophy of self-reliance are discouraging the establishment of industries which rely on the importation of raw materials. This means that the availability of materials places some constraint on the level of industrialization of building activity possible.

If therefore we consider the different stages in the process of industrialization in building, namely;

(a) Conventional methods
(b) Rationalisation
(c) Partial Prefabrication
(d) Complete Prefabrication

as different degrees of capital intensiveness, it is clear that it is in the range of rationalisation that developing countries have the greatest opportunity for construction cost reduction. By rationalisation, organisational, planning and control techniques in building are used to achieve the optimum utilization of labour, building elements, tools and equipment.

Some of the rationalisation measures include the following:

(i) Improvement of the site plans and operations
(ii) Co-ordination of site-work schedules.
(iii) Establishment of well-trained specialised teams of workers for specific and preferably repetative operations such as bricklaying, plastering, carpentry, etc.
(iv) Better utilization of local materials
(v) Improvement of currently used hand tools, machines and other equipment and the introduction of new and more effective ones.
(vi) Establishment of temporary plants and workshops on the site for the production of building components, e.g. carpentry and joinery, bending and welding of reinforcement bars.
(vii) The use of typical (model)designs.

The assembly of buildings from factory made components is the most effective means of industrialised construction. However, as stated earlier, in developing countries, this is viable only if processes by which the components are manufactured satisfy a number of factors. In many developing countries the manufacture of factory-made-components will depend to a great extent on the resources. For countries which are endowed with timber the standarddisation and industrial production of wood components like doors and windows is one of the first steps into industrialization. Where cement and aggregates areavailable as well as reinforcement, reinforced concrete components can be made utilising fairly simple methods of manufacture. The size of such reinforced concrete components will be determined to a great extent by the availability and type of lifting devices and to what extent there is a technology in the country for themanufacture and installation and maintenance of such equipments. Since in a large number of developing countries this technology is not available, the size and weight of building components particularly reinforced concrete will have to be limited.

However, there is tremedouns likelihood for the establishment of industries for the manufacture of building components which utilise various agricultural residues like wheat, straw, cotton, stalks, bagasse, flax hemp, rice hust, wood shavings, and coconut fibres. Some of the materials include:

(a) Particle board (flat, pressed and extruded)
(b) Fibreboard produced either by the wet or dry process
(c) Mineral-bound panels (wood/wool)cement or wood shavings type.
(d) Extruded panel manufactured from stalks of cereal plants.

For these processes the disadvantages of importing equipment and technology is more than compensated for by the use of the agricultural residues which may have little or no cost and may be the only materials that can be used in some countries.

VII. FACTORS INFLUENCING CHOICE OF TECHNOLOGY AT PROJECT LEVEL

The selection of technology for construction in many developing countries has not been preceded by any rational analysis for purposes of assessing the relative merits and demerits of the adopted technology. In many cases, the existing traditional technology is used mainly because it is the technology that is known in the specific area. In many countries, industrialised technology has been adopted for some projects where there is considerable external resources, to support them. There are times also when the adoption of such industrialised technology has been prompted by the bilaterial technology associated with the project, because the productivity of the efficiency of the construction industry is very important to the total national social and economic development. The choice of appropriate technology for construction is very imperative since it underlies the ultimate sucess of the various construction programmes resulting in the achievement of higher standards of living within the society.

There are a number of factors which influence the selection of technology for a construction project such as low-cost housing; these include the following:

(a) the extent to which the buildingprogramme is efficiently planned;
(b) the location of the housing project;
(c) the availability of labour;
(d) the requirements of time for construction;
(e) the availability of building materials resources;
(f) quality and standard of comfort;

Housing Programme

The type of housing programme influences to a great extent the choice of technology to be adopted. On the other hand the type of technology adopted also predetermines to some extent the type of programme that can be executed. In effect, there is a relationship between the building programme and technology to be applied which must be identified.

A number of major types of housing programmes can be easily identified. The programme could be a housing project for a sparsely populated rural community or a settlement project for a rural or urban community. It could be an urban housing project in a densely populated urban community or in a rapidly developing urban community. The project may call for a low rise housing development programme or a high rise housing development. It is also important to determine whether the project envisages the adoption of mass housing techniques or construction may be undertaken on individual isolated basis or through self-help techniques.

