THE RELEVANCE OF TIMBER PREFABRICATION TO HOUSING PRODUCTION IN KENYA

BY

AGNES WAITHAKA

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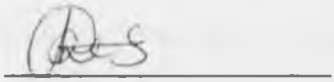
DECLARATION

I AGNES WAITHAKA, hereby declare that this thesis is my original work and has not been presented for a degree in any other University.



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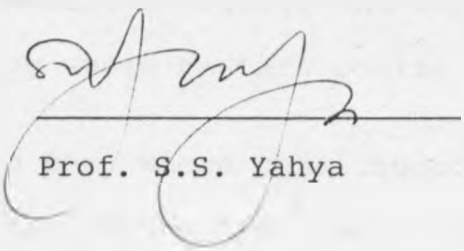

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ABSTRACT

This thesis constitutes a study which focuses on the relevance of timber prefabrication to housing production in Kenya. Prefabrication is an imported technology from the advanced countries and as such, a lot of emphasis has been laid on current issues regarding choice of production technology, technology transfer and measures of appropriate technology specifically as regards the construction industry in Kenya today. The core of the study focuses on the determination of the appropriateness of prefabrication of houses in Kenya using already developed economic criteria and the assessment of the economic impact of technology transfer in the construction industry using timber prefabrication as a case study.

There are six chapters to this study. The first section comprises the introductory chapter covering the general introduction formalities of the study. This chapter could be regarded as the backbone of the study setting out the problem statement, the objectives of the study, the study hypothesis, the scope and the significance of the study and the study methodology. Chapter two centres on the literature review especially as regards choice of production technique in the production process in general and in the construction industry in particular. Chapters three and four basically set out the historical development of prefabrication first in other parts of the world and then the discussion narrows down in chapter four to Kenya. Chapter five could be regarded as the core of the study

dealing with data analysis and finally chapter six gives the findings of the study, conclusions and recommendations.

To analyse timber prefabrication in Kenya, four firms were taken as the case studies. These includes Timsales, Economic Housing Group, GD Brothers and Forest Industrial Training Centre. The four firms comprises approximately 90% of the total prefab market in Kenya making it a good sample for any generalisations to be done. The data and information for these case studies were collected between August 1987 - January 1988 mainly through recorded information, interviews and field observations.

The results from the four firms have tended to have similar characteristics. Prefabrication in Kenya is practised on a very small scale with the main market limitations being the small size of the domestic market and the existing building regulations which prohibits the use of inflamable materials in urban areas. As it is currently, prefabrication may be regarded as an appropriate technology as far as production of houses is concerned. However, prefabrication on a large scale should be undertaken with a lot of caution because the prerequisites for large scale production are such that they render prefabrication in Kenya inappropriate. The dividing line is tricky and this requires a systematic approach to technology transfer to ensure that any foreign technology is carefully scrutinized to determine whether it is appropriate or not.

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CHAPTER ONE

INTRODUCTION

Problem identification

An important policy problem facing African countries and indeed all the developing countries is that of identifying the appropriate technology for their industries which would simultaneously be labour-intensive and efficient in the use of capital whether in agriculture, manufacturing or construction industries.

The dilemma cannot be more aptly put than in the words of UNIDO. The writer observes that independence for most developing countries has brought the desire to industrialize as quickly as possible and to maximize the inflow of technology from the advanced counterparts[1]. In the past, there has been a heavy inflow of capital - intensive technology from the advanced to the developing countries. Two basic problems arise from this state of affairs. First, capital - intensive techniques of production require very heavy investment in plant and machinery and these are unavailable to most developing countries or too costly to get. Secondly, capital - intensive methods of production are labour-saving, thus creating unemployment in such regions where labour is abundant and cheap. In recent times, there has been a lot of activities in trying to re-examine the factors and methods of production in the developing countries neccessitated by the rising cost of energy and the ever increasing debt burden.

Additionally "the increasing sophistication, volume and commercialization of science and technology on the international markets in recent years demand a more systematic and analytical approach to choice of production technology in the National Development Strategy"[2]. As a result, the National aspirations of most developing countries in recent years has been to end total technology dependence and achieve self-reliance in technology advancement in order to reach a stage where further development of the country's technology becomes self-sustaining. Such a move would place a country like Kenya in a position in which she would be able to solve her own social-economics problems without any undue interference from outside.

In most developing countries, the construction industry has also suffered from the above problems. The industry has tended to use capital-intensive methods of production in the face of abundant and cheap labour. Secondly, whereas the region is full of raw materials suitable for local use, building materials imports accounts for approximately 50% of the total cost of construction in most of these countries[3].

Kenyan construction industry is not immune to all these problems. Historically, the production technology - machinery, equipment, manufacturing process and the knowhow - has mostly been imported from advanced countries. As in other cases discussed above, this type of production has tended to be capital - intensive and labour - saving. In Kenya, policies documented on the choice of production

techniques have tended to be general in nature and unspecific. For example, whereas the government is aware of the need to do a systematic choice of technology as can be construed from the four development plans since independence, no quantitative method of achieving this is given.

The 1966-70 development plan for instance stated that:

> ..... in highly developed countries with severe shortages of unskilled and cheap labour a range of construction machinery has been developed which drastically reduces the demand for labour. To use such labour-saving machinery extensively in Kenya would mean almost a waste of capital and foreign exchange in the purchase of machinery, spare parts and maintenance expenditure and fuel ..... the government will keep such situations under review and will promote measures which would enhance use of manual methods of production wherever cost discrepancies are not prohibitive[4].

From the foregoing, it is clear that the government of Kenya realises the need to restructure institutional arrangements in order to ensure an effective process of acquisition and transfer of technology. However, there exists impending obstacles which in one way or other prevents the full realization of the national goals and objectives as far as choice and technology transfer is concerned.

The National Council of Science and Technology for instance has identified several problem areas which characterize the difficulties encountered by the government or the country at large in technology transfer.

(i) Firstly, the government has little say, if any, in decisions regarding the type of technology to be acquired and transfered into Kenya. A large proportion of production techniques is acquired by subsidiaries of multi-National Corporations operating in the country who, through conditional agreements dictates the type of technology to be acquired, capital equipment to be used, raw materials and other factors of production. Such arrangements leave no room for negotiation or modification of the technology thus acquired.

Another substantial part of production techniques is acquired through partnership agreements entered by the locals and foreigners. In most cases than not, the foreign partners holds the majority share and consequently has the majority votes in issues regarding the production techniques to be used and what factors of production are to be used.

Pathetically, even the local enterprenuers who are independent of foreign shareholders are dependent on the foreign salesman for advise due to lack of technical knowledge.

In addition, technical cooperation programmes provide financial assistance (tied credit) conditioned to the purchase of goods and services from specific suppliers or countries both through bilateral and multilateral agencies.

All these factors presupposes lack of autonomy on the part of the government in decisions regarding the choice and transfer of technology.

(ii) Secondly those involved in the production system lacks information regarding the sources, alternatives and conditions under which each technological package is negotiated. This in turn leads to two main problems - First, there is importation of expensive and inappropriate technology which is rarely modified and improved to meet the local conditions and secondly, there is lack of initiative to develop and improve local appropriate technology.

(iii) Thirdly, it is argued that there is lack of support from the public technical institutions that could help private sector in the selection and choice of foreign technology. Hence techniques acquired are inappropriate to the national needs and drain the country of foreign exchange because they are purchased at exobitant prices[5].

The transfer of technology from the advanced to the developing countries entails substantial outlay of national funds. For this reason, the choice and selection of appropriate production technology is of paramount importance especially in construction industry which is a major economic

activity in Kenya. The choice of the suitable production method is a very important task therefore and should be based on careful, systematic and detailed analysis. In the past however, such selection has been undertaken in an erratic manner and owing to the lack of formal procedure, the choice has been more a matter of persuasion or chance than of objective judgement. The choice in most cases than not has been based on profit and personal motives rather than on systematic economic analysis.

Innovations in and industrialization of the production process in the construction industry have been viewed as the most promising possibilities for reducing costs, increasing productivity and in certain cases improving the quality. It is interesting to note that even in the most advanced countries, the problems of industrializing the building sector have not been solved yet. In developing countries and Kenya in particular the problem is more acute and of greater magnitude in that there are a number of problems which are met with. Availability of cheap abundant labour, lack of mechanical equipment, the presence of simple organizational set-ups, use of simple tools and equipment and so on, pose as major constraints to building industrialization. These among others should be the factors against which the particular production technology being imported should be gauged to see how appropriate it is with respect to resource endowment.

Industrialization of building (prefabrication) may be uneconomical in Kenya given the resource endowment. No quantitative and systematic study has been undertaken in this area. It is the objective of this research thesis to try and determine the appropriateness of prefabrication in Kenya using already developed economic measures. The foregoing objective could possibly be re-stated in one major question.

Main question: what are the economic implications of prefabrication as a building process in Kenya?

Sub-problems:

(1) What are the economic measures of appropriateness

(2) What is the spread, extent and status of prefabrication in Kenya

(3) Is prefabrication appropriate in the building industry in Kenya?

Objectives of the study

(1) To determine the appropriateness of prefabrication of houses in Kenya using already developed economic criteria

(2) To assess the economic impact of technology transfer in the construction industry using timber prefabrication as a case study.

Hypothesis

Prefabricated building systems are inappropriate in the Kenyan context considering the country's resource endowment and the present level of economic growth and development.

The scope of the study

The study will try to determine the economic justification and impact of prefabrication in Kenya. However, due to financial and time limitations major or special attention will be laid on timber prefabricated housing. This sector has been selected for study for two basic reasons:- First, housing the poor people in Kenya has been a major concern for the government since independence as shown in the four development plans. Consequently issues touching on the choice of the appropriate technology in this area is of paramount importance. Secondly most prefabricating work has tended to be concentrated on timber structures ratherthan other building materials thus providing a good area for study.

The significance of the study

This study is expected to have a lot of significance to various people and bodies. To the policy makers, the need for a systematic choice of production technique in construction industry and indeed any other economic sector will be shown very clearly.

Secondly the study will make some contribution to the existing academic knowledge. No study has been found so far [illegible] the Kenyan construction industry which has used economic measures to determine the impact of an imported technology. The study's thrust and contribution in this area will be in the ability to use already developed economic theories in the context of construction industry.

Thirdly, the study will be of use to the students of building science in the department of Land Development. It is interesting to note that very little has been done on prefabrication of buildings in Kenya. This report will therefore give some information on the nature and extent of prefabrication in the building sector in Kenya.

Research methodology

(a) Basic procedure for technology selection.

It has been a point of general concesus that the knowledge and overview of available technologies is not only essential but also instrumental in the decision making process on whether to adopt a certain technology. The selection procedure as such has necessarily to be based on a systematic appraisal of specific conditions and requirements of the recipient country. The major question however facing many developing countries is what exactly is appropriate technology and how does one go about getting the right combination or the most appropriate technology among various alternatives. The answer to this question is not straight forward and consequently, there is need to look at what other writers have done in this area and the criteria they have used to adopt a given technology as appropriate.

(b) Appropriate technology

There has not been as yet an agreed precise meaning of the term 'appropriate technology' but there seems to be

a common thread in the arguments among many writers. From various literature, it is easily found that the major concern of finding appropriate technologies has grown out of the feeling that the present trends in the technological development if continued will lead to:-

- ° Dualistic economic development in terms of places and concentration of power in few hands;
- ° Permanent international debts.

It therefore appears that those who advocate 'appropriate technology' desire that the production process be organised on a scale which would ensure:-

- ° Widespread spatial dispersal of economic activities;
- ° Generation of adequate employment and
- ° Maximum exploitation of the resources found in a particular country.

In a bid to bring out the meaning and application of the term appropriate technology, Garg (1973) suggests that all work related to appropriate technology should address itself to two major questions:-

1. Appropriate to whom? and
2. What is appropriate[6]?

With reference to the first question 'appropriate to whom', he says that there are three levels to be considered:-

- ° The country as a whole;
- ° The particular region in a country and
- ° The individual or group of individuals.

He reckons that:

> The inherent tendency of concentration of production in particular regions as a result of adoption of large scale technology creates regional imbalances within the country with the concommitant problems of poverty, unemployment and social political tensions[7].

With regard to individual or group of individuals, Garg contends that:

> The problem become still more complex because while large scale technology of production may increase production per person tremendously and may also result in enhancement of wage rates to a level high enough to give a worker very good living conditions, it may simultaneously result in tremendous redundancy and unemployement[8].

With reference to the second question 'what is appropriate technology', Garg argues that:

> The main point to be considered is that the impact of a technology is limited to the surplus which it generates. Whoso-ever has access to this surplus is the biggest beneficiary. The modern large-scale automatic technology concentrates the surplus into few hands in a free enterprise country and to the state in a community society[9].

Based on all the above, Garg defines appropriate technology as:

> A technology which can carry out production activities on the smallest possible scale yet has capacity to produce the same quality product at a competitive price as that of large scale industry[10].

In a seminar held by United Nations Development Organisation (UNIDO) 1980, the concept of appropriate technology was viewed as being the technology mix contributing most to the economic, social and environmental objectives in relation to the resource endowments and

condition of application in each country. Appropriate technology was viewed as being dynamic and flexible in nature and in normal circumstances as responsive to varying conditions and changing situations in different countries. An important overall objective of appropriate technological choice was viewed as the achievement of greater technological self-reliance and increased domestic technological capability together with the fullfilment of other development goals[11].

Stewart (1973) further simplifies the meaning of the term appropriate technology by defining it as "that technology which is cheap enough to be provided in large numbers and simple enough to be used and maintained by rural and small town populations without sophisticated technical or organizational skills and with very low incomes[12].

Jhingan summarises all the foregoing by carefully pointing out the characteristics of an inappropriate technology relative to what is generally accepted as appropriate technology. Below are some of his important observations.

- Advanced technology tends to be capital-intensive and labour-saving. This is inappropriate in a country where there is a very high rate of unemployment and scarcity of capital. Secondly, imports of plant and equipment are not only expensive but also entail a number of difficulties with regard

to repairs, maintenance and availability of spare parts.

