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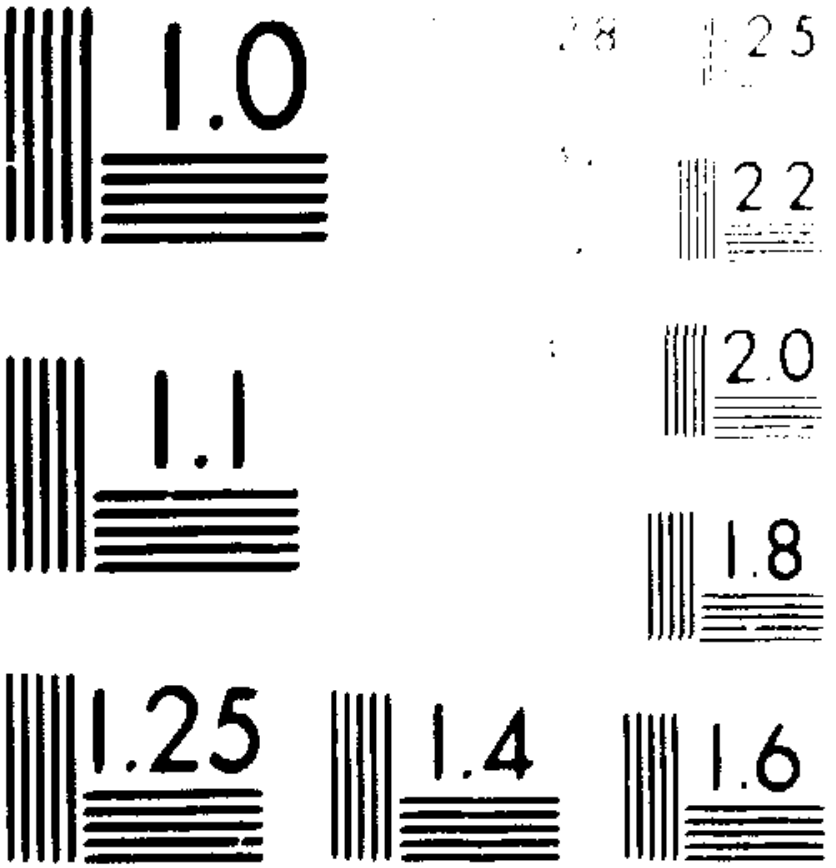
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FOR LOW-COST HOUSING

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UNIDO ACTIVITIES PROMOTING AND DEVELOPING CONSTRUCTION AND BUILDING MATERIALS INDUSTRY IN AFRICAN COUNTRIES *

prepared by

the secretariat of UNIDO

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CONTENTS

The building materials and construction industry is one of the most important sectors of economic activity and represents an essential instrument of socio-economic development. It provides a wide range of services and capabilities for designing and constructing facilities necessary for economic development.

The links between consumption, production and construction show that economic growth and social equality are dependent on construction. The activities of the construction industry are not confined to the construction of dwelling houses, but extend to infrastructure, equipment and services as well as their repair and maintenance. Thus, construction is a powerful stimulator of social growth and well-being. It is therefore not surprising that in the developed countries investment in the construction sector, including building materials, is higher than in any other sector, (over half the total investment). Considering the other factors needed for the smooth operation of the construction industry, such as the goods produced by other industries, manpower and other inputs, it is easy to see why this sector is so sensitive to socio-economic conditions and why political leaders attach so much importance to controlling its development by formulating and adopting clearly defined policies and strategies. Reciprocally, it can be said that, because they have in the past misjudged or are still misjudging the importance of the building materials and construction industries sector and its primary links with other socio-economic sectors, some countries, despite their material resources, have repeatedly made unsuccessful experiments in the field of construction which, instead of serving as an instrument of development, represents, in the last analysis, a bottomless pit swallowing up their wealth and efforts and constitutes no more than a socio-economic dead weight.

General characteristics of the construction industry in Africa

The construction industry appears twice in national accounts: first as part of capital formation by type of asset, and secondly as a component of GDP by industrial origin. In terms of capital formation, recent information shows that in the African region, the construction industry constitutes 40-56 per cent of total capital formation, whereas in European countries it constitutes between 51-66 per cent of capital formation. As far as GDP is concerned, the contribution of this sector in African countries varies between 4-11 per cent, whereas in the industrialized countries it ranges between 5-9 per cent.

It is well known that the construction industry usually employs a high proportion of labour. Because much building does not pertain to the industrial sector as such (repairs and maintenance in developed countries), it is extremely difficult to quantify the exact share of labour employed in the construction sector. However, in most highly industrialized countries, if nearly 10 per cent of the available labour finds employment in the construction industry at a time when its rate of growth is markedly slowing down, the job opportunities which this sector might offer in African countries can be appreciated, especially if labour-intensive techniques were to be promoted. A recent ECA study has established the share of labour working in the construction industry at between 3-5 per cent for African countries as against the figure of 10 per cent mentioned above for European countries.

In terms of its general characteristics, the construction industry in Africa is flexible and can expand and contract significantly in response to fluctuations in demand. Such substantial annual fluctuations in the output of certain sectors of the industry can be observed following the initiation and completion of major infrastructural works, such as dams, large irrigation schemes, airports and harbours. For such

projects, the industry relies on vast reserves of unskilled labour, easily recruited when a job is started, and dismissed as work nears completion. The price it pays for this ability to adapt to demand is high in terms of the effective use of human, technical and financial resources. Major works may also include jobs relating to the manufacturing industry, transport, trade, roads, public health, education and other public services. The major works subsector accounts for between 65-70 per cent of all building and has a direct impact on the development of the construction industry in African countries. Unfortunately, it is to all intents and purposes controlled by foreign firms which usually dispose of the whole panoply of technical and financial resources exclusively available to the large multinationals of the industrialized countries.