A housing programme which is part of a well though out housing plan whose execution will cover a reasonable period and therefore claim a determinable market for construction will allow the adoption of a technology which will be different if the programme were on ad hoc baeis or on self-help basis.

In recent years, consideration has been given to the construction of high-rise multi-dwellings with the hope of reducing the cost of providing infrastructural facilities such as roads, water, electricity, etc. But whereas low-rise construction is characterised by continoue reliance on traditional and local materials and the adoption of conventional technology, construction of multi-dwelling high-rise construction is characterised by a greater reliance on imported materials; that is a greater reliance on industrialised technology. It is necessary therefore to give adequate consideration to the design processes in order to achieve as high a density compatible with reasonably low rise construction which will at the same time reduce the cost of providing infrastructural services.

Rural and peri-urban housing programmes will necessarily have to incorporate traditional techniques utilising indigenous skills as well as locally available materials such as earth, natural stone, mud, wood and bamboo. Many a time, it will be necessary to undertake the programme utilising self-help techniques. Conventional technologies may be used for smaller housing projects built in the urban and rural areas. This technology will be based upon old established crafts, such as stone and brick masonry as well as carpentry work. The rationalisation of this technology and improvement will depend on the conditions of each country.

Modern housing technology fairly similar to that of developed countries but with a technology selected according to the circumstances of each country, which will be labour saving and might depend to some extent on imports of expensive materials and components as well as the use of sophisticated plant and machinery and of professional, managerial and supervisory skills might be required to support mass housing programmes in urban areas of the highrise type of the building if the decision is made to construction these. The appropriateness of technology to support a programme cannot, however, be separated from the appropriateness of the programme itself. A housing programme that in its entirety does not seek to satisfy the basic needs of the mass of the population cannot be appropriate.

Location of Housing Estate

The location of the housing estate, to a great extent, also influences the choice of technology to be adopted. This is why it is so important that the choice of technology is given some attention during the planning and design stages of the housing estate. The climatic conditions of the site will have some influence on the type of design. In tropical areas it is important that some allowance is made for hot dry weather conditions or for humid hot conditions for example.

The ground conditions as well as the geological structure of the site will determine to some extent the type of foundation as well as the method of construction. Areas susceptible to disasters such as hurricanes, flooding and earthquakes might also require special consideration and necessitate adoption of higher level of technology.

Availability of Labour

The type of technology to be selected for use in construction is influenced greatly by the availability or scarcity of labour as well as the type of skills available. In a large number of developing countries, there is considerable amount of unemployment associated at the same time with a severe lack of skilled craftsmen in comparison with a large number of unskilled workers. In most of these countries, therefore, the choice of labour in construction appears to be restricted essentially to only unskilled workers. This means, therefore, that for most of these countries, the technology which is appropriate for construction must to a great extent help resolve the problem of unemployment. And since the conditions relating to limitations in skilled workmen has to be overcome, it is necessary that proper training and good management are organised.

In those countries as a whole, wherever necessary in association with specific construction programmes, it will be necessary to analyse basic operations in construction and identify those which require special skills, and then suitable training of labour should be organised in such a way that concentration is placed on those skills required for those constructional operations.

The choice of labour in support of appropriate technology for construction must be undertaken in relation to materials and equipment. In a large number of developing countries, the improvement of basic tools and equipment for construction, their manufacture in these countries and their utilisation in construction will lead to considerable improvement in productivity and efficiency, and for most of these the level of industrial development is at such a stage that this is all that is required.

However, it is necessary to recognise that even in the developing countries, there are some constructional tasks which may be considered extremely strenous for human being to perform. Examples of these include moving heavy loads, transporting materials to very distant plaoes, executing very dangerous work without protection, working continously during many hours under severe physical conditions and many other tasks that are necessary in a construction site which might require the use of means other than artisan hand labour. For these, there is a strong justification for replacement by mechanical equipment.

Available time for construction

The time for construction also influences to a great extent the choice of technology that must be adopted in specific low-cost housing construction programmes. The more traditional construotion techniques oould easily be adopted in normal circumstances where there is enough time allowed for construction. However, when the time is very short and it is necessary to oonstruct a large number of houses in a short time, there is a need to resort to higher levels of technology involving rationalised conventional methods with levels of mechanisation and industrialisation.