- Advanced technology requires supplimentary supply of highly skilled, technical and managerial personnel who are scarce in a developing country.
- Heavy imports of capital and other inputs necessitated by the use of large-scale advanced technology leads to balance of payment problems and the resulting economic dependence on advanced countries. Secondly use of large-scale technology implies existence of domestic markets but the small size of markets in poor societies suggests use of small-scale enterprises.
- There exists a big technological spread - gap separating the techniques already in use in developing countries and those being imported from advanced countries - the larger the gap, the greater the social discomfort and unrest following industrialisation through introduction of imported technology.
- Lastly, the introduction of advanced technology presupposes the existence of transportation and communication facilities, power, institutional framework and so on which are non existent in a developing country or else will take decades to build[13].

Under the above circumstances, concludes Jhingan, the use of advanced technology will only result in "repeated breakdowns of machinery, lower production, increase of costs and waste of capital"[14]. Consequently, he observes that the appropriateness of a technology for an area is dependent on resources, patterns and markets and that these factors should be carefully analysed before any decision is made on the choice of production techniques in any industry.

In the construction industry and the housing sector in particular, a lot of factors have to be considered when dealing with the issue of appropriate technology. Abdul Kanoo, Under-Secretary of Housing in Bahrain noted that in his country a lot of factors are considered when adopting any industrialised building system. He lists the following as the basic factors taken into consideration.

- Flexibility of the system in meeting the local needs, for example, can the models be easily changed to meet the local specifications?
- Can the system be easily acceptable or will there be a cultural clash with the existing system?
- How feasible is the system in terms of costs of production, cost of plant and site equipment and so on?
- What is the contribution of the system to the economy in terms of balance of

payment position, employment promotion and so on?

° Is the managerial and technical personnel adequate to manage the building system[15]?

Looking at the choice of building method from Kanoo's point of view implies that if a given system satisfies the above criteria, then it can be considered as an appropriate technology.

Edmud uses almost the same criteria with different wording but adds a sixth one which is very important

° Does the particular system adopted conform to the laid down rules i.e. building laws and regulations and other housing policies of the recipient country[1] ?

For the purposes of this study, various economic measures discussed above will be adopted. These are:

(i) Capital/labour ratio

It is a point of general agreement among most writers that in general terms, there exists cheap and abundant labour and scarce capital in developing countries like Kenya. Capital scarcity and availability of cheap labour suggests the desirebility of labour-intensive economic activities in these countries. Capital intensive techniques on the other hand require specific conditions which the developing countries may find hard to get or too costly to get. Therefore when any country having abundant labour chooses to use capital - intensive methods of production or if the capital/labour ratio is high beyond other comparative

activities producing similar goods at the same time, then such a technique is regarded as inappropriate. A few distortions arises when a country like Kenya uses capital-intensive methods of production:-

- ° The unemployement rate in the country is accelerated. For example studies done by Edmud Ward suggests that industrialised building systems are saving 35-52% labour on houses and flats[17].
- ° There is an increase of debt burden resulting from importation of machinery and equipment and related spare parts
- ° Adoption of capital-intensive production techniques presupposes the availability of technical skills to man and operate the production plant which is hardly the case in Kenya. For example the 1966-70 development plan acknowledged the critical shortage of supervisory and skilled workers in the construction industry. To the present day the situation has not improved much[18].

Capital/labour ratio consequently forms a major basis for measuring the appropriateness of a given technology and is going to be adopted for this study

(ii) Organization of production

Stewart illustrates the importance of this criteria on the basis of a comparison between a multinational enterprise and a family enterprise. The multinational firm

consists of units of say approximately 1000 workers. Each of these units are producing on a mass scale parts of a product which are assembled later in another plant. This kind of organization is only possible if technical knowhow permits thorough specialisation, mass-scale production and sophisticated management techniques. The family firm on the other hand is much smaller in size so that necessary management techniques are less complicated[19].

In most advanced countries, firms have grown from the cottage industries of the 18th century to the increasingly large scale production units of today. This has resulted in substantial economies in the costs of production because of economies of large scale production, machine specialization and better technology development. The transfer of advanced country technology thus involves the transfer of large scale production which has a lot of disortations in a developing country like Kenya.

- Obviously the size of plant is related to the size of the market which is usually dependent on the income per capita. Assuming the same plant is operating in a developing country where per capita income is much lower, serious problems concerning excess capacity are bound to arise
- Advanced technology requires the existence of the modern organizational and managerial skills which are very scarce in Kenya.

Concerning this aspect Stewart has this to say:

> The large gulf between the organizational form to which advanced country technology is designed and suited - where a plant employing 1000 workers is typical - and the form of organization indigenous to most third world economies - where family enterprises employing less than 20 people are notably large and successful - has meant that the use of advanced country technology also generally requires the use of advanced country organizations. These organizations are directly imported in case of foreign investment, in other areas they are indirectly imported via management contracts or training managers abroad. Advanced country technology thus lead to advanced country techniques of management. It rules out the development of local enterprenuerial talent - the jump between current experience and what is needed is far too great[20].

° The organization of large scale plants requires appropriate infrastructural and institutional networks and services which are not available in Kenya or they will take decades to build.

(iii) Materials used and other inputs to the industry

Transfer of technology from the advanced to developing countries has the tendency to favour materials, base of their origin. As a result, there tends to be heavy reliance on imported materials thus draining the country of foreign exchange. It has already been mentioned that whereas most African countries have natural building materials, import of such materials continues to constitute about 50% of the total construction cost for most projects. A lot of studies have been undertaken in recent times touching

on the issue of appropriate building materials with a general feeling that developing countries would achieve more in terms of constructed facilities if use was made of local materials. Traditional materials such as soils, lime, timber and so on have long been in use in most developing countries without any standards or specifications regarding their production or use in construction. If standards, specifications and testing procedures are adopted on a large scale, they are likely to improve the acceptability of building materials and thereby reduce dependence on imported materials. A number of references are available on this issue and can be easily available. For example UNIDO publications, HRDU publications, Habitat publications and so on.

(iv) User reaction

Another important measure on how appropriate a given technique is, is on the user's reaction. As has been mentioned, a steady market is necessary to support large scale production of prefabricated elements. If the demand is low mainly because the particular technology is not acceptable to the 'locals', then the technology is inappropriate.

Secondly, the class to which the technology is directed is another measure. If in the case of Kenya the technology is supposed to meet the needs of the low income bracketed people and does not succeed in doing so, then the technology is inappropriate.

Four firms i.e. Timsales, Economic Housing Group, GD Bros and Industrial Training Centre have been chosen as the case studies. This is basically because they are the major leading firms in prefabrication taking about 90% of the market. These therefore constitutes a significant sample from which generalization on the impact of prefabrication in Kenya can be arrived at.

(c) Data Required

The data required for this study hinges on prefabrication in general and issues on choice of production techniques as applied in the Kenyan building sector. Specifically the following data will be required:-

- Nature, extent and status of prefabrication in Kenya;
- Capital/labour costs of prices for various systems;
- Production cost schedules for different systems;
- Organizational structure in terms of the requirements of managerial and technical skills;
- Materials used for the systems and their sources;
- Sales schedule for various firms and capacity utilization;
- Market opportunities and demand conditions in general.

(d) Collection of data

Questionnaires - a written questionnaire will be administered directly to various parties of interest to the study. The parties include managers and other officials of the four companies. Questionnaires will also be administered to selected users of 'prefab' timber houses to get information on user reaction.

Some data will also be obtained from company documents, book review, journals, conference and official meeting reports, Government documents and publications.

Field survey and personal observation will be an essential part of this study. The four companies and their production sites will be visited and the necessary observations made.

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CHAPTER TWO

LITERATURE REVIEW

Definition of important terms

There are some terms used in connection to industrialization and prefabrication of buildings which it is important to explain in order that the flow of argument in later chapters is not interrupted by a digression to explain their meaning. These are:-

(a) Industrialization

Testa (1972) defines industrialization as "a process which by means of technological developments, organizational concepts and methods, and capital investments tend to increase productivity and to upgrade performances"[1]. From this definition it can be construed that the major objective of industrilization in any sector of the economy as twofold

- to increase productivity and
- upgrade performance[2].

(b) Industrialised building systems

Dietz who has given one of the most comprehensive definition of industrialised building systems defines them as "those incorporating a total integration of all subsystems and components into an overall process, one fully utilizing industrialized production, transportation and assembly techniques"[3].

Testa goes a step further and classifies building systems into four comprehensive categories. These are, prefabrication, modular coordination, rationalized and equipment-oriented systems. He points out however that the four forms are not collectively exhaustive nor mutually exclusive and observes that "new forms may and will develop while the four forms can and do co-exist within the same organization"[4]. Below are the definitions of the four categories.

(c) Prefabricated building systems

It is well nigh impossible to define the term prefabrication in terms of compatible qualities. There seems to be no exact boundary between prefabrication and other forms or methods of construction and on this account, it is prudent to keep an open mind. The difficulty in its definition and in trying to give it boundaries can be easily seen from the various attempts by different authors to define it.

Kelly (1951), probably the one who has given the most comprehensive account on prefabrication in the United States admitted that a distinction between "prefabrication" and "conventional" construction may become meaningless within a few decades of his writing[5]. Rogers (1965) writing about ten years later agreed that the 2nd decade bid fair to vindicate Kelly's forecast[6].

Kelly attempted no definition of prefabrication of his own but quoted several definitions by other American writers. From prefabricated houses, Kelly cited them defining prefabrication as:

> the one having walls, partitions, ceilings and roof components of sections of panels varying in sizes which have been fabricated prior to erection on the building foundation. This is in contrast to the conventionally built home which is constructed piece by piece on the building site[7].

From Howard T. Fisher, Kelly quoted him defining prefabrication as:

> a question of degrees. To over-simplify and to look abit into the future, if you shove and snap a product into place in the field, that is prefabrication. If you mix, cut, spread, fit, patch, that is not prefabrication. If the field operation be essentially assembly rather than manufacturing you have prefabricated ..... The amount of scrap and waste that must be cleaned up from the building site may be taken as a rough index of the degree of prefabrication employed in any given building operation since waste result principally from a manufacturing not an assembly process[8].

From all these Kelly concludes that in general usage all "prefabricated" construction is "unconventional" but not all "unconventional" construction is "prefabricated". Secondly, there may be said to be various degrees of prefabrication which pre-cutting might be one, the fabrication of panels another, the construction of volume enclosing sections a third and the manufacture of a complete mobile dwelling unit probably the ultimate[9].

Rogers dealing with the history of prefabrication in Great Britain quoted R.L. Davison as defining prefabrication of a house as "the assembly in varying degrees of parts of sub-assemblies into sections to be assembled into a structure as distinguished from the assembly of parts during erection of the building"[10].

For the purposes of this study, prefabrication will be taken to mean a form of industrialisation which consists of producing parts which when assembled will give a finished product. When utilizing this form it does not matter whether it is factory or site-prefabrication. "Of more relevance" observes Testa is the fact that "when utilizing this form of industrialization we have first to design the finished product, then break it down into meangiful parts and finally assemble them in correct sequence and order"[11].

(d) Modular-system building

This, says Testa is "the system where dimensionally and functionally inter-related components are designed, general rules on how these components may be connected established and with the components the product is designed"[12]. Through the coordination of the various building parts and components, flexibility in use combined with ease of production is realised. The chief pioneer in this field is the famous American Albert Farwell Bemis who proposed the 4" module and argued that if building

materials and components were manufactured in coordinated sizes and with provision for certain standardized joints and connections, they could be assembled with relative ease and with little waste into a wide variety of structures designed along modular principles[13].

(e) Rationalized building

This method is based on the attempt to increase productivity and performance by application of all possible measures for streamlining production, for ensuring the best utilization of materials, equipment and labour on the building site[14].

(f) Equipment-oriented site production

In this production method, the objective of increasing productivity is achieved by utilization of highly sophisticated equipment which can with little human intervention produce complete buildings on the site[15].

(g) Conventional building

The consequences of traditional building constitute well defined boundaries between structural work, cladding, carcassing, finishing trades and decorations and so on. Such divisions are less clearly defined in system building where a structural element may contain service pipes and electrical conduits, be faced internally as to require only decoration on exposed room surfaces[16].

In conventional building method, most of the operations are carried out on the site in in-situ form. Note should be taken however, that even what we call conventional house building has been industrialised to some extent. This could be due to the time saving ability of fabricating at least some elements such as doors, windows, staircase etc off site rather than tidiously doing it on the site.

(h) Technology

R. S. Merill who has been cited by Francis Stewart defines technology as "the skills, knowledge and procedures for making, using and doing useful things"[17]. For the purpose of this study, technology will be taken to mean "the sum of all hardware components - machine and the process of production - as well as the software (knowhow) - skills, knowledge and procedure for making, using and doing useful things"[18]. This definition is appropriate because it covers the structure of production as well as the nature of the process adopted. It includes administration and management systems as well as types of machinery used.

(i) Appropriate technology

From the various definitions adopted by various writers, appropriate technology as used in and for this study will be defined as those technologies which take into account social - economical and environmental setting

and conditions of a given country or a particular region in the country under review. Inappropriate technologies have the tendencies to use resources of the country or region of origin ignoring those of the particular country or region under consideration.

Choice of production techniques

According to Jhingan, (1975) the major problem facing developing countries is how best to utilize the available resources in order to accelerate economic growth and development. The choice confronting most developing countries is between (1) labour-intensive or what is normally referred to as traditional technology and (2) capital-intensive or what most writers refer to as the modern technology. It is these two basic factors of production i.e. labour and capital which poses the problem on the choice of production techniques. It is generally agreed that different techniques implies different strategy for economic growth and development. If any country is to maximize its economic growth and development, it must choose those techniques which are most efficient than others - herein lies the problem facing the developing countries.

A significant question over which some dispute has arisen among writers and scholars in economic discussions is whether a developing country should use the technology

which maximize the use of existing resources especially the capital/labour proportions or whether it should anticipate the relative growth of capital and begin to use capital-intensive methods before its capital endowment is really suitable for this. In particular, the question is whether countries at early stages of economic growth with capital scarcity and abundance of labour should take advantage of modern technology which originates from advanced countries where capital is abundant and labour is relatively scarce or whether they should devise technologies of their own. Drawing from the vast literature on this issue, it is abundantly clear that the long awaited answer has not yet been fully discovered.