Housing accounts for about 30-35 per cent of the output of the building industry. Here a distinction can be made between traditional and modern structures. Little information is available on the volume of activities in the traditional sector, in which the work performed by most African people can be classified. The activities of this sector are basically characterized by the self-help construction of buildings, whose type varies from region to region. The most common constructions are stone walls, various types of mud walls, mud roofs on wooden rafters, and roofs of palm thatch.

Although various efforts are made in some countries to improve the building methods and materials used in the traditional sector, most African Governments seem to pay more attention to the problem of urban housing. Some countries have launched commendable programmes for the construction of inexpensive dwellings as an emergency measure aimed at meeting the needs of urban dwellers, the majority of whom are living in run-down housing. Most of the time, however, problems occur in connection with the high cost of buildings, the absence of a systematic

approach to the needs of users and occasionally flagrant errors in building methods. These housing programmes also point up the great gap in terms of style and of cost, between the buildings constructed under such programmes and rural dwellings. One possible solution to these housing problems lies in the efforts which can be made to eliminate the gap between programmes for the construction of urban dwellings and those for the construction of rural dwellings by introducing much more suitable building materials.

Information on the breakdown of building costs by production factor varies widely, depending on the type of work involved and the period in which it is performed. As for the construction of buildings, the breakdown of costs for reasonable well-finished dwellings, with electricity and plumbing fully installed, shows that building materials represent 45-65 per cent of total costs, whereas labour accounts for 20-25 per cent and equipment and overheads represent 15-25 per cent.

Major characteristics of African building materials industries

The building materials used to varying degrees in the African region are as follows: natural stone; agricultural fibre waste; timber; common clay and soil blocks; burnt clay bricks; tiles; lime; cement and cement products, including asbestos-cement sheets; corrugated-sheet iron; sheet aluminium; structural iron, steel and aluminium; sheet glass and ceramics (sanitary ware, tiles, pipes). The choice of materials is determined by the particular environment of their utilization (rural, urban and peri-urban), functional considerations, their availability, cost and facilities used.

Cement and cement products are the most widely used basic materials: they have displaced stone, mud, brick, and other traditional indigenous materials. The use of cement has also led to the widespread use of steel

in the form of structural steel, resulting in the gradual displacement of the traditional timber reinforcing material. The glamour of cement has escalated demand to such a degree that it now has to be imported to most African countries owing to inadequate domestic production.

In a similar manner, corrugated-sheet iron (and in some cases aluminium sheet) has become the principal material for roofing and other purpose, with the difference that, unlike cement, it has become an essential item for peri-urban and even rural sections of the population as well as for urban squatter settlements. Most countries have to import this item.

Of the other materials, glass and ceramics are secondary building materials with exclusive functions. Demand for them is at present confined to urban constructions, but it will eventually spread to rural areas. These materials are generally imported. Table 1 gives a rough idea of the trends of consumption, production and imports of some building materials, and it shows the efforts required to achieve self-sufficiency in the production of certain materials, such as cement.

Except in sophisticated urban constructions and in the use of building materials such as cement, steel and aluminium, all of which are derived from foreign systems, no hard and fast technology applies in building systems or in the production of building materials-it varies greatly from country to country. Consequently, much construction work in Africa seems to be based on antiquated methods and lacks a scientific approach to the production of building materials and their use. Many building materials, for example bricks and tiles, are of indifferent quality and fail to conform to recognized standards, thereby affecting the quality and durability of construction and necessitating repeated building repairs and expenditure.

Another common problem in the peri-urban sector and in parts of the urban sector is that design criteria barely fulfil the minimum construction standards as embodied in building regulations and do not come up to the health and safety standards governing thermal insulation and protection from natural hazards such as rain and water seepage, heavy winds, earthquakes, and atmospheric corrosion. The situation is even worse in the case of rural constructions most of which are self-designed and self-made and do not come under building codes and regulations.

Clearly, the new materials and new techniques for using traditional materials have not caught on sufficiently to justify expectations of achieving self-reliance in the present century. This situation arises from the following major weaknesses: absence of special policies and back-up (direction, promotion and dissemination); institutional gaps; inadequate knowledge and utilization of local raw materials; shortages of project finance, professional skills and trained labour; lack of organized information flow and communication and technology development; lack of quality control and standardization systems; lack of an appropriate research base; and inadequacy of requisite co-operation arrangements between countries.

Table 1

CONSUMPTION, PRODUCTION AND IMPORT TRENDS IN RESPECT OF SELECTED BUILDING MATERIALS IN THE AFRICAN REGION

Material	Unit	1975	1976	1977	1980*	1985*	1990*	1995*	2000*
Cement, lime and plaster									
Consumption	Mt	34.3	34.7	38.2	46.7	68.7	105.3	162.1	250
Production	Mt	23.4	23.5	25.1	30.7	50.0	88.0	162.0	260
Imports (net)									
Quantity	Mt	10.9	11.2	13.1	16.0	18.7	17.3	nil	nil
Value	$ million	522.5	532.7	850.3	-	-	-	-	-
Structural steel (rods, bars, sheets, pipes, joints, wire etc.)									
Consumption	Mt	5.0	4.5	4.7	5.7	8.3	13.4	21.6	34.8
Production	Mt	2.5	2.7	2.9	3.7	5.6	8.9	14.3	35.6
Imports (net)									
Quantity	Mt	2.5	1.8	1.8	2.0	2.7	4.5	7.3	nil
Value	$ million	2 278.6	2 106.1	2 309.0	-	-	-	-	-
Structural clay products									
Consumption	Mt	-	15.0	18.0	23.9	38.5	62.0	99.8	160.6
Production	Mt	-	11.6	13.5	19.2	34.6	62.3	100.3	161.0
Imports (net)									
Quantity	Mt	-	3.4	4.5	4.7	3.9	nil	nil	nil
Value	$ million	139.4	101.6	136.6	-	-	-	-	-
Glas									
Consumption	Mt	1.7	1.6	2.2	2.9	4.9	8.9	16.0	29.0
Production	Mt	--------negligible----------				2.5	6.6	16.0	29.0
Imports (net)									
Quantity	Mt	1.7	1.6	2.2	2.9	2.4	2.3	nil	nil
Value	$ million	67.9	63.7	87.4	-	-	-	-	-

* ECA estimates

Notes: Quantity of imports has been deduced from published value of imports. Source of information for imports: Yearbook of International Trade Statistics, 1973, vol. II, Statistical Office, DIESA. Source of information for consumption and production: World Statistics in Brief, Statistical Office, DIESA (United Nations publication: Sales No. E.78 XVII 9).