Available Resouroes

The choice of teohnology is also influenoed by the availability of materials resources. If the ohoice of materials is not limited to local materials then imported materials might be used which will lead to high cost of construction and might be considered inappropriate. If the ohoice is limited to the local materials that are available, as normally is the case, then the greater or lesser limitation depends in principle on the resources of the country. Since construction materials can be changed and improved for better performance it then becomes necessary to look into the various methods by which the local material resources can be developed and improved for use in low cost housing.

An essential part of the selection of materials relates to the methods by which the raw material itself is turned into the manufactured material. This method must also be appropriate otherwise the cost of materials will be very high and the objectives of low cost housing will not be achieved. Therefore, in selecting a choice of technology, account must be taken of the availability of local resources, and the appropriate technology for their manufacture. Examples of materials which can be developed for manufacture include cement, from local limestone and clay deposits, bricks and from clay, sandlime from sand and limestone, wood can be transformed into various forms for use in construction and a number of others.

Quality and Standard of Comfort

The quality of construction specified as well as the standard of comfort aimed at in housing construction also help in determining what should be the choice of construction technology. By specifying high quality in construction and demanding higher standards of comfort the need is established for adopting the use of machines andindustrialised techniques and on the whole a high level of technology in order to achieve these high quality finishes. It must be recognised that in developing countries, there is need to reduce quality through specification to a level such that the standard of houses for normal healthy living is not impaired. By reducing the quality of finishes, it is possible to adopt appropriate methods of technology for construction which will lead to significant reduction in costs.

VIII. CRITERIA FOR CHOICE OF TECHNOLOGY AT PROJECT LEVEL

A detailed consideration to the choice of appropriate technology for a single building construction operation may now be undertaken. This may, for example, cover the construction of a building, construction of a foundation or a wall. The choice of appropriate technology for this operation can be based on either essentially economic consideration or else on the basis of social implications. Generally, in engineering economics studies, economic considerations are given the greater weight and therefore the choice of appropriate technology is based on economic considerations. The next step is to identify the various alternatives for undertaking this specific operation in building with various combinations of labour materials as well as equipment requirements. The resources that are used will carry prices in accordance with their availability in a country or as in this particular case, in a specific location concerned. Thus, the resources that are relatively plentiful in a country will carry prices that are low compared to the prices of relatively scarce resources.

Three distinct concepts of costs relevant to the selection of appropriate technology in building construction are identifiable. These are:-

(1) financial or market costs which are costs as usually conceived by Government budgeting agencies, by contractors or managers in an industrial operation;

(2) foreign exchange costs which pertain to payments for imported goods and services (and, less obviously, to costs represented by reductions in the foreign exchange receipts of the country arising from any reason); and,

(3) national economic costs.

National economic costs differ from (and are usually lower than) ordinary financial costs for two principal reasons. Firstly, financial costs such as taxes are not really costs when viewed from a national standpoint. Taxes are essentially tranferred payments. Secondly, market prices may be artificially suppressed or inflated so that such distortions of prices appear characteristically to induce the choice of inappropriate technologies. The kinds of prices which are typically so distorted include:-

(a) wages of local labour, especially, unskilled labour
(b) interest rates
(c) foreign exchange rates

Market wages, especially for unskilled labour, in many developing countries tend to be distorted upward by devices, such as legally - imposed minimum wages, that lift market wages above the levels justified by labour productivity.

In some developing countries, the government tries to help consumer borrowers and small business-borrowers (and also the government as a borrower) by placing a ceiling on interest rate. The ceiling reduces interest rate below the level that would otherwise prevail.

The distortion of foreign exchange rates appears in the international over-valuation of the national currenty which is typical of developing countries. Most developing countries tend to establish and maintain low rates of exchange on foreign currencies. Such exchange rates operates to encourage the choice of technologies that require a relatively high proportion of imported resources and a relatively low proportion of domestic resources. If teohnologies that are appropriate in terms of national costs are to be selected, there is a need to use prices that are consistent with national costs, these prices may be different from market prices. They are commonly called <u>Shadow Prices.</u>

The shadow price of any resource - expressed as a wage rate, an interest rate, or a foreign exchange rate - needs to reflect the values currently produced by that resource which would no longer be produced if it were allocated to the project at hand.