For a long time now, there has been a strong belief that massive investments into the developing countries is the only answer to the economic problems of such countries. In the past, the feeling has been so strong and many scholars felt that the only way out for third world countries is through high importation and heavy reliance on advanced technology. Among the most outspoken on this issue are Galenson and Leibenstein who are quoted by Jhingan as alleging that "... successful economic development ..... particularly on the face of gross backwardness hinges largely upon introduction of modern technology upon as large scale as possible"[20]. They base their argument on the premise that labour

productivity will be higher since productivity of labour is directly proportional to the amount of capital injected and this in turn will have positive effect on the surplus available for further investment and miraculously the vicious poverty circle will be broken. The major question to ask then is "has this actually succeeded in countries where massive capital investments have been undertaken?"

Once again drawing from the vast literature in this area it is very doubtful whether this has taken place. Stewart, a leading economist on technology choice and transfer argues that "despite the rapid investment and output growth in most underdeveloped countries, underdevelopment has persisted and seem to be on the increase"[21]. The next question that we are bound to ask is why and how does this happen?

Mier (1984) writing on the leading issues in economic development attributed the many economic problems facing the developing countries to the tendency of such economies to rely on advanced technology which are "ill-adapted" or "inappropriate" to the conditions prevailing in such countries thus causing a lot of inefficiences in the production process. He pointed out the fact that the characteristics of a particular technology as largely determined by the nature of economies for which they were designed. Such characteristics are in turn determined by various factors such as the general income level, resource availability, environmental factors such as

climatic conditions and so on. Mier observed that in each of the above respects, advanced countries differs grossly with the developing countries. This in essence implies that, no matter the amount of capital injected to developing countries, development will and does not occur because the wrong factor proportion is used. Although labour, as Galenson and Liebenstein suggested is likely to be more productive, it may well be found that productivity is only limited to a small proportion of the labourforce leaving majority of the population unemployed or grossly underemployed[22].

Hayek (1972) for instance says that advanced countries would be doing more good in less developed countries by spreading understanding of basic economic principle instead of elaborating sophisticated economic growth theories prevailing in their countries where resource endowment favour them. He gives an example of a bulldozer costing $5000 and shovels costing $2.50 each. He argues that if 150 men can shovel in a day what one man can move with a bulldozer and if manpower is abundant, capital can be saved by buying $375 worth of shovels and thereby avoid open or disguised unemployment[23].

Jequier (1976) tends to give a very good summary on all the foregoing. He argues that advanced technology is inappropriate in a developing country's setting mainly because, it is very costly, draining the country of its

foreign exchange; such technologies tend to favour educational and infrastructural institutions which takes decades to build and most of all their introduction tends to inhibit the indigenous innovative capabilities which are necessary if development is to be realised. He observes that:

> The symbols of modernity can be purchased in the international markets, but development is a complex social process which rests largely upon the internal innovative capabilities of the society. Imports of foreign ideas, values and technology has a major role to play but very few societies in history have developed exclusively on the basis of imports ....[24].

Therefore, as the problems associated with advance technology become apparent, new positions based on local handicraft techniques, self-help and use of simple building raw materials such as earth and bamboo become fashionable[25].

Industrialization of buildings and issues on appropriate technology

A lot of debates in this area has been based on how appropriate these systems are in a developing country's setting given the resource availability. Testa commenting on this issue argued that industrialisation of buildings may not be an answer to the existing housing problems in developing countries mainly because:

> °It is a foreign technology and might clash with the cultural and social set-up of these societies thus causing resistance;

- successful industrialization presumes that technical and managerial skills are available and that a network of subsidiary manufacturing industries exists[26].

Tom Kajumba in his thesis report on prefabrication in Uganda, observed that prefabrication of houses in that country has caused:-

- A drain of foreign exchange due to importation of raw materials;
- High capital investment in a land where labour is abundant and;
- Reduction of employment opportunities resulting from mechanization[27].

The conclusion which can be drawn from the above is that there is need for carefull consideration before prefabrication is accepted wholesale in a country like Kenya. Davis cautions that "the history of innovation has been strewn with failures because either their proponents did not comprehend the prerequisite of industrialization or underestimated their impact on the innovation's future"[28]. The question to be asked at this juncture is what these prerequisites are which should be taken into account when selecting any construction technology. Davis pointed out two basic prerequisites to prefabrication. These are:-

(a) Production continuity

It is well known that the primary objective of industrialisation is one of reducing unit cost through continuous production of standardized elements. To achieve

this, the production line has to be sustained for long periods of time. Only then, asserts Davis "will management and labour reach high levels of productivity and the risk of undertaking the investment start to pay off"[28]. This in essence suggests the need for big and steady markets to support the production line. Unlike the case of a conventional builder who builds 5 to 25 units per year, the prefabricator must produce hundreds of units annually to obtain real cost savings.

(b) Steady supply of elements

In addition to the need for continuous production, other supply factors are necessary. These includes adequate and cheap land for factory location, steady supply of raw materials for volume production, dependable supply of labour, availability of machinery at reasonable prices, supply of money at reasonable interest rates, good and efficient organizational and management structures and other infrastructural institutions to support mass production.

Moavenzadeh writing on industrialization of the building industry in developing countries agrees fully with Davis on the above two basic prerequistes for industrialisation. He goes further however and adds standardization, integration and mechanization as prerequisites which should not be ignored. He argues that "standardization and intergration are mandatory to permit mass production and predictability of interface.

Mechanization of both muscle power and brain power with machinery and automation respectively results in standardized products at reasonable prices or costs"[29].

Industrialization requries the introduction of mechanical equipments in building and assembly operation inorder to increase productivity, minimize heavy manual work and improve quality. Site operations such as concreting and mixing of mortar, vibration and compaction, transportation, plastering etc. could all be done by the use of machines which are faster, precise and efficient. On the other hand, standardization and mass production together with functional simplicity are necessary if savings in time and money are to be realised.

Integration and good coordination of the various subsystems in the building process implies a smooth and continuous production avoiding all delays and time waste which is a characteristic of conventional building methods where the parties involved in the building process are separated with each trying to advance their own interest regardless of the goals and objectives of the overall project. The coordination of the building process in industrialised system tends to be more complex requiring well trained and experienced managers to cope with the extra responsibilities . This issue implies a good liason between the professionals and the contractors, planned supply of raw materials, timely delivery of finished

goods and efficient stock control measures. In this way it is easy for the firm to achieve an overall optimization goal.

The presence or absence of subsidiary and supportive factors which may not affect industrialization of buildings directly but which nevertheless have profound impact should be seriously considered. For example, institutions and facilities for training manpower in the new skills, subsidiary factories for the manufacture of raw materials; prevailing local by-laws and building codes; availability of suitable means of transport to facilitate delivery of essential goods and so on.

Materials used for prefabs

Almost all the building materials can be used in prefabricated form. This of course presupposes the existence of the necessary production technology and economic status supportive to the development and maintenance of the technology. Presently however, wood, concrete and steel are the predominant materials used in prefabrication of houses. Throughout the development of the industry, wood has been the oldest and widely used material in prefabrication mainly because of its ease in handling, availability and in most parts of the world it is one of the major traditional building material. With time however, the use is becoming less frequent because of:

°rising costs of timber due to shortages

° wood frame construction can only be used for low-rise structures thus limiting its use in storeyed buildings.

Concrete and steel are equivalent in use, and their functions are often interrelated. In most parts of the wolrd, however, steel is an imported item and its use places a severe pressure of balance of payments. Its use in construction is, therefore highly curtailed. In addition steel structures in the tropics are very uncomfortable due to high temperature levels. Consequently steel and aluminium are mostly used for building frames leaving enclosures to be made of other materials.

Concrete as a building material has several advantages -: It provides excellent sound insulation, has good thermal qualities, good fire resistance qualities, can be moulded to almost any shape and provides a monolithic structure when properly reinforced. Consequently many systems especially in Western Europe are concrete because it is readily available in most areas, versatile in its use and relatively cheaper than most other building materials on a cost/unit of volume basis.

Prefabricated systems

A building system is often defined as "the method by which a variety of structural and mechanical units are assembled, erected and installed to produce structures that will function for a specific use or combination of uses"[30]. There are two distinct categories of system buildings:

(a) Open system

These are precision systems requiring that all the components needed for a complete building should be standardized and obtainable from various sources and that they should be able to fit and work together. Such components are offered in markets through catalogues, just like any other manufactured product. Inorder to facilitate interchangeability between components from different sources, manufacturers adopting this system should be ready to guarantee specific tolerances for their factory produced components and should ensure the most exacting standards of accuracy. The open system offers greater scope for extensive industrialization and allows a lot of freedom in design. But one of the major problems with the open system is the development of a basic module which is a basic neccessity if diverse components from varying manufacturers are to fit together. It is generally agreed that some kind of modular coordination is needed if construction and building design are ever to

be simplified, but as yet, no standard module has been generally accepted.

(b) Closed system

The closed system is characterised by components which are peculiar to one system and which cannot be combined with those of other systems. In general the elements of such a system cannot be ordered individually, but must be purchased as a portion of an entire project. The elements are manufactured to a specific requirement for use in a known operation, and they need not be standard. There need be only a requirement for a sufficient number of identical units so that an economically satisfactory production can be established. Though all the details are predetermined and flexibility is limited, the closed system is appealing in that all parts for a complete system come in a single package.

Types of prefabricated elements

Prefabricated construction involves the fabrication of building components either off-site in a factory or on-site away from the final position of the components in the building. In the ideal situation there are major cost saving factors of factory fabrication as compared with on-site fabrication-:

° There is likely to be an improved material handling e.g. quantity purchasing, reduced

wastage and/or vandalism;

° In the factory use is made of cheap labour resulting from a reduction of hours needed due to high labour efficiency, complete control of adverse weather conditions and substitution of industrial labour for skilled craftsmen.

° Improved management, control and scheduling of activities;

° Production of likely better quality product as a result of controlled site conditions and accumulated experience.

In turn of course, the above economies are reduced by the need for transport; need for special mechanical equipments both for factory and on-site investments; high initial research; development and design costs. While some prefabricators produce components essentially by traditional craft method in a factory setting; others replace at least some of the hand labour by machines.

The various types of prefabrication are often classified into three main groups:

(a) Structural frames

These constitute the frame parts of a building such as beams and columns fabricated off-site but assembled on-site. Into these structural frames are fitted infill

units such as walls, partitions, floors, ceilings and roofs using in-site construction or fabricated panels.

This system is the least sophisticated as compared with the others. Its main advantage is that it requires light machinery for erection thus reducing investment in mechanical plant. It also provides for very rapid construction. In concrete construction for instance, one can fill in the floor panels immediately after erecting the precast elements as opposed to waiting eight or ten days for the frame to reach its cured strength in the conventional method.

The major set-back for this system is that the contractor has to deal with many more joints which in turn tend to increase cost of construction and gives poor acoustical privacy between adjacent enclosures.

As far as their use for housing and commercial buildings is concerned, transportation costs off-set substantially any advantage of prefabrication. Since the elements are simple, the ratio of transportation cost to production costs increases rapidly to uneconomical levels. The economics however change when they are considered for industrial and educational buildings which usually require very large open spans. In this case post and beam systems (especially concrete and steel) can be used to their fullest potential.

(b) Panel systems

This is the most widely used system in both Western and Eastern Europe. Depending on the size and weight, panels can further be classified into two sub-classes-: Heavy weight and light weight panels. Many connections and joints in panel system should be avoided as much as possible. Normally the higher the number of elements, the higher the number of joints and connections and the more complicated is the system. Many joints and connections have two main disadvantages:- First they provide less continuity in the structure, and more possiblities of leakage or infiltration through imperfect joints and secondly it requires more labour on the site.

(c) Box system

These are factory produced and preassembled volumetric elements with a high degree of finish and a minimum amount of required site erection time. This method encounters many obstacles; some of which are technical such as the excess weight of the modules which creates problems in the handling and erecting operations. This implies that

- within the plant. powerful, thus expensive cranes are required to move the boxes out of the production to stock area.
- Road transportation is problematic. Expensive tractors of very large capacity are

needed to haul the units. As the boxes exceed permissible dimensions on the road, special authorization from the police is necessary. The driving hours are also severely restricted thus wasting on time.

° very powerful cranes are needed on the site for the lifting operation.

Other problems are architectural in nature. For instance stacking boxes adjacent to each other means the doubling of adjacent walls - this is unnecessarily wasteful and such arrangement provides very limited flexibility. Other solutions such as staggered box systems whereby one additional room space is provided by the exterior walls of four boxes require on-site finishing for those "bonus" spaces thus cancelling a good part of the advantages derived from complete finishing in the factory. Limitations therefore both in dimensions and weight make the use of box units on a mass production basis difficult.

Production facilities

Just as the various building systems and components vary widely, their production process are very diverse. The prefabricating plant can range in size from small to large, and in sophistication from the manual production of beams and columns to the manufacture of complete housing modules in an enclosed and highly automated factory. It could also be either producing materials and components

with a high degree of prefinishing or not with the former requiring new types of machinery and more automatic production in order to be efficient - this in turn require a high initial investment.

Plants may also be specialised in the production of certain types of units or they may be general purpose plants suitable for producing a variety or types of components. This implies economies of scale due to specialisation for the former but it also means more problems to the contractor at the site who must coordinate various deliveries.

The choice between all these variety of prefabricating plant design depends on a number of factors:- projected useful life of the plant; type(s) of units the plant intends to produce inorder to meet the market demand; availability of money; the level of technical knowhow among a host of other things.

Production procedures

The concept of factory production involves two basic alternatives:- assembly point configuration and assembly tree configuration.

The first alternative implies a situation where equipment, labour and materials move from one stationary building component under construction to the next. This approach is similar to conventional on-site construction except that it takes place in the factory. Each component

is assembled in a separate area and moved only once it is completely built and ready to be transported to the site. This alternative is most practical when the components vary considerably in design. It may be useful also in small factories or in factories which require labour intensive rather than capital intensive method of production. Its major drawback is that it does not provide incentives to the workers since there is no feeling of urgency experienced in waiting line conditions. Secondly, it is a highly inefficient method making planning and control of production nearly impossible and completely excluding the possibility of a high level of mechanization.