Production of building materials

Binder

As far as the production of building materials is concerned and taking into account the conditions prevailing in the African region, the guiding principles should be: diversification, decentralization, balanced plant size matching the size of local markets within reasonable distance, efficient utilization of capacity, quality standardization, and linkages with other industries. Although some materials, such as brick and cement, are intended exclusively for consumption by the construction industry, others such as iron, steel, wood and glass may be used in a number of sectors. A material such as lime is widely used in foundries, acids, non-ferrous metals, glass, heat-resistant materials, wood pulp, soda, ammonia, oil, fats, cosmetics, fertilizers and food processing industries. It is also used to purify or neutralize water, to serve a number of purposes in fish-breeding and pharmacology, to control epidemics and fulfil other purposes, apart from its various utilizations in the construction industry itself, including road and railway construction. Taking into account these multiple uses of lime and some other factors, such as the wide range of raw materials which can be used for its production, the broad range of technologies available, the low capital investment cost (see table 2), lime is certainly one of the building materials the production of which should be given high priority in each country.

Similarly, and for the purpose of diversification, technologies are available for the production of cement substitutes based on the

utilization of lime. The most important of these products is lime-pozzolana which could be produced in almost every country and could advantageously replace cement in most urban, peri-urban and rural housing programmes, including human settlements improvement schemes.

Because cement is universally used in all types of building and civil engineering projects, the cement industry is an important subsector of the building materials industry. The process of manufacturing cement is simple, but nowadays it is so highly mechanized that, most of the time, a large capital outlay is required. For this reason and also taking into account other factors such as the availability of raw material resources, energy, and market, the pooling of which might necessitate joint actions at the subregional level, split-location of cement production should be encouraged whereby clinker produced in large clinker plants could be ground in plants set up near the points of consumption, whereas the use of pozzolanas in existing cement plants as a means of improving their profitability and increasing availability of cement for construction (by making pozzolana cement) should be considered by African countries. Similarly, the utilization of rice husk or other agricultural residues to produce ash-masonry cement on the basis of technology developed by some developing countries should also be considered by countries where these waste materials are available.

Moreover, in some cases, and for the exploitation of small limestone deposits at various locations, consideration could be given to setting up mini cement plants to match the limited availability of power, water and other inputs and to meet the demands of a local captive market, thereby reducing the strain on the national transportation network, permitting the participation of local smaller entrepreneurs and helping to boost the local economy. Nevertheless, the setting up of mini cement plants should be preceded by comprehensive techno-economic and social studies to ensure sound decision-making. In this connection, it might be necessary first to set up, with the assistance of relevant international organizations a few demonstration-cum-training pilot plants. The same approach could be adopted in respect of the production of the cement substitutes mentioned above.

Table 2:

COMPARATIVE CAPITAL INVESTMENT COST IN THE PRODUCTION

SELECTED BUILDING MATERIALS

Material	Investment cost ($ per tonne)	Basis of plant size in arriving at investment cost (tonnes per day)	Cost of material ($ per tonne)	Source of information
Cement	150	100 (rotary kiln)	72[a]	Intermediate technology group, London
	200	600 (rotary kiln)		Intermediate technology group, London
	50	600 (rotary kiln)		India
	25	100 (shaft kiln)		India
Burnt clay bricks	98	60 (Hoffman kiln)	24	UNIDO
	110	60 (tunnel kiln)	26	UNIDO
	48	125 (Hoffman kiln)	19	India
Stabilized soil blocks	3[b]	-	384 CFA/m^2	Togo
Cement blocks	5[b]	-	494 CFA/m^2	Togo
Lime	3[b]	-	·17 C	United Republic of Tanzania
Sand-lime bricks	3	-	12	India
Cellular concrete (lime and flyash)	13/m^2	1.7 million m^3	-	India
Lime-pozzolana (Surkhi (Surkhi)	14	20	10	India
Clay-pozzolana	8	20	10	India
Sisal-cement sheet	5[b]	-	2	United Republic of Tanzania
Asphalt roofing sheet	0.3/m^2	2 million m^2	1.4/m	India/United Republic of Tanzania
Corrugated-iron sheet	300	-	4.2/m	United Republic of Tanzania
Corrugated-aluminium sheet	300	-	4.93/m	United Republic of Tanzania
Gypsum plaster	12.4	10 (rotary kiln)	22	India
Sheet glass	50 (Fourcoult)	40	-	India
	80 (PPG)[c]	40	2	India

[a] Cost prevailing in United Republic of Tanzania in 1980
[b] ECA estimates of investment cost
[c] Pittsburgh Plate Glass process

Notes: Lime-pozzolana can replace up to 40 per cent Portland cement. Clay pozzolana can replace up to 25 per cent Portland cement. Stabilized soil blocks can replace up to 75 per cent cement blocks. Corrugated asphalt/sisal-cement sheets can replace up to 50 per cent corrugated-iron or aluminium sheets in roofing. Machine-made clay bricks can reduce cement consumption by 10 per cent.

Clay-based products

Apart from binders and their components, clay-based products constitute another group of building materials, the development of which is likely to have an immediate impact on the promotion of the African building materials industries. Of these materials, special attention should be given to the production of burnt bricks and roofing tiles, at reasonable cost and using the various technologies available, as a viable alternative to the conventional materials currently used, particularly cement and cement products. Depending on the location, needs and requirements, the Bull's Trench kiln or the clamp kiln could be adopted using, as much as possible, wood or agricultural wastes as fuel.