The process of calculating the economic costs associated with the use of any given technology, involving the use of shadow prices, is usually undertaken in order to identify the technology that is appropriate in the sense of minimising costs to the developing nation. Furthermore, such cost minimisation is sought in order to maximise the net economic benefits to the nation of completing the building project. Net benefits may be thought of as the increase in the present discounted value of a real output aggregate such as net national product. Since the gross benefits minus costs equal net benefits, the flow of net benefits from a given building project is maximised by minimising the national cost of constructing it.

By comparing the present discounted values of the net benefits the time duration aspect of alternative technologies is taken care of.

In comparing technologies of different duration, the more appropriate technology can be identified by, with respect to each alternative technology, discounting the value of the flow of project benefits back to the initiation of the project and discounting similarly the flow of costs. The present value of the net benefits, i.e., the different between gross benefits and costs, indicates which technology is more appropriate from the standpoint of enlarging the real national product.

Another criterion for the selection of appropriate technology is based on the minimisation of the outflow of scarce foreign exchange.

The comparison of alternative technologies by this criterion does not involve shadow prices; rather, foreign exchange flows can be measured in a monetary unit, e.g., US dollar and the net flows over the relevant span of years can be discounted back to the date of project initiation. Generally, the more labour intensive a technology, the less foreign exchange would be required and thus the more appropriate the technology would be by this criterion.

A building construction project consists of a number of individual building operations, each of which may be undertaken by a range of alternative technologies. Thus, a building construction project may be viewed as a collection of sub-projects for which a corresponding assortment of technology ranges must be determined. In order to identify the appropriate technology for a whole building construction project therefore, it is necessary as a first step to prepare a list of the various clearly identifiable building operations for which a level of technology is identifiable.

The next step is to identify and list the alternative technologies, be they the traditional ones currently or formerly employed in the country, or the more advanced technologies used in the country or elsewhere for each building operation.

Such alternatives may be found by investigating the following:

(i) current government, academic and private research or improving the properties of construction materials and adapting them to new uses.

(ii) the development and use of indigenous building materials,

(iii) the possibility of increasing, with the current technology, the productivity of labour and capital resources by eliminating lost time and motion and/or by reducing waste of materials.

(iv) the possibility of increasing, for a given mix of labour and capital, the productivity of the workers by increasing their motivation, by changing the allocation of tasks among them, by changing the number of personnel under a supervising unit, or by alternative methods of payment;

(v) the possibility of increasing the usefulness of capital without changing the labour/capital mix, by replacing one unit of capital equipment by an alternative more productive piece of equipment; and

(vi) the possibility of devising an alternative mix of labour and capital; e.g. by using another technology which can accomplish the task.

The next step is to compute the discounted cost of executing each specific building operation by means of the several alternative feasible technologies. The appropriate technology for each operation being the lest cost alternative. The appropriate technology for the total project will be the combination of the individual appropriate technologies.

To be able to undertake this exercise, engineers, planners, as well as people involved in the decision making process are required to know the general implications relating to the choice of technology and also should have specific adequate knowledge about various techniques and relative productivity data on all the various building operations. There is a modest amount of data available pertinent to extreme manual techniques but useful information relating to intermediate technology is rare. In order to make available to planners and designers the information required to facilitate the choice of technology for various building operations, there is a need to increase the supply of data relating to intermediate methods now being used, and also a need to develop new building construction methods in this intermediate technology range. It is necessary that such date be compiled.

Let us now consider the choice of technology in relation to a housing programme in the country covering both the rural as well as urban sectors. First, we must realise that the factor endowment will be different for the rural sector as supposed to the urban sector. That being the case, the procedure outlined for determination of the choice of appropriate technology will yield different levels of technology, with the technology suitable for the urban sector probably being more capital intensive than the most appropriate technology for the rural sector. If a technology, that is intermediate between these two levels of technology can be chosen for both, this is likely fit in with a more unified or integrated economy.

If on the other hand the two different levels of technology are applied, this will lead to a dualistic economy. In terms of the macro economic analysis aggregation of the output arising out of application of appropriate technology in these two sectors will be maximised in the sense that it will contribute greatest to the growth of national product, but since, however, this will also promote dualistic economy, it will not alleviate poverty and unemployment, particularly in the informal sectors.