The second configuration, the assembly tree, is patterned after a standard assembly line process in existence in most manufacturing plants today. The building elements move along an assembly line, and at each point along the way, some part is attached to the element until the building component is complete and ready for installation. One of the major problems with this process is that the rate at which an item progress down the assembly line is highly dependent on what is happening to the items ahead of it. Thus the efficiency of the whole process can be destroyed by improper allocation of men, machine or materials to any one assembly point. Similary each of the steps along the assembly line must take about the some amount of time in order to avoid back-ups and

delays. In order to make such an operation profitable a steady demand for large lots of similar components is required. Nevertheless, the assembly tree configuration has a number of good points as well. Since it is the components that move and each step along the assembly line consists of a small number of repetitive tasks, the process lends itself to a high degree of mechanization and use is made of unskilled labour. Secondly pressure to maintain the steady flow of components is felt by all workers and the production process is considerably easier to control than the previous one because it is more structured.

Basic advantages of prefabrication

(a) Saving in scarce materials

Saving in scarce materials occurs in basically three main ways. First, it occurs through the purchase of large quantities which in essence results in big discount from the sellers. In buying directly from the producers, middlemen are eliminated giving a good saving to the prefabricator. Secondly savings in the cost of raw materials in a prefabricating firm is realised through the decrease in dimensions of elements and components. Lastly savings occurs through the decrease of wasted materials. For instance in a timber prefabricating firm, timber shorts which are otherwise waste in conventional building process

are used for making doors after they are probably joined together.

(b) Saving in labour

Saving in labour cost occurs in two basic ways. In a prefabricating firm, labour tends to be more productive due to the improved working conditions in the factory as compared to a building site. As a result less but well equiped labour is likely to achieve better results than more labour on the site. Secondly a lot of machinery are introduced in a prefabricating firm thus eliminating the number of men or the man hours required to do a specific job. In this respect, there is saving also in the use of skilled labour which is substituted for factory semi-skilled labour which is relatively cheaper.

(c) Shorter construction time

Saving through shorter construction time affects a number of items including, interest paid on borrowed capital, interest paid on working capital, increased revenues due to earlier occupation of building, lower overhead costs etc. In addition, the harsh climatic conditons in many areas of the world considerably restrict the construction process during the winter seasons. Factory production can bypass climatic obstacles and hence regularize the volume of construction over the whole year. Recent

research show that industrialised building systems are saving 25%-40% in building time for multi-storey flats and as much as 40%-50% for housing systems. It has also been shown that certain industrialised systems offer savings of labour in the order of 22-35% for both houses and flats and some much more[31].

(d) Reduction of production costs.

The main contention here is that costs of production are considerably reduced through mass production of components thus enjoying economies of large scale production. But as far as this aspect is concerned many writers are of the view that industrialised building systems may not be necessarily cheaper relative to conventional ones. Edmud and his friends for instance have this to offer:-

> In terms of cost alone, it is extremely difficult for industrialised building to compete with traditional building. This is basically because with notable exceptions the building industry lack in an adequate supply of competent site supervisors with a modern concept of management. Many managers are ill-equiped to organize their work and labour sufficiently in advance to take full advantage of factory made components[32].

Secondly, at the factory higher wages and better conditions for workers and the amortization of plant and overheads add to the basic costs as do the costs of transporting, wraping and protecting components on transit. There are problems too, related to stock piling which adds extra cost of stock keeping. The difficulty particularly for

systems which requires large capital investment is that of organising demand. Several factories especially in western and eastern Europe have been known to produce large structural components and thus requiring orders of 500 to 1000 units per year (and much more) within a limited radius of distribution say 100 miles for economic production to be viable. This is a very high figure and in most cases the demand is not that high making the factory produce under capacity.

Basic problems of prefabrication

(a) Joints and connections

Joints and connections are a feature of all precast systems. In any building system joints and connections perform a number of basic functions.

- Accommodate changes in the dimensions of structural components or differential settlement.
- Keep water and wind out of the interior.
- Provide a good thermal insulation.
- Sustain and transfer loads due to shear and tension forc
- Allow for limited movements of element under clip, shrinkage or temperature changes.

There are basically two classes of joints - closed or open joints. The former is formed by sealing the open space between two components with some elastic material

such as mortar etc. Elasticity in this case is required to maintain the water tightness of the components. This type of joints has created a lot of problems due to high rigidity and the tendency has been to use open joints. Open joints design is based on the concept that wind along an elevation loses its pressure if it passes over a ballon - like hollow space referred to as the decompression chamber. Open joints are more flexible and allows for structural and shear movement of the structure minimizing the possibility of damage experienced in closed joints.

Connections on the other hand serve structural purposes. Different elements and members must be well connected so that all loads are well transferred to the ground safely. Therefore, depending on their function i.e. the load it must transfer and the type of member it connects, a connection can either be rigid, hinged or semi-rigid.

(b) Stability

From the existing statistics, prefabricating systems (especially panel and frame systems) raise special problems by reason of the joints and other factors affecting stability. The problem of overall stability in a prefabricated structure is that of the interaction of all components. It is rather difficult to obtain a high stiffness by merely connecting the prefabricated members at the joints. At these connecting points the lack of space limits the possibilities of making connections, especially when the forces to be obtained are rather high.

(c) Standardization

The degree of standardization is a vital question to be faced by the prefabricating industry. Reducing variety can help to increase the demand for a standard component but this may conflict with the user's needs. The problem facing the prefabricator therefore is one on how to reduce the number of components but at the same time match as far as possible the range of conditions most frequently found in the market. The higher the reduction of variety, the lower the flexibility of the system to individual users needs and the reverse holds true.

(d) Dimensional coordination

This is a system that reduces the dimensions of all building components, and of building themselves to multiples of one basic dimensional unit called the BASIC MODULE. It is a crucial point that a basic module is widely devised and that the same is widely accepted, especially for open systems. The module must be small enough to provide the necessary flexibility in design but large enough to promote simplification in the number of sizes for various components.

(e) Tolerances

In prefabrication construction it is necessary to make allowance in design for the inaccuraces that occur during manufacture and construction. Allowed tolerances are based on experience and there is a great need for information on the sources of inaccuracy and how accuracy can be controlled, and on the relationship between the accuracy achieved and the cost of achieving it.

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CHAPTER THREE

PREFABRICATION OF HOUSES: ITS STATUS, PROBLEMS AND PROSPECTS

Historical overview

(i) Prefabrication in the advanced countries.

Prefabrication of buildings is not new. Kelly (1957) notes that since the days of the primitive man a certain amount of prefabrication has been done[1]. For instance it has been recorded that as early as the 17th Century prefabrication was used in Britain for providing shelter to persons on their arrival to new settlements. Kelly quoting from Peterson observed that as early as 1624 the English had taken with them to Cape Ann a wood prefabricated house which was "subsequently disassembled, moved and reassembled several times"[2]. During this early period of development, wood was predominantly used as a structural material. With time however and as the technology advanced, other building materials have been increasingly used such as caste iron, steel, aluminium, clay, plastic, concrete etc. The development process can be categorised into 4 main phases.

(a) Early development

From the existing literature, it seems conclusive that during this early part of the development of prefabrication, the technology had been mainly used for special purposes buildings such as provision of shelter for new settlements, camp cabins, labour cabins and vocational cottages

All these were uses in which a decrease of site work was desirable irrespective of the cost of production. Note should be taken also that the period before the 20th Century was a time when the western world was so much interested in the exploration of what they referred to as the "unknown" world and consequently demand for quick methods of constructing shelter in new settlements was on the increase. This played a big role in boosting the development of prefabrication before the 20th Century.

By the turn of the century however, the emphasis of prefabrication seemed to have shifted from provision of special purpose houses to the provision of low-cost houses for the bulk of housing need which existed from the effects of the industrialisation and urbanisation. The leading person in this respect was an American by the name of Gosvener-Atterbury who argued that prefabrication was appropriate for the provision of low-cost houses mainly because of two major reasons.

- first he advanced that prefabricated houses were less costly to produce as compared with conventional ones and
- Secondly they are easy and faster to produce[3].

These two factors posed as potential solutions in meeting the need of the time and thereafter, prefabrication was associated more and more with the provision of low cost

housing in the western world. Whether the potentiality was finally realised is a different matter all together but existing literature seem to suggest that prefabricated houses are not necessary cheaper as compared with conventional houses.

In the course of industrial revolution, manufacturing of products became industrialised and most industries became more and more capital - intensive while labour became more and more expensive. In the construction industry however, it is observed that industrialisation was delayed. Apart from some attempts for industrial construction all over the world, building construction remained a complexity of labour-intensive process carried out by a great number of contractors and craftsmen. As a result,prefabrication seem to have exercised a perenial fascination only on industry -minded architects and others "searching for the magic key that would unlock the factory that was going to produce the 'house' of the century, houses that would be marketed like consumer goods and whose price would reflect the economies attributed to mass production"[4]. In their argument they cited the case of the automobile industry where a lot of economies had been realised as a result of mass production. But as was discovered later, the building industry cannot compare favourably with the automobile industry. Kelly (1957) noted that a lot of differences occur when one

tries to compare the two industries. For instance

- ° unlike cars, houses are not complete until they are placed on land and the price of land is part of the total cost over which the house manufacturer has no control.
- ° The general public tend to overlook industrialisation of houses unlike other goods. This could be because of cultural values that a house symbolizes in relation to other goods.
- ° Unlike the automobile industry, there exists a perfect substitution in the case of prefabricated building and hence competition from conventional houses. There is also the question of competition from the existing stock basically because of the long durability of buildings[5].

All the above factors tended in one way or another to restrict the industrialisation rate of the construction industry in the western world. It is interesting to note that to the present day none seem to have discovered the 'magic key' and as a result prefabrication has not gained a lot of popularity as have other manufactured goods.

(b) The two world wars

Most writers seem to agree that the real impetus to 'prefab' as having been the two world wars in the early part of this century. During this period, prefabri-

cation was extensively used for three main reasons. These are:-

- ° speed in construction
- ° Demountability
- ° Reduction of on-site labour and congestion to a minimum.

The above three factors were very favourable for war circumstance where time and ease in demountability were of paramount importance. The prefab houses that came up during this time were considered temporal and any time a permanent house was needed, conventional methods were employed.

(c) The immediate post war period

The immediate post-war conditions when thousands of people in many bomb-destroyed towns and cities were without proper shelter called for a new approach to methods of construction. Traditional methods were improved and prefabs may be said to have "come to its own". Three main factors can be advanced as the reasons favouring prefabrication of houses during this period.

A survey by the European Economic Agency articulated the grave housing shortage and financial difficulties of the immediate post-war period as the major factors which compelled the countries of Europe to adopt "cheaper, faster and rationalised methods of house building"[6].

It was generally felt that a solution to the problem of "putting a roof over the head" of the population lay in industrialised methods of construction and specifically in prefabrication[7]. The high demand that resulted from war destruction called for immediate action from both the public and the private sectors. This high demand attracted a lot of people into the prefab industry who had little or no experience at all in prefabrication. As a result quality was sacrificed for quantity and in general houses put up during this period did not meet the requirements of would be occupants. This is one of the reasons why prefabrication on large-scale in the preceeding years and to some extent even the present day meet very little success. In most of the western countries, prefabrication has often been regarded as inferior. (However, mention should be made here of the success in the Scandinavian countries and part of the Eastern Europe but this has mainly been through incentives and a lot of support from the state and the fact that these countries are well blessed with timber which as was mentioned earlier is one of the widely used prefabricating material).

The second factor which boosted prefabrication during this post-war period was the acute shortages of labour and natural materials that followed the immediate post-war time. A lot of traditional craftsmen were killed during the war and this posed a problem to the conventional

builder since he largely depended upon the skills of the building craftsmen. Secondly, the few craftsmen who survived had to be paid higher wages than building labourers. Consequently it was more economical to prefabricate making less use of craftsmen and using more building labourers.

Thirdly, the predictably long winters which tended to limit outdoor activities could now be avoided if all building activities were done in a factory enclosure. This was quite favourable and had a good effect on the development of prefabrication.

(ii) Prefabrication in the developing countries

There is as would be expected very little reliable and compatible information on the status, extent and success of industrialised building system in developing countries basically because the industry is still disorganised to a large extent. In the course of literature review, it has been obvious that very little study has been done on industrialization of the building industry in developing countries and the treatment of the subject by most writers has tended to be partial and to some extent subjective. It has also been obvious that in most developing countries, prefabrication in an appreciable scale is a 20th century phenomena. With time however,

this building technique is tending to gain more and more popularity within various circles. This interest has been promoted by one or a combination of the following factors:-

° In most developing countries population has been a major problem to deal with. Population growth rate has tended to grow at a higher rate than the rate at which constructed facilities are coming up. Consequently a lot of untold problems - Overcrowding, construction of illegal structure, and general lack of adequate accommodation - has been common place. In most cases, therefore, demand has tended to be higher than supply. The in-situ construction methods have obviously failed to meet this demand due to a number of problems internal to the industry. This has given incentives to developers and government officials to look for alternative construction methods which would produce houses on mass production and help them to reach the annual targetted figures.

° Secondly, the construction industry in most developing countries has exhibited signs of

ever increasing costs of production. This has been attributed to the disorganised nature of the industry. As a result many people have been feeling that it is time new methods of construction, which are better organised are adopted in the construction industry.

° Traditional methods of construction are based on methods which basically rely on the skills of craftsmen. In most developing countries, it has been alleged that lack of skilled manpower is the major bottleneck for the industry's development. Those who advocate prefabrication argue that, it will be possible to use unskilled labour which is in abundance in most developing countries.

° Prefabrication of building has also been advocated because of its time saving ability as compared to the in-situ construction where all the operations are performed on the site giving rise to a lot of slack time.

° Many argue that prefabrication is likely to give better quality product as compared to in-situ since the parts are prepared in the factory under controlled conditions

as opposed to on-site construction.

Nevertheless, a number of writers have cast doubts on the ability of prefabrication to meet all the above conditions especially in a developing country where resource endowment does not exactly favour large scale production.

Carlo Testa observed that industrialisation of buildings may not be the answer to the existing housing problems in most developing countries because:-

- Industrialization of buildings is a foreign technology and as a consequence it might clash with culture and symbolic meaning put to a house and consequently provoke resistance.
- Successful industrialization presumes that technical and managerial skills are available and that a network of subsidiary manufacturers of raw materials are available[8].