Wood and wood-based products

As far as the utilization of wood and wood-based products is concerned, national and subregional efforts should concentrate on the need to:

(a) Draft and adopt building codes that allow the rational use in construction. Measures should be taken to promote the use of wood, whenever applicable, including a wider range of species and applications than hitherto. National and regional standards for manufactured timber components should be drafted and adopted;

(b) Develop low-cost timber engineering designs in the construction industry both for urban and rural areas;

(c) Produce wood-based panels from secondary species and forest and saw mill residues;

(d) Introduce the rational groupings of species and grading (including stress grading) of timber;

(e) Introduce scientific processing techniques.

Since the region contains both countries with abundant forest resources and others with a lack of forests, the use of timber in construction in the latter countries should be combined with other materials. Panels should be produced from agricultural residues. Considerable savings could be obtained in timber utilization through the rational design and use of shuttering forms (using whenever applicable appropriately surfaced panels) for concrete work.

Other building materials

Similar to other products such as iron and steel and allied materials, the production of glass, sanitary-ware, electrical fittings and accessories should be envisaged in the framework of other sectors and mainly on a subregional basis.

Tables 2 and 3 give some indication of the comparative investment costs for production of selected building materials as well as an estimate of investment requirements for the development of additional capacity.

Table 3:

ESTIMATE OF INVESTMENT REQUIREMENTS FOR THE DEVELOPMENT OF ADDITIONAL BUILDING MATERIALS CAPACITY

(In millions of dollars)[a]

Material	1980-1985	1985-1990	1990-1995	1995-2000	Total
Cement	2 000	4 560	11 100	16 600	34 260
Structural steel	600	1 155	2 160	10 650	14 565
Sheet glass	125	387	940	875	2 247
Structural clay products	316	692	1 140	2 428	4 576
Total	3 041	6 794	15 340	30 553	55 648

[a]Cost escalation factor included

Research

Above all, the smooth and rapid development of the African building materials and construction industries based on the utilization of locally available resources can only be achieved through the development of research (up-grading existing national research facilities and setting up subregional building and building materials research centres). Research priorities should include: techniques for optimizing the production of critical building materials (primarily cement) from existing plants; new technologies for using traditional building materials and local materials for improving the quality of rural buildings; development of techniques for material substitution and conservation of scarce resources; techniques for converting agricultural and industrial wastes into building materials; methods of reducing building costs; medium-and small-scale production of building materials; and the reformulation of building codes and regulations.

Training

The development of the building materials and construction industries in the African region depends on the technical, managerial and organizational know-how of the local construction personnel. Le of financial support is usually due to the above deficiencies. Hc in the final analysis, it is the local contractors who will encourage local production and utilization of building materials. It is therefore essential that these contractors be trained or retrained at the national and subregional level in courses offered periodically in specific subjects. The same also applies to middle-level technicians and workmen who experience great difficulty in using new materials.

UNIDO's committment in the construction and building materials field

It is quite natural that UNIDO is committed to promoting the development of the construction industry in developing countries and has extensive programmes for this purpose. In Africa the construction industry, including the manufacture of building materials, is one of the areas slated for concentration in the "Industrialization Decade for Africa", proclaimed by UNIDO, the Economic Commission for Africa, and the Organization for African Unity. Self-sufficiency in building materials is one of the stated targets to be achieved within this decade according to the Lagos Plan of Action for the economic development of Africa.

UNIDO supports the development of the building materials industry in Africa through technical assistance projects in almost every African country. Four construction industry and building materials specialists, who are staff members of UNIDO's Chemical Industries Branch supervise close to 30 on-going technical assistance activities throughout the world, at a cost in 1982 estimated at US $ 7 million. The construction and building materials industry receives 25 per cent of the technical assistance provided by the Chemical Industries Branch and 6 per cent of all technical assistance provided by UNIDO. Examples of UNIDO's technical assistance to the building materials industry are:

- Trouble-shooting at existing plants
- Assistance in operating existing plant
- Setting up research institutes and pilot plants
- Investigating local sources of raw materials
- Carrying out feasibility and pre-feasibility studies
- Negotiating contracts
- Carrying out marketing studies
- Dissemination of information on technological developments
- Promoting projects including the seeking of sources of finance

UNIDO's planned activities

Based on the project ideas above, UNIDO is planning the following major activities:

(a) Assessment of long- and short-term requirements for building materials, component and construction services, taking into account those aspects of national economic development plans directly or indirectly related to construction activities;

(b) Conducting of studies and surveys of such factor inputs as basic raw materials, resources and other inputs, production and infrastructural facilities and skilled manpower, on the basis of which gaps can be identified;

(c) On the basis of the assessment in (a) above, completion of an overall evaluation of the sector's development, clearly indicating requirements and possibilities, the relationship between consumption and production, and the methods for developing the factor inputs cited in (b) above;

(d) Identification of the developmental actions required with particular regard to:

(i) Raw material exploration, investigation, mining, and beneficiation;

(ii) Energy, water and other resources;

(iii) Transport and communications infrastructure;

(iv) Production of essential building materials, such as cement, bricks, tiles, lime, building stone, and durable roofing materials in the first stage of development followed by the manufacture of glass, ceramics and metallurgical products at subsequent stages;

(v) Marketing and distribution systems and services designed to satisfy consumer needs;

(vi) Development of skills for the production of materials and construction services.

(e) Promotion of the rationalization of construction systems through the reformulation of building codes, regulations and building standards, thus leading to greater utilization of local building materials and helping to reduce construction costs;

(f) Organization of and support for research and development and training activities geared to the development of indigenous building materials and appropriate techniques for their utilization in construction;

(g) Keeping abreast of developments in the building materials and construction industries in other parts of Africa and other developing regions, with particular reference to co-operation arrangements between countries;

(h) Conducting of studies into traditional housing systems and techniques in order to promote those suitable for industrial production.