This indicates the problems involved in extending the procedure for selection of appropriate technology at project level to cover sectors. In the latter case it becomes necessary because of the complexity of the problem to identify the appropriate technology by also considering qualitatively the relative factors involved.

IX. NATIONAL ACTIONS

The major constraints to the selection of appropriate technology in construction could be split broadly into three:

(1) lack of information

(2) lack of adequate institutional arrangements, and,

(3) vested interest.

Lack of Information

In order to facilitate the smooth selection of technology, adequate information must be accessible regarding the available technology and their relevance to the specific situations in the country. This information should cover the resources available for use, the various tools and equipment that need to be developed or can be used.

A country without its own scientific and technological capacity will not be in a position to even identify let alone select the relevant appropriate technology. Thus, every country must first of all seek to build its own scientific and technological capacity, through establishment of the necessary scientific and technological training institutions covering the middle-cadre as well as the professional level staff. It is particularly important that countries encourage and sponsor research into the development of appropriate technology from the adaptation of existing technologies to the development of innovative technologies. Such research should give particular attention also to finding different methods of raising productivity as well as determining the optimum needs of labour and equipment for specific construction operations. Developing countries that sponsor such research activities will be in a position to benefit from the experiences of others. In order to ensure that the results of such research from a number of countries find applicability in most countries it is necessary at an early stage that attempts be made to standardise the collection of data and the results in order to facilitate the assembling and collation of such data.

Studies into various aspects of appropriate technology will have limited impact unless at the same time attempts are made to develop methods for the costing and administration of projects which will encourage the use of appropriate technologies. Attempts will also have to be made to develop governmental administrative procedures which will induce private contractors as well as other agencies to adopt appropriate technologies particularly those that are relatively expensive in terms of market cost.

In a region like Africa where there are limited resources, institutions dealing with the various aspects of the selection of appropriate technology for building construction, consideration may be given to the establishment of or else sponsorship of some of the existing ones by equipping them with staff and facilities to undertake research in the development of appropriate technology on a regional basis and to organise courses on the selection and application of appropriate technology in building construction.

Training on the selection of appropriate technology on building construction

One of the constraints to the adoption of appropriate technology in a wide range of construction operations is the fact that training courses in developing countries tend to rely on handbooks and teaching materials essentially obtained from the developed and highly industrialised countries. The compilation of appropriate handbooks as suggested will be a first step towards making available to university institutions which offer courses in building technology and building construction and also to technical institutions, materials which can be used in training students in the selection and adoption of appropriate technologies in building construction. But in order to facilitate the adoption of a changed attitude towards the use of appropriate technology university institutions as well as technical institutions should offer courses which will cover economics and other behavioral sciences as well as techniques of management which are essentially for an understanding of appropriate technology in construction.

Lack of Adequate Institutional Arrangements

A number of developing countries have not established the necessary institutional arrangements for controlling cost in construction and for promoting the selection of appropriate technology in construction in spite of the size of expenditure on construction. In many countries, the existing structure encourages excessive costs. Payment of consultants on the basis on percentage cost of the project is not likely to encourage the adoption of techniques that reduce costs.

In many countries, national organisations for planning, designing and construction of projects with interests extending over mere maximization of profits have been set up. But without adequate incentives for staff and essential machinery for review and appraisal of the stated objectives for these organisations have not been achieved. This has to be corrected.

Vested Interests

Perhaps one of the major constraints to the selection of appropriate technology is the existence of vested interests. These may be in the form of multinational co-operations operating in developing countries whose interest are not served by selection of appropriate technology in ay relevant area; or a private firm which finds that the selection of a particular appropriate technology may not be in the interest of the firm; or in the form of various individuals in government or private organisations who for a variety of reasons may seek to protect their interest by ignoring to adopt the relevant technology.

It has been stated earlier that the selection of appropriate technology must necessarily be within the context of the national social and economic goals and that the appropriateness of a technology cannot be dissociated from the appropriateness of the product.

If the national social and economic interests are to be served, it must be first recognised that public participation for technological decisions is a must; that political institutions themselves must be such as to make public participation possible in order to avoid the interest of select groups from swamping the interest of the majority. It is the view of some scientists and technologists that it is irrelevant to discuss appropriate technology within a political system which does not allow for the free expression of the people and where the interests of the governing class tends to ignore the wishes of the people. There is no doubt that unless the political system is geared towards ensuring the formulation and implementation of national social and economic goals which satisfy the basic needs of the people the question of the choice of technology will be irrelevant.