He consequently recommended a very slow local development, starting with the production of basic simple components like windows, structural members, sanitary equipment and so on. Through this way workers with little training should be capable of assembling the above mentioned components which should be intergrated with local materials. Secondly local builders may be encouraged and trained and new and sophisticated components introduced. If the introduction is done this way, it will ensure that

there is no loss of foreign exchange to foreign licence holders.

Carlo's suggestion is credible but like many western [illegible]s, he seems to have avoided the heart of the problem. The question is "should a developing country use the technology which maximizes the use of existing resources especially the capital/labour proportions or should it anticipate the relative growth of capital and start to use capital-intensive methods before its capital endowment, is really suitable for this?" The point at hand is when should a country start to use advanced country technology safely? It has already been mentioned that a paradox exists in the developing countries in that there exists abundant cheap labour and scarce capital. This makes it uneconomical to adopt foreign technology without prior analysis of the local conditions. Although a good number of developing countries have attempted to use prefabrication, there has been a common thread in the existing literature of the feeling that developing countries are ill-suited to prefabrication.

In Hong Kong for instance, a successful project was accomplished but total costs were slightly higher in comparison to in-situ construction methods. The project was undertaken by the locals and expatriate from Japan who designed the systems taking into account local needs and resources. Maintenance costs of the houses

were found to be normal after a period of observations. Nevertheless, a number of problems were encountered:-

- Lack of site for factory location (need for areas to store materials)
- Poor transportation and communication problems inhibiting the action radii and increasing cost of production
- Lack of knowhow on the climatic and environmental conditions on the part of the expartriates caused a lot of delay[9].

In Ceylon prefabrication of houses started in 1940 with systems built of concrete being dominant because of its availability, versality and cheap prices relative to other materials. Various types of prefabs designed in collaboration with foreigners were seriously considered but it was found that the foreign exchange requirements were such that they far outweighed the advantages to be gained by such collaborations[10].

As a consequence, the State Engineering Corporation whose members had studied prefabs both in east and western Europe took the challenge and got down to design prefabricated flats making use of components which suited local conditions without copying what existed in Europe. For example they took into account local climatic

conditions, the degree of mechanisation, the high rate of unemployment and so on. At the very outset, a decision was made to minimize the degree of mechanization as much as was practically possible in view of the severe unemployment that existed. The project was a success because:-

- The construction of the multi-storey flats necessitated a lot of repetition which made standardization and consequent economies of scale possible.

- Building codes and regulations were favourable. People are free to build using any method provided there is provision of adequate lighting and ventillation.

Despite such success, a number of shortcomings were encountered

- Heavy draw of foreign currency due to import of machinery;

- Fewer people were being employed;

- Costs especially at the initial stages were higher mainly because of scarcity of constructional and other equipment and shortage of trained personnel for this job.

The recommendations given at the end of the project supports the argument that industrialization of buildings

faces some constraints in developing countries

- ° Higher degree of mechanization would be more successful to offset the high degree of absenteeism and poor labour productivity;
- ° Need for adequate land especially storage or stocking space for the products;
- ° Re-orientation of skilled labour to prefabrication. Construction method has been a problem. The workmen especially carpenters, masons and the like were used to methods of construction which are different from prefabrication. At the initial stages, incidence of accidents was very high,but,as the labourers became more and more apprehensive, the rate of accidents reduced.
- ° There exists a general feeling of the need for institutional set-up to train contractors on the new methods of construction and the advantages thereof[12].

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CHAPTER FOUR

PREFABRICATION IN KENYA: ITS STATUS, PROBLEMS AND CONSTRAINTS

Historical Development

In Kenya prefabrication of houses is very a recent phenomenon. The earliest recorded appeared in the scene in late sixties and early seventies. In most cases than not the initiative to prefabricate has been the private sector with the public sector acting very pessimistic and detached. Consequently in-situ construction techniques have been predominate with no emphasis at all laid on the role of prefabrication in the five development plans since independence. The few prefabricating firms (private) seem to have launched on prefabs mainly because it was an avenue for business rather than any economic analysis of the technique. The result has been alarming with little or no records at all on such important issues as market analysis; technical tests of the system; and so on.

As was observed in chapter two, almost all building materials can be prefabricated. In Kenya, a few firms have tried to use timber, steel, glass fibre, stratmit and concrete, but the real impact of prefabrication has been on timber houses. On most of the other materials it has been quite difficult to get information on demand trends; user reaction and other related information, mainly because pre-fabrication covers a very minor section of the firms activities.

Below are the three major materials used for prefabrication

(a) Concrete

So far, only one firm was confirmed as dealing with prefabrication of wall panels - concrete pipes and products. No mass prefabrication, however, is practised but panels are made on order. The percentage of work devoted to prefabrication of panels is very low; hence would not say it is solely a prefabricating firm. For concrete panels there is a very high competition from the ordinary precast concrete blocks, natural stones, brick etc, which are considered stronger and thus more permanent building materials.

(b) Steel

Steel is an imported material and has the big disadvantage of draining the country of the precious foreign exchange. Secondly, steel as a building material is limited in use for tropical regions like Kenya because of its heat absorbing characteristics. As such, steel is mainly used as framework for storeyed commercial and industrial buildings leaving the enclosures to be filled with other materials. Its use in residential house construction is rather limited as compared to other building materi
A good number of firms engage in the production of steel products such as structural frames, doors and window frames throughout major towns in Kenya with main concentration in Nairobi.

(c) Timber

There has been a lot of contention in recent times from various circles that timber could be a potential low cost building material in Kenya if its potentiality is well exploited. The validity of this view is doubtful in the face of the existing literature which will be discussed later. However, a number of observations have been made as to why timber is not widely used as a building material to ease the existing housing shortage in Kenya.

(i) It has been felt that due to lack of proper technology, timber as a building material has been misused by the builders and this has bred a lot of prejudice against it.

(ii) Timber has been used for a very long time as a traditional building material in most parts of Kenya. In such a transtitory era when minds are turned towards 'progress' anything remotely related to traditional culture is likely to be rejected as regressive.

(iii) Although now controllable, insects, fungi and weather have been natural hazards to wooden houses.

(iv) Wooden houses have been considered fire hazards by the public, insurance and mortgage companies and as a risky endeavour.

(v) Most people consider wooden houses temporal and this has created a sense of personal insecurity in a wooden house as compared with stone or block houses which are associated with power, permanency and nostalgia thus down grading timber houses[1].

Among others, the above has led to the general feeling that timber is a poor man's material which is mainly used for shanty estates because it is cheap and easily workable but rejected by everyone wishing to construct a 'decent house'. For the well-to-do in the society, timber is used as a decorative material or finishing material for ceilings, floors and the like.

(i) Timber housing in the public sector

In 1965 Forest Station at Eldoret started the prefabrication of a standard house type for the forest department employees but did not capture public opinion until in 1966 when a full size example of a two bedroomed house appeared in the FAHARI YA KENYA Exhibition at the City Hall in Nairobi which could be bought at half the cost of the conventional low-cost house at once aroused great interest[2].

The Central Housing Board (CHB) which at the time was the executive hand of the Ministry of Housing had started feeling the weight of the housing shortage in Nairobi. The timber prefab house was consequently seen as perhaps a solution to the housing problem. A proto-type of an improved CHB design of prefab was

manufactured at Eldoret and erected at a demonstration site at Ngong but later in 1966 the prefab plant was moved to the modern sawmill at the Forest Industrial Training Centre (FITC) at Nakuru and the firm started producing houses for public consumption. The panels produced by FITC however, were uneconomical for long transportation because they were large and heavy thus limiting the action radii to a minimum. Secondly the general public was not in favour of these houses also because they were aesthetically poor and a number of jointing and connecting problems were common place[3].

Simultaneously the MOW embarked on a feasibility study to investigate the possibility of using timber frame construction in housing construction for government employees. Consequently a joint working team of the MOW, HRDU, and the Forest Department was set up in 1968 to investigate on demand for timber houses, the supply and cost of timber, the existing sawmilling facilities, supply of contractors and skilled labour and management. Their objective was to improve the FITC houses which were found unsuitable for rail or road transportation due to weight and size of the panels and to upgrade the planning and aesthetics of the houses[4].

The venture was discontinued a year later unfortunately due to lack of finances. Various other attempts were made particularly through the efforts of the City

Engineer to find out whether timber prefab was viable. For instance, in 1968 inspired by a site office supplied by the FITC to Nairobi City Council's Kariobangi Housing Scheme, the City Engineer of Nairobi directed an official request to FITC for the supply of suitable fire-proofed components to a planned 5000 unit timber housing scheme of high density in Nairobi City. This was probably premature and it never materialised and the FITC turned it down due to inadequate production, treatment and production facilities[5].

The matter was taken up in Septmber 1968 by the acting Assistant City Engineer in connection with a proposed scheme of 400 housing units against which both an on-site treatment plant and an assembly plant could be written off. The timber houses were to be designed in collaboration with HRDU. It is interesting to note that the scheme had the full support of the Nairobi Fire Brigade which issued an advisory note on fireproofing the scheme but again the project did not materialise[6].

In October 1968 the Nairobi City Engineer's department set up a comprehensive working party with participation from the Ministries of Works, Economic Planning and Local Government, NHC, Forest Department, the Commissioner of Lands, the Provincial Commissioner and HRDU. Four working parties were established to consider the following aspects:-

- Civil engineering aspects of timber houses
- Timber utilization
- Design and finance
- Administration[7]..

Eventually the working groups proved unable to produce any conclusive report. Some in the group felt that timber housing was crucial in all faces of urban development while others felt the introduction would bring in the prospects of building a slum.

With success or failure undecided, the city engineer's department decided to press the matter further and appeal for a wider support by convening a symposium on timber housing. This was held on the 17th December 1968 in a panel room of City Hall. It was attended by 46 delegates with a cross-section of interests ranging from timber housing, urbanization to urban development[8].

But although the timber symposium undoutedly became a success as a means of communication, it hardly constituted a victory for the convenors. One perceives the dissappointment from the covering letter to the Minutes by the City Engineer.

> One thing is certain, it enabled forty six professional minds to focus for two hours on the urban development problems and timber housing in particular. All the relevant departments of Government and City Council were represented, together with certain other interests. The working parties can now get down to the job in the knowledge that other people know what they are doing and that everything possible has been done at 'officer' level to arrive at the basic solution[9]..

The symposium recommended a Timber Development Committee which was inaugurated on the 17th January 1969. The terms of reference were:

> To advice on timber research and priorities and coordinate these, to be available for comment on timber designs, and to collect and disseminate data on timber in service[10].

At the subsequent few meetings the chairmanship was transfered from the acting Assistant City Engineer to the Chief Architect of NHC, whereafter the City Engineer's department largely withdrew its active interest from the undertaking. With some delay, the Kariobangi Timber Housing Pilot scheme was seen through in December 1971, three years after the symposium, 27 middle - to - high income families were able to move in. The low-income inhabitants of Mathare Valley who were the main target for the project were nevertheless supplied with timber houses but in a different way (see timber housing in the informal sector)[11].

(ii) Timber housing in the informal sector

Traditionally the use of sawn timber as a building material for rural housing was accelerated by a number of factors-: the establishment of colonial saw-milling industries, the introduction of fast growing softwoods, introduction of simple methods of preservation and the distribution of imported building hardware.

In the period around sixties, there was a high influx of people from rural to urban areas in search of jobs. With them, they carried the rural building methods specifically the use of timber and many timber structures flourished in the Nairobi's then unauthorised areas such as Kawangware, Dagoretti, Mathare Valley, Pumwani and the like.

The earliest recorded prefabricator was a builder-cum-manufacturer who was originally based in Kikuyu but moved to Kawangware in 1970 when the population influx was on the climax. Supplied with timber from Kinangop, he started out as combined building materials supplier and building contractor in and around the area. Later when business increased, he included prefabricated wall components in a primitive adoption of a well established but rather expensive Nairobi prefab system.
In the consequent years many small industries flourished. For instant around 1966 many-small scale industries started in the central Pumwani area just about the time of the first expansion of the squatter settlements in Mathare Valley. One particular prefabricator seem to have done very well[12].

The proximity of his business to the industrial area helped the owner to obtain raw materials in the form of used packing crates which he bought from AUTO spare parts dealers. After the nails had been removed and straightened for re-use the crates were converted to building materials and components like doors, windows and so on

The owner was just unskilled, trained only as a casual labourer in a carpenters shop. He learnt his skills by merely watching builders at work and by relying on his natural skills of management. He supplied building materials not only to Mathare Valley but also to some rural centres using the nearby country-bus-terminus for shipment[13].

In a way these small components industries are only one aspect of a large economic system in the informal sector of urban society which in spite of services and employment opportunities they offer, lacks the necessary official recognition and backing. It is regrettable that so little attention is paid to this sector. The Kawangware builders primitive adoption of a sophisticated building system and the sheer productivity of the Mathare builders illustrates the potential for more rational building methods at this level which could have emerged if these builders had been supplied with the assistance and backing.

(iii) Timber housing in the private (formal) sector

The prefab market for the private sector is limited artificially by the existing by-laws. Largely based on pre-independence regulations, the present building code of Kenya was conceived in 1968 for the purposes of standardization and has since been adopted on voluntary basis by various local authorities. The main set of

regulations in the Kenyan Building Code, the Grade I By-Laws which comprise the full By-Laws or general urban standards and the schedule special areas and special building by-laws which mainly through space requirements specify relaxed urban low-cost standards. A second set of regulations, the Grade II By-Laws clearly make provision for the use of timber wall construction in rural and peri-urban areas. It is the omission of specific regulation in timber walling which effectively prevents the use of this form of construction in the urban areas.

Prefabricators therefore have most of their market ir the rural areas where staff houses for large sugar or tea estates, road building companies, research and missionary organisations and so on are which prefer instant delivery and erection to cheaper but more tidious traditional building methods. A limited market also exists in the urban areas for the so called temporary houses such as watchmen houses, construction site offices, temporary dormitories for schools and colleges, showground stalls, guest houses etc. The leading manufacturers of prefabricated structures in Kenya are, Timsales, Economic Housing Group (EHG), GD Bros and the Forest Industrial Training Centre (FITC) covering an estimated 90% of the market. Three of the firms, i.e. Timsales, EHG and GD Bros will be discussed here but FITC will be discussed under the sub-heading on government's activity in prefabrication.