Institutional framework

The institutional mechanism, in particular at the national level, essential to the successful implementation of the projects and activities identified above includes the following:

(a) Introducing a "nodal mechanism", as part of the Government apparatus, responsible for the comprehensive and co-ordinated planning of the building materials and construction sector, due account being taken of the needs of other economic sectors. This mechanism, which will bring

together all major sectors involved in various aspects of the building materials and construction industry, will facilitate the identification of operational and other constraints upon project programming, execution, evaluation and follow-up and indicate to the decision-making and executing agencies policies to be adopted as well as the means;

(b) Setting up and strengthening research, development and training institutions so as to promote the rational and efficient utilization of local resources in construction, thereby increasing construction industry output and reducing construction costs;

(c) Establishing and strengthening institutional capabilities for project elaboration, engineering and management, product standardization, quality control, raw material investigations, building materials production and distribution.

The development of a mechanism at the subregional level, for example, through the establishment of a building materials and construction industries development council within the framework of the existing and planned economic groupings might constitute an appropriate framework for promoting joint subregional activities, harmonizing policies and elaborating methods for project planning and execution in areas of common interest. These mechanisms should be co-ordinated at the regional level.

Steps should be taken to establish a regional network with subregional and national linkages for information on building materials and construction industries, similar to the one just established in Asia and the Pacific, supported by UNIDO project DP/RAS/82/012- Low-Cost Building Materials Technologies and Construction Systems.

ANNEX I

UNIDO - World Bank
Co-operative Programme
in Construction and Building Materials
in Africa

UNIDO in co-operation with the World Bank has over the past several years become increasingly involved in surveys aimed at identifying problem areas and constraints to the development of the construction industry in developing countries. The World Bank has established the office of Construction Industry Adviser in order to help in formulating ideas for assistance and to co-ordinate the Bank's work in this area. UNIDO's contribution has been through the joint programme with the World Bank, which has over the past four years completed surveys of the construction industry in several developing countries, viz. Swaziland, Burundi, Liberia, Madagascar, Yemen Arab Republic and Sudan. In the case of Burundi, the work initiated by the Cooperative Programme in Vienna has led to the World Bank's first comprehensive loan for the development of the domestic construction industry. Additionally the Co-operative Programme has identified and prepared projects related to the building materials industry in the Yemen Arab Republic and Nigeria.

A study of the construction industry in West-African countries was proposed to be carried out under the UNIDO-World Bank Co-operative Programme in 1982. Due to changes in the organization the study was implemented and financed by the World-Bank/International Finance Corporation in consultation with UNIDO, and reviewed Niger, Upper Volta and Mali. The findings and recommendations of the study are as follows:

Because of the generally similar geographic, climatic, social and economical conditions existing in these three Sahelian countries, nearly identical building and construction traditions have developed. Approximately 90% of the combined populations live in houses built from banco. Banco is a commonly occurring clayish soil, an African equivalent to adobe. The soil is wetted and shaped into bricks, which are dried in the sun. The main use of banco is for residential housing. Recently, there has been an effort to utilize banco for low rise public construction such as schools and hospitals; so far most of those were under the umbrella of demonstration projects. It is this kind of effort that should be supported and improved by application of optimal technology. The so-called modern construction technology using modern construction plastics and non-ferrous metals, is typically confined to a handful of

larger cities in each country and comprises office buildings, modern hotels, airport buildings, market halls, hospitals, factories, meat processing plants, and villas for the few affluent. This type of construction directly affect lees than 10 per cent of the population. In addition, there are a few types of modern infrastructural systems and projects such as roads, railways, dams, power systems, irrigation systems, which consume cement, rebar, steel, asphalt etc., as well as fairly large quantities of local aggregates, clays, laterites, etc. It is estimated that the above large, modern construction consumes over 80% of construction investments, over 90% of structural steel, and rebars, over 70% of cement, over 80% of burnt clay bricks, almost 100% of glass, non-ferrous metals, plastics, paints and other modern construction materials. Typically, these types of construction are carried out by a few international enterprises, through local agencies with foreign engineers and a core of local technicians and foremen. Labor is hired for specific jobs; however, local value added of these construction jobs is extremely limited since all large equipment, most materials, engineering and sometimes even skilled labor, are imported.

In addition to the above type of construction, predominantly financed by foreign bilateral or multilateral agencies there is a need for another type of construction which affects more broadly the everyday life of over 80% of the population. This type of construction comprises housing, despensaries and small hospitals, schools, storage structures for crops, as well as administrative buildings and small hotels in smaller cities; secondary and tertiary feeder roads, and small scale infrastructural systems.

As is natural in countries with extremely low income levels, these needs are either met through self help or artisanal construction as well as multilateral agencies, are active in these areas, assisting with urban projects, in hospital construction in health projects, school buildings in educational projects etc. Typically, these projects are being executed with a low content of imported inputs, by making use of locally produced concrete blocks or burnt clay bricks, local wood, locally

formed corrugated steel, all with a high content of local manpower input. Yet local value added content of cement, (if produced locally as in Mali or Niger) of burnt clay bricks and of corrugated steel is low, since the high cost inputs i.e. energy and sheet metal are imported. For all these projects which can be carried out without utilizing the modern construction technology typically applied in the industrialized countries, there is a need for a construction technology which maximizes local inputs, is easily learned by local technicians and labor, and permits artisanal or semi industrial production of needed building materials, hopefully at locations close to the centers of consumption.

All three countries experienced a building boom during the 1970s which caused the consumption of main building materials to grow at annual rates above 10%. During that period the small cement plants in Diamou (Mali) and Malbaza (Niger), reached capacity utilizations of 80% (Mali) and 90% (Niger). In addition, sizeable and growing quantities of cement, as well as all of the required steel rebars, steel sheet, non-ferrous metals, plastics etc., were being imported. Several medium size brick plants were installed but their management found it difficult to compete with conrete blocks made in artisanal manner. In expectation of continued rapid growth all three countries planned to build large cement plants (300,000 tpy).