The governmental actions therefore should include the establishment of the necessary administrative institutions which will formulate realistic national social and economic goals reflecting the basic needs of the people and that such institutions should actively encourage the full public participation in their activities.

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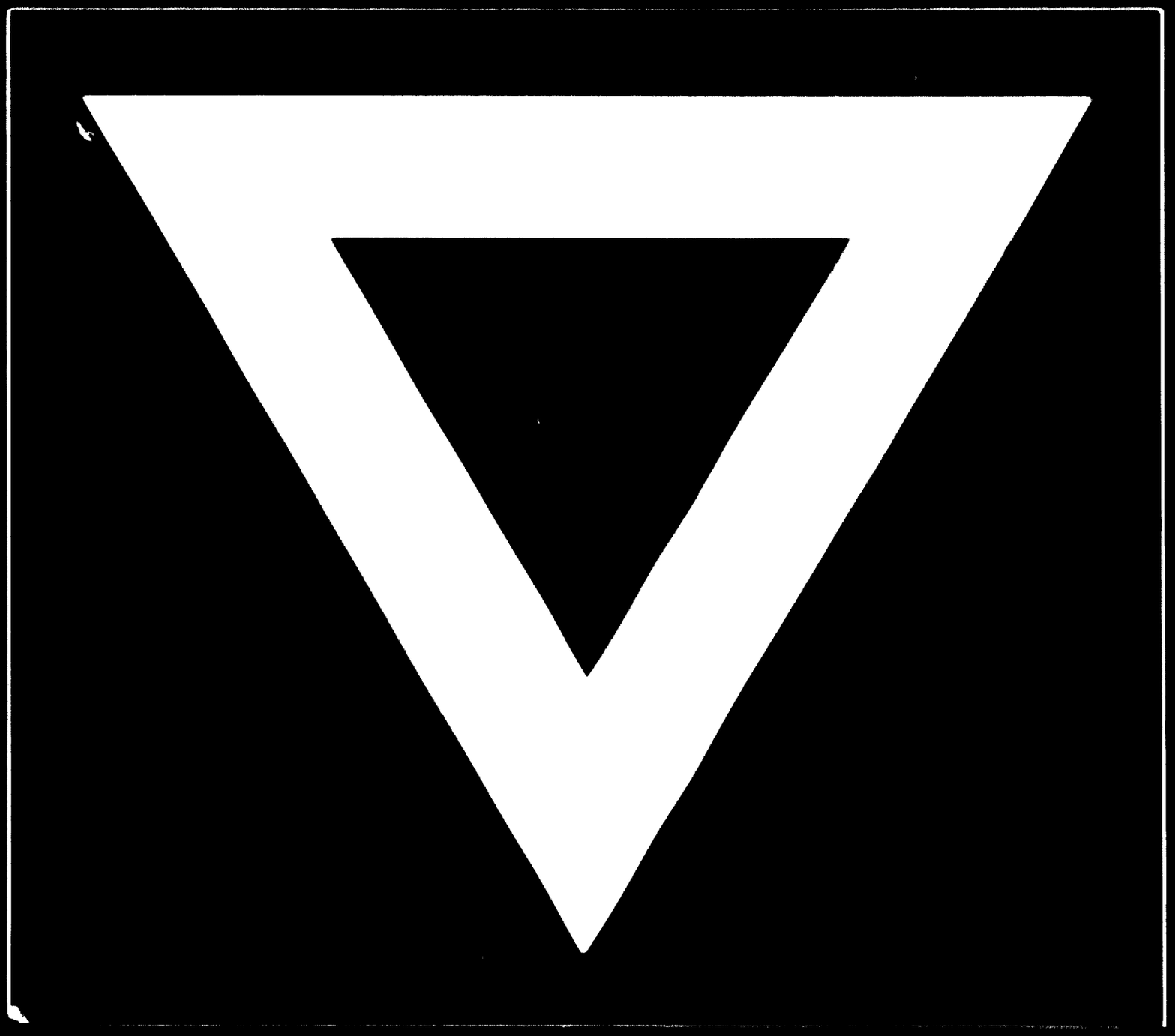

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