(a) GD Bross

The firm is situated along Kirongothi Road, Redhill Limuru. The firm started its operations basically as a sawmilling enterprise in 1957, but with time, diversified it's operations to other activities such as manufacture of polythene bags and wire nails, stocklists of building and fencing materials and prefabrication of houses. Prefabrication of houses per se takes a very small share of the economic activities of this firm. Factors of production such as machinery and labour are thus used rotatively among all the above activities depending on demand for each type of product. For example if there is a high demand for prefab houses relative to the other products, factors of production (especially labour) are switched from the other activities easily to prefab. This state of affairs makes it very hard to measure such important ratios as labour/capital ratio and so on. Another general observation made was that GD Bros is a family enterprise passed down the line from father to son. As a result, it proved impossible to get records or information on such issues as the reasons for the establishment of the firm; economic considerations taken into account at the project appraisal stage and the like.

The prefabrication system used by the GD Bros is a Swedish one imported to the country through consultancy. No formal documents existed on conditions and circumstances under which transfer of this technology took place. The

existence of such a gap in technolcgy transfer leaves us with the guess that the choice and transfer of technology was erratic and did not follow any laid out economic system.

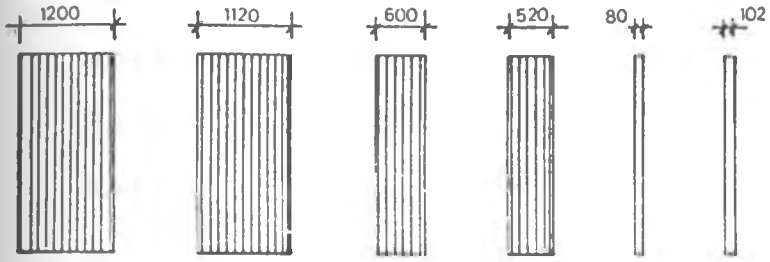
GD Bros generally deliver panels or assembled buildigns for labour lines, guest houses, stores, garages, dormitories, watchman houses and laboratories. All structural timber used for their system is pressure impregnated (tanalised) for preservation purposes. External wall units are completly prefabricated consisting of 70mm x 45mm framing cladded with 10mm or 8mm tongue and grooved cypress boarding for the inner facing. The maximum size for the wall units is 2414mm high by 1200mm wide but a lot of variety exists in width of panels depending on the particular requirement and the job. The panels come in three basic types: plain, with window and with door. Windows and doors are pre-fitted to the wall panel before assembly to ensure accuracy. As roofing is used 26 gauge GCI or asbestos sheets, optional are wooden floors on cedar posts or concrete floor with the option of parque or vinyl tiles; hardboard or softboard ceiling; interior hardboard lining or timber lining. If requested the company also carries out flooring, plumbing, electrical wiring and painting. The company supplies type plans but will quote for any plan required. There is no mass production of panels but they are rather

produced on order. No systematic market research is undertaken by the company for their product. However, advertisements are done through most of the local newspapers and magazines.

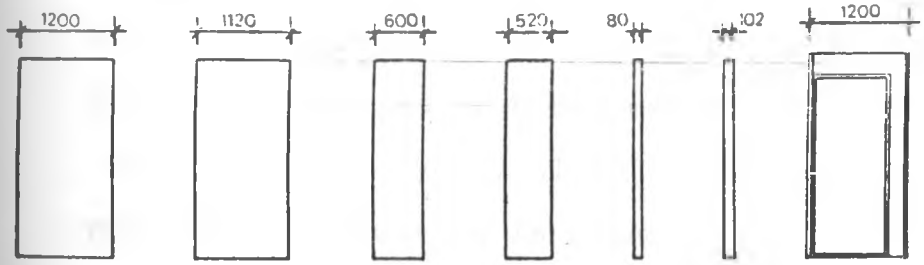
Below are examples of typical prefabricated components produced by GD Bros.

BASIC PREFABRICATED COMPONENTS.

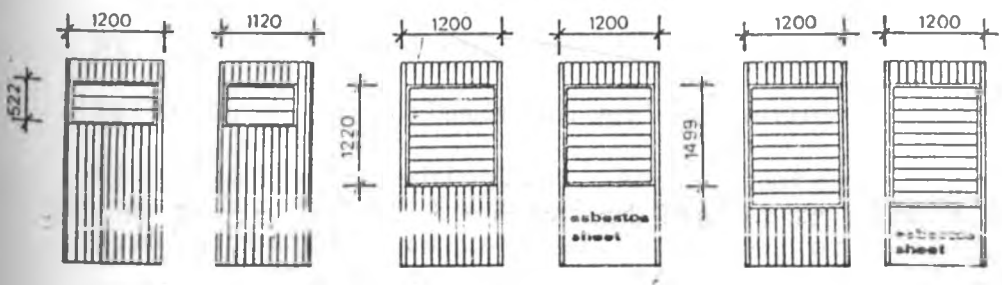
EXTERNAL PANELS



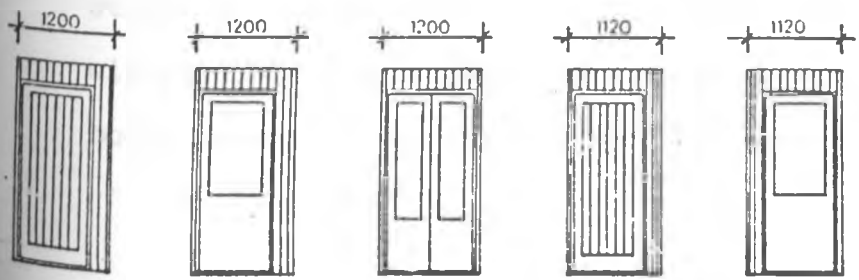
INTERNAL PANEL



WINDOW PANELS



DOOR PANELS



(b) Timsales Ltd.

This is the largest and the oldest prefab company in Kenya. It is located on a 12 acre piece of land along enterprise road, industrial area in Nairobi. Timsales is basically a sawmilling and timber products company and prefabricating takes a very small section of the entire business. The company is an association of some 10 sawmilling companies, seven timber yards, a plywood, softboard, hardboard and blockboard factories situated in different areas of the country such as Njoro, Maji Mazuri and Elburgon. Timsales has produced ranges of prefab systems ranging from the 8,3,4 system; 2,5,1 system and the 2,4,1 system. Currently the firm is using the 2,5,1 system which is based on a fixed panel size of 2.5 metres high by 1 metre wide. The wall panels come in 3 basic types; plain, with window and with door. The roof construction is based on prefabricated trusses in stadard spans of 10,'13' 4", 16'8" and 20', which are mounted at varying distances according to the weight of the roof. The customer has the choice of 5 roofing materials, GCI, aluminium and asbestos sheets, cement tiles and cedar shingles. As raw material for the '251' system building is used either pine or cypress grade 11 pressure impregnated with 'celcure'. Windows are either standard steel casement or six blade louvre windows, with burglar bars and mosquite gauge shutters as optional. Doors are manufactured to the client's choice. Floor

screeds are normally laid after erection as a weather seal, otherwise a seal of bitumen is laid under the sill plate.

Prefabrication for the Timsales came around early sixties resulting from a high demand for site offices in construction sites and labour lines in big plantations. Prefabrication came automatically as a by-product of their activities in timber products. The technology used for their system was imported from Britain through the influence of the Managing Director of the company who is himself a Briton. No systematic transfer records were available to show the conditions and circumstances of the transfer or at least show whether any modifications were made to suit the local conditions. Being basically a sawmilling and timber products firm, Timsales does not pay a lot of attention to prefabrication and it forms a very minor section of the big enterprise. Just like the case discussed earlier of the GD Bros, the inputs - labour, capital and raw materials are switched from one activity or section of the enterprise to the other depending on demand of the particular product.

No mass production is undertaken by the company but production of panels is to order. The major market for the Timsales prefab system are big research projects coming up in the country which normally require faster

and temporary construction to the more tidious in-situ construction. As a result, orders tends to be erratic and demand very unpredictable. Nevertheless, they also make prefab houses for any other type of client and although they have their own type plans, they quote for any plans required.

The erection procedure for a '251' system building is as follows·

(i) Casting of the 4" foundation slab and 12" deep ring beam, leaving holes for foundation bolts.

(ii) Fixing of a sill plate and cementing of foundation bolts; one day is required for the cement to harden.

(iii) Erection of wall panels which are connected and fixed to the sill plate with 3/8" coach screws through pre-drilled holes in the frames.

(iv) Cutting away of the sill plate under the door.

(v) Fixing of the wall plate.

(vi) Mounting and temporary bracing of trussing.

(vii) Nailing of purlins to trusses.

(viii) Fixing of exterior cover strips.

(ix) Plumbing and electrical wiring if required.

(x) Fixing of roof sheeting.

(xi) Interior lining with hardboard, plywood or softboard.

(xii) Fitting of facias and burglar boards.

(xiii) Fixing of ½" sofboard ceiling on brandering flat at 8 feet high.

(xiv) Fitting of moulding finishes or cornice, skirting, architrave and quadrand

(xv) Painting[14].

(c) The EHG

The company was conceived in 1971 and set up in 1972 at least after a thorough examination of a feasibility and pre-investment study. Although the company could carry out a wide range of commercial transactions according to the Memoradum and Articles of Association; the initial specific intention was to manufacture low-cost prefabricated timber houses particularly for the rural areas. A local expert (HRDU) conversant with the conditions of East Africa and familiar with the use of timber was established as the companys technical adviser on matters relating to design and engineering of the building system.

The factory is located in Naivasha which is a 100km from Nairobi. The choice of this area was basically to have an access to the ample and rural manpower, existence of good communication and transportation facilities and a uniform and constant supply of pine which is the basic material used by the factory from the surrounding forests.

The factory layout is simple with 8 fundamental arrangements or sections.

1. Storage of timber
2. Cutting of elements (members)
3. Treating of timber
4. Storage of treated timber
5. Fabrication of components
6. Finishing (windows, doors, linings etc)
7. Storage of finished elements
8. Dispatch

Currently the factory layout and production time is not utilised to capacity and the company has opted to produce other products such as portakubes, stores, stables, utility buildigns furniture etc. because demand for prefabs is small and very unpredictable. The system used for the panels is Canadian in origin and is 2400m high by 1050m wide. For the exterior walls, tongued and grooved cypress or pine weather board are used on timber framing. Concrete or timber foundation is used while the type of floor finish used depends on the client's reuqirement. For the ceiling, hardboard is used. GCI pre-painted or plain, asbestors or tiles are optional as roofing materials.

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CHAPTER FIVE

DATA ANALYSIS: THE ECONOMICS OF PRODUCTION

General Observations

In very general terms the prefab industry in Kenya may be said to be in its very early stages of development as compared to the western world. Consequently, the industry's potential has not been fully tapped leaving a lot of scope for improvement and further development.

As in many other parts of the world, the major constraint facing the prefabricator in Kenya is lack of adequate and consistent demand that would warrant heavy investment in this industry. The major market for Kenya's prefab industry has been for road construction works, plantation workers and big research operations. All these operations have in most cases tended to be erratic in nature and very unpredictable. This in turn has made prefabrication a very risky endeavour for enterprenuers to invest their scarce resources in.

In three out of the four firms visited, prefabrication has evolved as a natural by-product of their routine activities in timber production. In these firms, prefabrication is just a small section of the entire enterprise with the firms concentrating in the production of other timber products. Consequently, factors of production mainly, labour and capital are used interchangeably between the various activities of the firm depending on the demand prevalent at a given time. Prefabrication in the fourth firm i.e. EHG unlike the other three firms evolved

as a result of a conscious move and detailed economic analysis of the viability of the project. With time however, the firm started diversifying its economic activities because demand for prefabs was not adequate to support a viable economic enterprise. In addition to prefab houses, the firm is currently producing furniture, building components such as windows and doors and other timber products. As a result of all the above considerations, it is apparently difficult to analyse prefab on its own since it is part of a big enterprise and figures on important factors such as labour and capital are given as gross not by section.

It was also observed that the four main firms visited have adopted the simple panel system building with slight modification from one firm to the other. The production of these panels is simple and is mainly by unskilled labour (who are given on-the-job training) with the help of simple tools and equipments. The prefabricating process is therefore labour-intensive and has a lot of similarity with the conventional in-situ production except that the production for prefabs is in the factory. Handling and erection of the panels is generally manual with little use of simple equipment such as pulleys, troileys and un-mechanized cranes.

Data Analysis

In chapter one, a number of criteria were advanced to help in determining the appropriateness of prefabrication in Kenya. These were, labour/capital ratio, material inputs, organizational set-up, and market conditions all of which will be analysed below with respect to prefabrication of houses in Kenya.

(a) The labour/capital ratio

For all the four firms visited, it was impossible to measure the labour/capital ratio because of two main reasons. First, the factors of production are used in rotation from one activity to the other depending on what product is in the greatest demand at any given time. For instance, if in a given day there is a big order for sawn timber, all the labour and machinery is shifted to the production of sawn timber to meet the order assuming the demand for the other products is nil. On the other hand, labour and capital is shifted to the production of prefab panels incase there is a big order at any given time. Secondly the four companies visited do not keep records on such factors as the exact proportion of labour/capital used on prefabs annually and this made it impossible to measure the labour/capital ratio.

However, from my own observations, it is apparent that the prefabricating method used is labour intensive in nature unlike the situation experienced in developed

countries where prefabricating is a capital-intensive process. As has been mentioned, the production, handling and erection is basically done by labour with the help of simple equipment. This observation was very well supported by estimates obtained from an analysis of Kariobangi timber housing project where the capital/labour components of the total cost were given as follows according to various house types:

Labour/Capital components of the total cost

House type	D_1	D_2	E_1	E_2
Labour	7433	7894	6680	5502
Plant	748	200	1139	17069

Source: HRDU (1)

Although no explanation is given on the discripancies in capital investment from one house type to another, the figures roughly show that prefabrication in Kenya is relatively labour-intensive. On the average the labour capital ratio for Kariobangi housing project is

l/c = 13:1

Given that the l/c ratio is high, then my hypothesis that prefabrication is inappropriate because l/c ratio is low is nullified and hence accept the alternative hypothesis that all other things being constant, l/c is high and

consequently prefabrication is appropriate in Kenya.