However, the second oil price shock and the international economic recession caused several problems. The balance of payments situation deteriorated, investment levels dropped, locally produced energy intensive materials (cement, burnt bricks) ceased to be competitive. Imported cement became cheaper than locally produced cement due to marginal pricing by foreign producers, who had access to cheaper fuels (coal firing). Burnt bricks lost out almost entirely against concrete blocks and stabilized banco bricks. For the first time in many years an over-supply situation exists for many imported building materials as construction demand declined during 1981 and 1982. For the remainder of the 1980s, demand for imported building materials is unlikely to grow

much above 5% per year from present depressed levels, due to relatively limited investment funds and the high cost of these materials. However, needs for construction, particularly construction which affects the poorer 90% of the population, will continue to grow. It is with these perspectives in mind, that the following sections identify constraints and issues and make recommendations for an action programme.

Each of the three countries is about 1000 km away from the nearest port (which is located in a foreign country). Thus imported materials are about 50% to 150% more expensive, than they would be in the coastal areas of West Africa, due to multiple handling, high transportation costs, breakage and pilferage, and several layers of profits for transporters and traders. The resulting high price makes it impossible for the majority of the population to afford these imported building materials. The market for the modern building materials remains very small.

While the high cost of transportation on imported products would normally provide enough protection to set up local manufacturing facilities, the constraints of the thin market prevent sufficiently large production units which would afford economies of scale. Moreover, energy costs are exorbitant. Because of the high transport cost component, only high-calorie-fuel is worth utilizing. Delivered fuel oil costs are above US$ 350/ton. For building materials, where energy costs already normally account for about 50% of total production costs, such a fuel price becomes a problem. Deposits of low quality coal have been discovered in Niger, and conversion to coal firing, could be considered for the existing small cement plant. However, the conversion may require such a high investment, that it appears uneconomical, particularly since only partial coal firing may be feasible due to the low calorific value of the coal. Moreover, these countries have little industrial tradition and very little manufacturing on an industrial scale has taken place, so that managerial talent and technical expertise are lacking. The cost of utilizing foreign managerial and technical assistance becomes extremely high for small scale production units. Not surprisingly, as a consequence only few production units for cement (two) for lime (two), ceramic bricks (seven) have been installed and very few of them have succeeded. Production costs for these plants now exceed the sales price of imported products.

In recognition of the high costs of imported building materials and the growing need for low cost housing, schooling, hospitals, and infrastructure, various institutions have started to look into the possibilities of making better use of local inputs. Research has been initiated with regard to improving the traditional banco brick through addition of reinforcement fibers from plants or fruits by adding small quantities of cement or lime, resins or even synthetics, by using manual presses for compression, by applying solar auto-claving etc. Specialists have gone into the villages in order to revive past practices and knowledge such as mixing of vegetable oils with banco for the outside plastering, which over time will render the walls waterproof.

However, these efforts face the following obstacles:

i The population perceives work with stabilized earth, rammed earth or banco bricks as "backward" and would rather build with "modern" concrete blocks, clay bricks etc. So far, too little attention was paid to promotional efforts and marketing in the various research and demonstration projects.

ii Too little is known regarding the location and quality of deposits of local raw materials such as banco, laterites, pumice, pozzolanas, and construction grade rock. While geological surveys have produced geological maps in each of the three countries, very little attention was given to identifying deposits of raw materials for the building and construction industry. What is needed is a survey based on mobile units comprising simple drilling equipment and laboratories, appropriately staffed and equipped to carry out (a) the geological search and mapping for that purpose (b) quality control of material production.

iii Existing building codes often date back to the time of French administration and discourage if not forbid the use of banco construction. Moreover, engineers and technicians are trained

in Europe and like to think "modern", using industrial countries' standards, materials and equipment.

iv Government institutions, which give far more attention to medium and large scale projects and have little time, sympathy or funds for the low cost projects. Responsibilities are widely dispersed between various ministries making it difficult to coordinate activities toward the development of low-cost locally based construction materials.

v Lack of coordination: while research and practical application of low cost construction is practiced in many different ways throughout the three countries, there is little effort to exchange information, compare results and learn from each other's experience.

vi Lack of credit: it is hard to persuade banks and other lending institutions to accept banco construction, even if some sort of soil stabilization has been employed. The small artisanal contractor normally cannot give a tangible guarantee, that the house would last over 10 years, which makes lenders hesitant to provide mortgage funds.

In recognition of the above constraints the study sees a need for a comprehensive action programme for the building material sector as follows:

1. Detailed Sector Study

This study should review the existing institutional and policy framework including norms and standards for materials as well as construction technologies. The study should take stock of existing production facilities, distribution systems and pricing policies. It should gather information of all ongoing research on appropriate construction materials and methods and check results of applications.

It should carry out geological searches for appropriate raw materials to be used for low cost construction materials close to consumers. Findings of the study should lead to recommendations for required institutional support, improved policy frame work, development of new codes and standards. Analysis of raw materials, existing facilities and ongoing research should lead to proposals for industry restructuring, rehabilitation of existing plants with remaining economic life as well as proposals for new investments.

ii Promotion of Selected Demonstration Projects

To support the recommendations of the study, typical demonstration projects (housing, hospitals, schools, irrigation systems, and low cost road construction) should be carried out in each of the countries using the recommended technology. Careful records should be kept as to execution time, costs, and performance compared to specifications. These projects should also contain an element of "marketing" the results, "selling" the optimal products.

iii Implementation of Recommendations after Analysis of Demonstration Projects

This part of the action programme would provide for an investment programme involving rehabilitation of existing production facilities for construction materials, exploitation of newly discovered raw materials, training of personnel in production and use of "new" materials, further demonstration projects for publicizing and marketing the "new" products.

ANNEX II

UNIDO Programmes in the Field of
Construction and Building Materials Industry
in Selected African Countries

1 - Cameroon
2 - Madagascar
3 - Ghana
4 - Gambia

1 CAMEROON

The Government of Cameroon is assigning high priority to activities aimed at increasing the rational exploitation of the country's natural resources and among the sectoral activities identified as being particularly significant in this context are the development of local building materials and construction industry as well as of non-conventional energy sources both with particular reference to rural areas.

In spite of an abundance of raw materials comprising non-metallic minerals such as limestone, clay, sand, pozzolana as well as wood and other vegetal materials the building materials industry has not undergone any appreciable development over the past several years. Outside the traditional sector the overwhelmingly dominating materials are cement and concrete and corrugated sheets which, however, still to a large extent are imported.

Manufacture of fired clay bricks was a common artisanal occupation during the period of German colonial rule and was until a few years ago represented by a now idle mechanized brick plant in Yaoundé "Les Argiles industrielles du Cameroun" producing 30-100.000 pieces (mainly hollow Blocks) per month in a Hoffman kiln. However since the closure of the Yaoundé plant apparently due to inferior product quality resulting in excessive breakage during transport, brick manufacture is virtually non-existing apart from a few manual family operations (in the Eastern Province) and sporadic efforts of missions in connection with church construction.

In the urban construction sector which so far has received most of the Government's attention excessive housing costs indicate the need for a change to more economic materials for low cost housing. Nevertheless urban centres and particularly Donala and Yaoundé now experience a growth rate of 7 - 3% per year and considerable emphasis should be placed on activities favouring the development of housing and infrastructure outside these cities in order to render the life in the secondary towns and rural centres (agrovilles) more attractive and thus to reverse the trend of the rural exodus.

Electrification of rural areas and more extensive use of non-conventional energy sources will contribute towards the same objectives. The energy requirements of the country are still exclusively satisfied from conventional sources, i.e. oil and gas as well as electricity generated by conventional hydro and thermal power plants. However, only 22-23% of the population have presently access to electricity and this percentage is not expected to exceed 30% by the year 2000 unless non-conventional energy sources are exploited.

An important potential for establishment of mini hydro power plants exists in the many rivers and streams of the country and there are also plans for the development and application of technologies based on the utilization of biomass including wood, agricultural and animal wastes with particular emphasis on fermentation alcohol and biogas. Several institutions are already involved in energy related activities and some of them are operating pilot units for research purposes. One of the important future tasks will be to translate the experiences so far gained into practical action resulting in the increased availability of energy (particularly electricity) in rural areas.

Recently a UNIDO study was prepared with respect to the local building and building materials industry. The conclusions of the report are as follows:

- There is only a small number of different building materials, and they are often of poor quality. The supply of industrial materials is good, although these materials are very expensive.
- The local building materials are at site. There is almost no production of bricks and lime.
- All over the country, apart from a few places, the soil is of adequate quality for the production of mud blocks or "rammed earth". Soil stabilization is not practiced.
- Appropriate clays for the production of fired bricks can be found almost everywhere.

- There are a few places where deposits and layers of limestone were identified which may be used for the production of lime. A detailed study has to be carried out.
- More than 90% of the houses are built out of local materials. The buildings are mostly built either by the individual people or (particularly in towns and urban centres) by small entrepreneurs. Every region has its own specific type of houses.
- The housing requirements, i.e. the size and the standard of the houses, of the people living there now bring up the problem of the adequacy of building materials and technologies which often do not meet with the new requirements.
- It is expected that mostly small towns and centres will expand in the near future, a trend which has been quantified in the report.
- The housing sector is not very well structured for people with a low income: assistance in this sector is not usual.

2 MADAGASCAR

There are several raw materials available as building materials in Madagascar: sand, stone, clay, laterite and timber. Nevertheless, the country depends heavily upon imports for the materials and components required to implement its construction plans. This is partly due to limited manufacturing capacity and partly to lack of road and railway networks and transport capacity. Occasional, and in some cases chronic, shortages and frequent delays in deliveries of building materials constitutes the most serious bottleneck for the construction industry.

Cement

The country's only cement plant, with an annual capacity of 75,000 tons, is located in the seaside town of Majunga. Raw materials are imported gypsum rock, local marly limestone and puzzolan. In 1975 it produced only 58,000 tons, due to occasional breakdowns. In 1976 estimated demand was 180,000 tons , which remained unmet to a large extent. The largest quantity of cement was imported in 1971 (93,300 tons), the least in 1976 (24,000 tons); 66% of the imports came from Kenya, 13% from Mozambique and 5% from France. Although no statistics are available in this respect, it is estimated that the actual cement consumption of the country may be subdivided as follows:

1.	Public works (roads, bridges, ports, airports)	40%
2.	Urban buildings	20 - 30%
3.	Rural buildings (unauthorized)	10%
4.	Rural civil works (irrigation, etc.)	20 - 30%
		100%

It is difficult to estimate future demand for cement. Considering the need for road construction, the hydro-agricultural projects and the 20,000 flats/year housing programme, 300,000 tons per year is a plausible estimate.

Two new cement plants, with a total capacity of 200,000 tons per year are planned to be constructed in Antsirabe and Toliary.

Another serious problem facing an adequate cement supply is that of land transportation. With the only local plant situated at the port of Majunga, and the imported cement arriving by sea to Majunga and Tamatave, every bag of cement has to be transported on the overcrowded road (Majunga) or the narrow-gauge railway. As a result, prices for cement in the capital and the central part of the country (Haut Plateau) are extremely high and cement is scarce. It is therefore recommended to develop materials to replace and substitute cement, as well as to develop construction technologies using less amounts or no cement for housing in the central part of the country. On the other hand, relatively cement-intensive reinforced concrete prefabrication systems could be operated along the coastline, where cement supply is relatively simple and cement is abundant.