Explanation

One of the major explanation of the high l/c ratio is that it has been a deliberate policy among the four firms visited to use capital-saving methods of production in order to utilize the available cheap unskilled labour and save on the scarce and relatively more expensive capital resources. This is a very commendable move which should be encouraged even in other production activities in the whole economy.

Secondly the building system adopted by the four firms, that is, the simple panel system is very simple to produce and light in weight. Thus production, handling and erection is basically done by manual labour with little help of simple tools and equipment . There is therefore no economic need to invest more in machinery as is the case in the advanced countries. Again, not much site investments is needed apart from simple saw-milling facilities and the shed for the production purposes. In the factory, production is basically conventional in nature with in-situ production methods being transfered to the factory. Capital investment per person is therefore low and this makes prefabrication economical especially when considerations are made on the capital scarcity in Kenya and the unemployment problems being experienced currently.

(b) Materials used and their sources

The two basic materials needed for timber prefabrication in Kenya are pine and cypress. Kenya's territory measures 58 million hectares of which 3% or 1.7 million hectares is covered by forests. Despite this limited timber area, the government has managed to successfully and timely create a growing supply source of timber products directed towards national self-reliance and expanding export potential[2].

The majority of Kenya's forest domain consists of indigenous stands which has been extensively exploited for over 50 years[3]. Traditionally, podo and cedar were used as the main timber building materials but the slow regeneration of these species has now virtually eliminated these native forests as a viable source of marketable production. Additionally, the price of these two species has tremedously increased making it very expensive to obtain them.

In the face of this reality, the government had the foresight to develop over the past 40 years a plantation program of fast-growing exotic pine and cypress. The supply and the distribution of Kenya's forest resources is under the management of the Forest Department which is under the Ministry of Environmental and Natural Resources. The plantation area of pine and cypress covers 130,000 ha. with a 1980 log supply of 1.170.000 m3.

As the plantation program progresses, the estimated yield will have increased at the end of this decade by 62% to 1.900.000m3. By the year 2000, output is expected to have climbed by 122% to 2.600.000m^3..

In line with the ongoing afforestation schedule and concurrent with the annual 4½%-5% consumption growth rate, the industrial log intake is projected as follows

1990 - 1.445.000m3

2000 - 1.110.000m3

Therefore the industrial roundwood balance in Kenya will be

Industrial roundwood balance in Kenya

Year	1980	1990	200
Production	1.170	1.900	2.600
Domestic consumption	800	1.445	1.110
Balance	370	455	1.490

Source: FITC Files 1980

All the above figures are indicative that Kenya has a good supply of pine and cypress and in fact a good surplus. The prefab market is therefore assured of a good supply of timber which is locally produced in various forest reserves in the country. From this point of view, then prefabrication may be considered as an appropriate technology in that it uses locally

produced materials thus boosting the economy as a whole through economic multipliers. This however is not without limitations. First, the price trend for pine and cypress has tended to rise making it more and more expensive to build in timber. The royalty charged by the government gives one a glimpse of this situation.

Timber Royalties: Rates of increase

1974 - 1984

Year	Rate of increase	Basic rates per m3
1974/75	10%	
1975/76	15%	115
1976/77	32.9%	152 8
1977/78	23.5%	118.75
1978/79	28.7%	242.92
1979/80	20.7%	293.2
1980/81	23.2%	361.2
1981/82	24.3%	448.97
1982/83	13%	507.53
1983/84	26.7%	643
1984/85	39.5	
1985/86	28% cypress 18% pine	

Source: FITC Files

Note should be taken of the fact that the actual sawmill prices are higher than the above basic prices and that there is a great deal of variation in timber prices and in the retail margin charged by the sawmillers from one area to another all over the country. Consequently

it is becoming more and more expensive for the prefabricators to secure timber at reasonable prices. For the firms to break-even, the costs are pushed to the customer who bears the most weight of the price increase. Although timber prefabricated houses were initially seen as the solution to low-cost housing problems, today manufacturers of the panels and clients alike agree that they are more suited to the middle and partly the high income earners who are financially able to demand them. Cost of the prefab house has tended to be higher and higher and although no supportive data exists on cost comparison between conventionally built and prefabricated timber houses, there is a strong feeling that prefab houses do not necessarily offer any appreciable cost advantage over the conventionally built ones and at times prefabs could be more expensive. The figures below showing the basic prices for various types of houses by GD Bros are representative of the prefab market and give a clear picture of the prices for various types of houses.

Basic price for various types of houses

No.	Type of House	Square metres	Basic price
1	1 bedroom	34.56	45,800
2	2 bedrooms	60.48	65,800
3	2 bedrooms	61.92	65,900
4	2 bedrooms	69.12	72,800
5	2 bedrooms	100.80	94,400
6	3 bedrooms	120.96	113,300
7	4 bedrooms	141.12	135,500

Source: GB Bros Official Brochure, 1987

Note:

All prices are ex-factory and consist only the following

1. Exterior walls: T & G timber panels with 3mm plywood lining
2. Partitions: Panels lined with 3mm plywood both faces
3. Roof: Gable trusses with 26 gauge GCI sheets
4. Doors: Cypress Tee doors and flush doors with mortice locks
5 Windows: Louvre glass windows with fitted burglar bars
6 Ceiling: Flat ceiling 2.40m high with 3mm plywood
7 Delivery: Free of charge to Nairobi. All nails provided

Note: The prices exclude floor, painting, plumbing, electrical and erection. However these can be arranged with extra cost.

Roughly the cost per square metre of the gross floor area is approximately Ksh.1,050. Note, however, that this cost excludes floors, painting, electrical wiring and erection meaning that the real cost could be 10-15% higher. If prefabs houses are to be provided to the low-income earners, then something substantial need to be done to control the prices of pine and cypress which are the main construction materials used. Currently it is unlikely that timber walling with its relatively high initial costs, recurrent maintenance requirement and fire hazard is unlikely to be as competitive as conventionally built ones even among the middle and high income bracketed people.

The second limitation to the production and supply of exotic timber is primarily administrative in nature. The utilisation policy as set in Sessional Paper No.1 of 1968 is vague thus leaving a lot of room for misinterpretation and abuse. For instance, whereas the policy gives the Forest Department the responsibility to manage the supply and distribution of all forest products; in practice there is a lot of political interferance from DCs and DOs of the given area who can grant or refuse the cutting of trees regardless of the decision by the Forest Department. This state of affairs makes it exceedingly hard for the Forest Department to properly manage or plan independently of outside interferance. For example,

there has been a lot of talk concerning the uncontrollable depletion of forests for domestic and industrial purposes reflecting lack of legislation which would enable the Forest Department to control and protect forests on trust and private lands[5].

The third limitation to the efficient production and supply of exotic timber is technical in nature, lack of technical knowhow on where and how to use pine led to a lot of abuse and misuse of this species when it was initially introduced in Kenya. Pine unlike cypress deteriorates faster when it is used in wet areas and as such should be used in dry areas. Lack of this knowledge made clients look down on pine as a building material leading to under-utilisation of pine plantations and at the same time over-utilisation of cypress. This has temporarily created an apparent shortage of cypress whereas over-mature plantations of pine have not been utilised.

Other materials

Other materials used together with prefabricated wall panels and roof trusses include; hardware, sanitary and electrical fittings, paint, roof material and so on. Most of these are imported products and involve foreign exchange. Whereas it is hard to get local substitutes for some of the above items, it is relatively easier

to get substitutes for others and this has not been fully exploited not only in the prefab industry but also in the construction industry as a whole. For example the roofing materials options for the four companies visited includes GCI, asbestos, and tile completely over-looking the use of shingles which could equally serve the purpose.

c) Market conditions

Emphasis has already been laid on the fact that productivity continuity is necessary for mass or large scale production. The latter on the other hand is believed to ensure lower production cost because of the economies of scale and consequently lower sale price. In Kenya however, the market available cannot guarantee mass production for two main reasons. First, the market available is too small for enterprenuers to undertake such a risky endeavour. Secondly, the small market available is erratic in nature and very unpredictable as was discussed in chapter four. Prefabrication in Kenya has mainly been geared towards roadworks, big research projects, temporary dormitories, offices and so on all of which depend on extrenous factors making it hard to predict demand trends. Prefabrication as such has tended to be taken as a part-time economic activity with firms only producing on order. This has resulted in higher production costs → higher sales prices → lower demand and the vicious circle repeats itself.

It has already been strongly advanced that the existing regulations governing the specifications and choice of building materials acts as a major bottleneck or constraint to timber prefab housing especially in the urban areas. This has tended to limit prefab housing to rural areas and peri-urban areas. In the rural areas, prefabs are not easily considered for two main reasons. First is the fact that the rural comunities construct their own houses using un-sawn and untreated timber in a predominantly traditional way or secondly buy timber from nearby sawmills and construct their own houses using self-help construction methods. Prefabs therefore are considered unnecessarily expensive and are in disfavour. This therefore limits the prefab market, to big agricultural plantations, research projects, mission centres, temporary accommodation etc. Owing to the small size of the market, the enterprenuers have to cover their overheads and investment through higher sale prices.

Prefab houses in Kenya have been taken by most people with a lot of reservations. This could be attributed to a number of factors some of which were given out in chapter four. Among them includes the following:

° Due to lack of proper technology, timber as a building material has been misused by

the builders and this has bred a lot of prejudice against it.

° For a very long time, timber has been used as a traditional building material in most parts of Kenya. In such a transitional era, when minds are tuned towards 'progress' anything remotely related to the traditional culture is likely to be rejected as regressive.

° For a long time, insects, fungi and weather have been natural hazards to wooden houses.

° Wooden houses have been considered as fire hazards by the public and many lending institutions and as such being a risky endeavour.

° Most people consider wooden houses temporary and insecure as compared to block houses. For instance 14 out of the 18 respondents in Kariobangi experimental housing scheme preferred block house to a timber one.

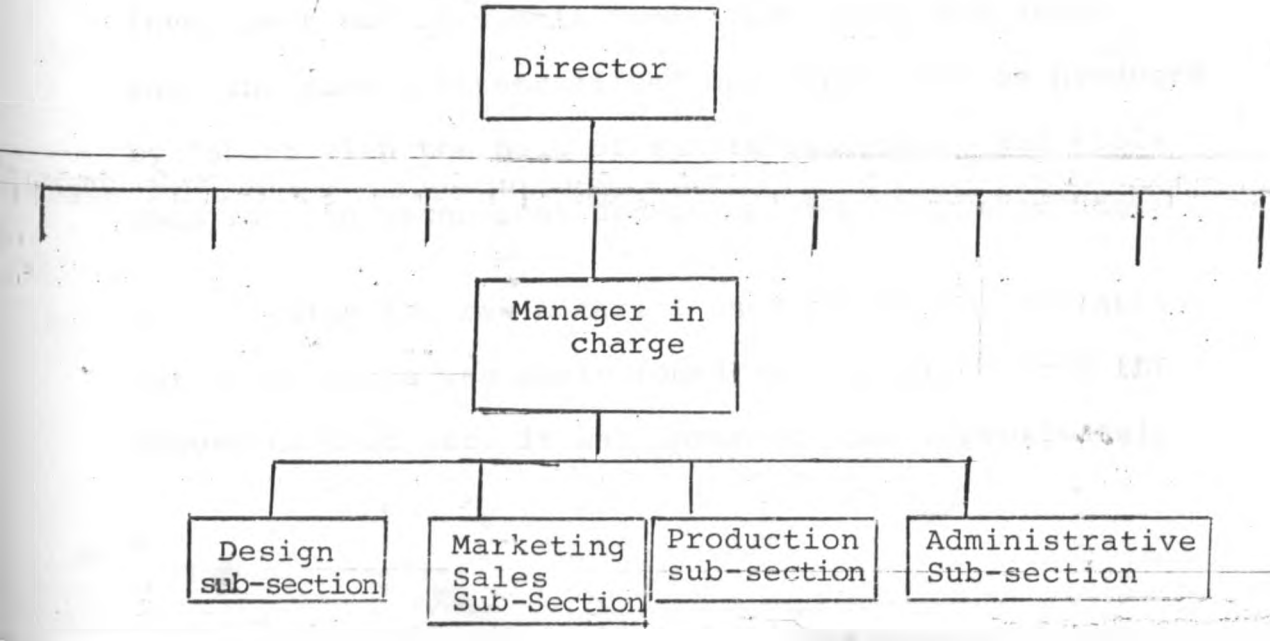
Additionally, prefab houses have tended to favour the financially able people and completely out of reach for the common man. For instance, a survey carried out on Kariobangi experimental timber houses showed that in 12 out of the 27 households who occupied these houses earned a monthly income of 1,000-3,000 Kenya shillings. Seven out of the 18 households visited had employed maids.

Although there is a school in the estate, only 2 parents sent their children to this school. The majority took their children to more expensive schools outside the area. The survey showed that although the scheme was intended for low-income groups, it is occupied predominantly by middle-income groups of people[6].

d) Organizational structure

The organizational structure adopted by the four firms visited is the simple type without complicated hierarchical lines. Emphasis has already been laid to the fact that prefabricated panel production is on order not mass production. Unlike mass production methodswhere skilled managers with modern oversight techniques are required, production to order can be achieved with very simple planning. The foregoing could be illustrated by the organizational structure below which is a representative of the four firms visited.

A simple organization structure



Findings:

From the analysis of the study, a number of facts become more apparent and thus worthy noting. The analysis has nullified the hypothesis that prefabrication of houses is inappropriate in Kenya. Using the various criteria set up in chapter one, it has been shown in this chapter that prefabrication per se is not inappropriate in Kenya. For instance the labour/capital ratio was found to be relatively higher in Kenya while the reverse is the trend in developed countries. The use of labour-intensive method of production has been a conscious move in the four firms visited. This has two main implications. First it implies that although in most cases there was no record of formal transfer of technology, the importers of this technology tried to modify the technology to suit the local labour/capital proportions. Secondly, the premise that industrialised building methods of production can only succeed through the use of sophisticated capital investment has been nullified. The study has shown that the same (industrialised buildings) can be produced by labour with the help of simple equipment and tools. Thus far the technology can be considered appropriate.

Using the raw material used criterion, prefabrication in Kenya was again found appropriate. From the survey carried out, it was apparent that approximately

90% of the materials used in prefabricated panel system are locally produced. The need to use local materials in the economic development of Kenya has already been emphasised throughout the study.

Prefabrication of houses in Kenya was also found appropriate from the organizational point of view. The organizational structure used is very simple. This is of importance in a developing country like Kenya where managerial skill is still grossly underdeveloped.

Nevertheless, it should be emphasised here that the industry is at its early stages of development and conclusions reached here may need to be revised in the future as the industry develops. For instance today the industry is small in size and future development should be closely monitored to ensure that the resources available are maximumly exploited and the industry becomes more and more adapted to the local conditions. Policies in this area need to be directed towards the development and improvement of small scale industries which should be able to cater for the small domestic market. The labour/capital ratio should be maintained and manpower development encouraged to help ease the existing unemployment problems.

Lastly, although prefabrication of houses is appropriate in Kenya today, a number of constraints limits its full exploitation. Among them are, the small size of the market, the inflationary price trend of the main constructional material (timber), the existing building regulations which limit the use of inflamable materials especially in urban areas, lack of incentives by the government to encourage prefabricators and lack of a consistent and systematic policy on the choice and transfer of foreign technology to Kenya. Speedy removal of these limitations and the realisation of the part prefabs would play in the Kenyan housing market, would help promote the prefab industry and thus the prefabricators would achieve their aim i.e. provision of prefabricated timber house to the low income groups.

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CHAPTER SIX

CONCLUSIONS, RECOMMENDATIONS AND AREAS OF FURTHER STUDY

General

Although many countries throughout the world have developed sophisticated and heavy building prefabricated elements, prefabrication on small scale without use of cranes and machinery still has a significant meaning in the provision of houses as has been demonstrated in the case of timber prefabricated house in Kenya. This therefore nullifies the popular presumption that industrialised methods of construction (prefabrication for that matter) can only succeed by use of highly sophisticated capital investment in factories and site works. From the findings of the study, the assumption that prefabrication per se is inappropriate in Kenya has also been nullified although not without conditions as will be seen shortly . The main idea in this simple systems of prefabrication lies in some transformation in the process of production and erection by mere use of simple tools and equipment and not heavy machinery. The main points or areas of emphasis in this simple prefabrication as compared to conventional construction are:-

- A strong emphasis on modular coordination. This is because every simplification of various components reduces costs. This in the case of timber prefabrication has been achieved through the production of simple panel systems

which are easily erected by unaided labour.

- Standardization: This is inorder to reduce the number of different types of components
- Reduction in weight or lightness of components since this gives economy in transportation
- Simplicity in technological process which is very suitable for unskilled workers.

Prefabrication in Kenya however has been faced with a number of problems and therefore has been limited in its success.

One of the major bottlenecks to the industry is the prevailing building codes and regulations. As discussed in chapter four, the current codes do not allow timber building in urban areas and any time one is put up, it is considered temporary. This in essence restricts demand for prefabs to rural and peri-urban areas thus heavily restricting the market.

Secondly there is a prevalent belief that the standards of prefabricated buildings are inferior to those of traditional construction. Additionally, the use of timber in the rural areas is regarded as retrogressive in the face of changing times and where anything remotely associated with the old traditional way is not respected. Consequently, anybody wishing to build a 'decent house' would prefer block construction to timber construction. This further restricts the demand for

timber houses in the rural areas leaving us mainly with big plantations, road construction works and research projects as the main market for prefabs.

The third factor which hinders the success of timber prefabs is the inflationary cost trend of timber and timber products. Being the main raw material, the cost of timber definitely affects the total construction cost of the building. This results in two basic problems:- first the cost of timber houses tends to be relatively higher or just comparable with block construction given similar specifications and standards. Secondly as a result of the high cost of timber, prefab houses tend to be affordable by middle class families as was illustrated in the case of Kariobangi housing project discussed in Chapter four. This actually defeats the main objective of prefab timber houses which is production of simple structures for disadvantaged low-income earners.

Fourthly, prefab industry in Kenya has been faced with technical problems which are common place to prefabrication all over the world. Jointing and connection problems have tended to downgrade the worth of timber prefab houses to the clients. Incidents, especially in the early stages of the industry's development have been noted where big gaps at the connection of adjacent panels have developed shortly after the erection of the house. These problems relate to the issue of tolerance and precision.

The fifth factor hindering the development of the prefab industry is the inefficient consideration of the feasibility of the adopted system. In chapter four, it was observed that most of the firms enter this business for profit and normally do no formal and systematic analysis of the system adopted. As a result the firms passively accept the conditions dictated by the market without bothering to improve the market through thorough market research and so on.

Lastly, there is lack of proper planning and incentives on the part of the government to support or create demand for prefab houses.

Policy Guidelines and Recommendations

In introducing any prefab system in Kenya and indeed the rest of the so called developing countries, a number of factors need to be taken into account.

a) Nature of prefab elements

The basic prefab elements should be made by artisan methods or with simple machines. These elements should be light enough to be handled by at most four workers with minimum use of machines - simple machines such as pulleys and non-mechanized cranes.

b) Codes and regulations

The need to revise the current codes and regulations need not be overemphasised but is abundantly clear that the

prevailing building codes in Kenya - an inheritance from the colonial era - are out-dated and do not take into account the local needs in some cases. For instance the restriction on the use of timber houses in urban areas has greatly restricted the timber prefab market in Kenya and ironically thousands of people for instance, in Nairobi continue to live in poor dwellings. It is necessary therefore to incorporate in the local building regulations, structural systems and sizes of prefab components that would be suitable and acceptable. These regulations should be subject to regular assessment and review as conditions change.

c) International tenders

Due caution should be exercised when international contractors get tenders to start prefab plants either on their own or in joint ventures with the locals. When such foreign contractors get tenders in a country like Kenya, they tend to use their own managers and supervisors who are unfamiliar with the particular problems of the recipient country. Under such circumstances, a lot of related problems arise because such managers tend to remain national at heart tending to use materials and products manufactured in their own country when less expensive and equally suitable products could be obtained locally. Secondly international contractors tend to adopt sophisticated management systems most familiar

to them ignoring the skill development at the local level. In case of joint ventures, there is a tendency of very poor planning and budgeting which is all blamed on the local partners whereas in actual fact they are only consulted in times of crisis and difficulties (See UNDP publications on joint ventures). For instance in Bahrain prefabrication done before 1975 used local materials and expertise. A change however came in 1976 when international contractors were invited for tender and many contractors turned up and pressed for their bids. Once they were given the tenders, many imported materials, machinery and expertise from their own countries were introduced putting a lot of strain on the foreign exchange. This was very disastrous and at its best led to a lot of cost overruns. It was also observed that most of these international contractors and consultants failed to study relevant experience and publications on problems of the industry and as such developed designs and specifications which were inappropriate to the local conditions[1].

d) Recognition and role of the indigenous informal construction sector

The importance of the indigenous construction sector as a contributor to social and economic development is being increasingly recognized. Consequently, particular emphasis needs to be given to the role and contribution of the informal sector in the construction industry. Governmental policies need to be re-formulated placing particular emphasis on the

potential of the informal sector not only in the construction industry but in the whole economy. This can be achieved through:-

- ° Giving special attention to the needs of the sector and coordinating all the facets
- ° Examining the nature and scope of the sector as as a matter of priority in order to formulate ways of ensuring its promotion and growth
- ° Preparing long-range social, economic and physical planning proposals with the role of the indigenous construction sector in mind.

i) Promotion of construction resources

The promotion and the use of domestic construction resources not only in prefabrication but in the construction industry as a whole should be based on a new source of partnership between the private and public sectors. Action in this respect could focus on the following areas:-

- ° Mobilizing promotional finance for investment and working capital and making it available for a variety of specific groups such as house owners, small enterprenuers, contractors and retailers in the field of construction.
- ° Increasing man-power resources through the upgrading of skills, the improvement of management, the formulation of operational and interprenuerial unit in the public and private sector and the setting up of a construction - industry manpower - development organisation.

- Designing procedures aimed at allowing the informed selection and use of appropriate construction techniques with a view to promoting the rationalization of indigenous construction capacities.
- Increasing the exploration and production of building materials and products to meet basic development demands and designing and producing a range of simple tools and plant for informal sector.
- Discouraging imports where there are clear possibilities of developing indigenous building materials and products of the required quality and in the required quantity.

ii) Technical support programmes

One constraint on the effective growth of the indigenous construction sector and specifically in prefabrication is the lack of organizational, managerial, technical and accounting ability. Expanded technical support programmes should focus primarily on the informal sector, and it should be recognised that the outcome of such programmes should cover:-

- Training for construction trades and professionals.
- The improvement of the management skills of the contractors and especially the organizational capabilities of small-scale companies.
- The provision of financial assistance for research and development programmes aimed at

making practical improvements in conditions in the indigenous construction sector.

- The identification of appropriate procedures for the evaluation, comparison and selection of cost-effective, efficient and appropriate designs and technologies for building and infrastructure, with emphasis on residential programmes.
- The establishment of information systems and services including data collection systems especially in the informal sector.
- The rational utilization of construction equipment and tools through the development of local arrangements such as hire services etc.

e) Government policies

There is a prevalent need to recognize and incorporate timber house construction in development plans. This in turn would help to restrain the inflationary price trends of timber and timber products. The cost of putting up a prefabricated timber house could be greatly reduced by undertaking measures to ensure that timber is available at affordable prices. This would help manufacturers and at the same time present the product at a price that people can afford especially the low-income earners. It is exciting to note that the government has adopted a lot of measures to expand the existing forest resources through

policies such as afforestation, 'cut one plant two' etc but there is still lack of a systematic measure to enforce these policies. If these measures are adhered to and a speady removal of an inflation in the timber market effected; then many factors would turn in favour of timber prefab houses.

In summary, industrialisation of construction industry is a trend which has validity for all countries. The objectives are always the same - to make construction more efficient. The actual solutions however are different and have to be defined depending on a country's conditions in a given period. The study of industrialised techniques used in other countries is useful and even necessary but technical solutions should not be copied blindly. The optimum policy of industrializing construction industry has to be worked out for each country separately and even that has to be revised from time to time to take into account changing conditions in a country.

Throughout this study, three challenges have been posed to the decision makers

- Need to define construction standards appropriate both to the local resources and needs
- Need to clearly define parameters to be considered against which choice of construction technology will be based.

° The need for appropriate technology to be considered in terms of its linkages to a wider policy making environment.

A systematic approach towards resolution of the problem of decision making concerning construction standards and methods appropriate for simple building needs necessitates that the factors and interests implicit in the use of appropriate technology be examined and the criteria or parameters identified. Consequently appropriate technology need to be in line with the following:

a) 'Matching' the resource position of the given country or particular region thereir. This is in terms of:-

° Materials resources
° Financial resources
° Human resources
° Foreign exchange
° Technical resources

b) It must be regarded and promoted as a tool of increased (increasing) self-reliance. As such, it would refer to three elements essential to the assimulation of technology within the growth process

° Identification of constraints regarding the success of indigenous technology and economically feasible upgrading of the same.

° The careful scrutiny of available foreign technology to identify the specific one to be used and the areas where it has to meet the "matching".

° The development of such mechanisms as vocational training and specialisation, research institutions etc as would facilitate the upgrading of indigenous technology and the modification of imported technology.

The third implication of appropriate technology concerns its evolutionary continuity. If appropriate technology is to succeed, it must not only be competitive today, economically, technically and socially with existing technologies but must also have what might be called an evolutionary capacity. The problem is not merely to develop technologies to meet an immediate need, but also to build up an innovative capacity or innovative system.

c) Currently mass production or large scale production would not be appropriate in Kenya or any other African country for the following reasons:-

Firstly capital equipment would have to be increased. The capital investment in machinery in the local building industry is relatively low. Mass production on the other hand requires very high capital investment in equipment for factories and cranes for

work sites. In addition, sophisticated industrialised methods require higher amortization rates and higher profit margin to allow for depreciation. This in turn is very difficult in Kenya where proprietors are faced with problems of acquiring starting and working capital. Therefore, sophisticated industrialised technologies are almost certain to give rise to high initial cost unless very large contracts are secured. Secondly the cost can escalate because factory employees usually received higher wages than site operatives.

Secondly, with industrialisation the integration of site operatives demands the availability of a certain number of trained plant and material operatives in addition to thorough and skilled programming.

Thirdly, the resources have to be controlled in order to increase productivity. This increases the demand for modern management techniques. Very competent site organizers have to be engaged to ensure the production of prefab components in accordance with the schedule, so that there is no idling of either workmen or machinery. Again incompetence in planning or organization can waste a lot of money due to idling either in the factory or on the site. This is unlike the case of simple prefab or traditional construction

where if there is delay at the site, the workers can easily be absorbed at the construction sites or in other activities. But in case of sophisticated prefab production, a breakdown in machinery implies that work has to stop for several days or even weeks awaiting the repair or replacement of parts - this involves further delay due to importation of spares and thus drain of foreign currency.

In Kenya competent site organizers are few and none of them are experienced in large scale production of prefab. This limits the advantages that would be derived from good planning and management which ensures that gangs and materials are at hand when required and that whatever is intended to be done is done at each stage of construction.

Areas for further study

a) Availability, production and marketability of timber

b) Design of prefabricated components and its relationship to the maintenance costs

c) The incidence of fire hazards in residential timber structures

d) Modular coordination and standardization in prefabrication of buildings

e) Ways and means of alleviating the jointing and connection problems encountered in prefabricated buildings

f) The marketability of prefabricated products.

The possible financiers of the areas for further study identified above are:- The Government of Kenya through the Ministry of Lands and Housing; various United Nations agencies interested in Human Settlements such as Habitat, World Bank, United Nations Development Programme and so on, Shelter Afrique, Non-governmental Institutions such as Mazingira Institute; University of Nairobi etc. The studies could be undertaken by interested parties in the housing sector such as HRDU, Ministry of Lands and Housing; Habitat and so on. Postgraduate and Doctorate students could also take the studies and broaden them to a considerable scope.

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