Lime

Although Madagascar is rich in good quality limestone, very little burnt lime is used, and even less is produced in the country. In the province of Diego-Suarez, three limestone quarries exist near Remena, Jangoa and Amilobé. In the province of Majunga 19 quarries are known. In the province of Tamatave, one quarry is known, in Foulpointe. Large deposits are apparent near Ambatondrazaka. In the province of Tananarive some limestone quarries have been operating for a long time, and some deposits have not yet been exploited near Ambolimirkitra, Ankaratra, Madera, Arivonimano, Ambohibary, Imerintsiatosika, Ambotolampy and Antsirabe. In the province of Fianarantsoa, relatively few and minor deposits are known near the towns of Fianarantsoa, Ankaremana, Ambalavao, Kisopa, Volafotsy-Vinany, Mananjary and Ambatofinandrahana. In the province of Tulear, big deposits are known near Sakoa, Sakamena, Soalara, Miandrivazo, Belo-Sur-Tsiribkina and Ankilizato. Quarries exist near Befandriana, three near Tulear town and one east of the airport.

It is recommended that lime kilns should be built all over the country in order to replace part of the cement presently used for housing. It appears that industrial lime kilns (both vertical and rotating) could be built in the Diego-Suarez, Majunga and Tulear areas. The coastal area of the country (up to a depth of about 100 km) could be supplied from

the production of these kilns by coastal boat transportation. The establishment of several small lime kilns is recommended to supply the inland (Haut Plateau). Depending on the quality and size of the deposits, vertical kilns, or preferably beehive kilns, could be used.

It should be mentioned that once good quality lime is produced in the country, this will be used not only by the construction and building materials industry, but several other branches of the economy which have to depend on importation at present.

Brick

Burnt clay brick is a traditional construction material in Madagascar. Most of the houses in the towns and villages of the central part of the country were built of burnt clay brick. A recent ILO study on brick production estimates that 10 million bricks per year are produced in the rural area by hand-moulding and field kiln firing. On the other hand, the four mechanical brick plants in the country produce about 2.5 million bricks per year. The ILO report estimates that if all the 28,000 housing units per year scheduled for construction in the Government Development Plan were to be built with bricks, 276 million bricks per year would be needed. The 12,5 million bricks actually produced represents only a fraction of this amount.

Although we cannot agree with the assumption that the entire housing programme should be realized with bricks, it is certain that the brick production of the country, particularly in the central area, should be dramatically developed with respect to both quantity and quality.

The present poor quality of hand-made bricks is mainly due to the primitive technology of moulding used as well as the lack of mixing and pressing. As a result, the bricks are not homogenous, of irregular shape, extremely fragile, low in strength and non-durable. Due to these factors, and to the lack of a reasonable road infrastructure, they can only be used in the immediate vicinity of their production site, since it would be impossible to transport them economically to further distances.

It is recommended to establish four mechanical settled brick plants with a capacity of about 8 million bricks per year each in

Antananarivo, Fianarantsoa, Tulear and Diego Suarez. These could supply good quality bricks to the four major urban settlements.

The lack of good roads and transport facilities and the dispersed character of the market would not justify the establishment of further settled big mechanized brick plants, since their products could only be marketed economically within a relatively small radius, which would soon become saturated, nor would the large investment needed bring returns, and the more distant areas of the country would not be served. Rather, it is recommended to develop a system of a few mobile brick production units, consisting of a mixing press, a fine rolling mill, three conveyor belts and a manually operated cutter, all mounted on a trailer. Such a cheap mechanical unit can be towed by truck from one location to another. It can be errected and made operational within a few hours of its reaching the selected production site. Driven by a 40 kW engine, it can produce 1,000 to 1,500 good quality normal bricks per hour. Such a mobile unit permits the production of good quality bricks and tiles close to the construction site. The bricks might be fired in the traditional type cottage kiln.

Laterite

All over Madagascar, lateritic soil is dominant. It is used in the rural areas for building in the form of mud walls or for making sun-dried bricks, in which form it is obviously a building material of very inferior quality with respect to strength, water resistance and durability. In the last few years two separate technologies have been developed for the stabilization of laterite with lime and/or cement in order to increase its strength, water resistance and durability, namely (1) the Latorex system mixes the laterite with lime and cement and produces blocks with a press; and (2) the Mayer system uses a forced mixer-kneader to mix laterite with considerable increases in strength. The Mayer system is superior with respect to water resistance and durability. It is recommended that a pilot project should be started for producing building materials with stabilized laterite.

Rice Husk and Straw Boards

Huge quantities of rice husk and straw are produced each year in Madagascar, which remain unused waste materials, since they are hardly combustible and, due to high silicic acid content, not suitable for foddering or littering. A technology has recently been developed for the production of panels and blocks for construction, heat insulation, sound insulation, fire protection, etc. using rice husk with cement or synthetic binders.

It is recommended that a pilot plant for the production of rice husk boards should be launched.

Roofing Materials

Among building structures, roofing deserves a special consideration. In the traditional Madagascar housing, roofs were covered mainly with burnt clay roof tiles, supported by timber roof structure. In the past few decades, both in rural and in urban construction galvanized metal sheet (flat and corrugated) roof covering gained considerable ground. This was mainly due to its relatively low initial cost and ease of handling. This is considered by all means to be a negative tendency. The moist climate of Madagascar is extremely aggressive and the galvanized sheets are completely corroded within 4 - 5 years. Thus, considering the short lifetime, sheet metal covering is an extremely expensive roofing material. In addition its thermal conductivity reduces comfort.
It is recommended to develop four different kinds of roof covering materials:

(a) Improved burnt clay roofing tiles. These could be produced by the mobile brick plants, discussed in C. Bricks.

(b) Corrugated asbestos cement roofing panels. With the "tropical" type of panels (4 mm thick, profile 5 standard) these would have an initial cost less than that of galvanized metal.(Report by UNIDO expert H.G. Klos, 1974).

(c) Sisal reinforced corrugated plastic panels. Using the short waste fibres of sisal production and some kind of plastic resin binder (e.g. polyester) corrugated roof panels could be manufactured. (Société d'Aide Technique et de Cooperation - report by B. Blay, October 1967).

(d) Corrugated sisal cement roofing panels. Using the short waste fibres of sisal production, asbestos fibres could be partly or completely substituted, resulting in further cost reduction.

The use of mobile, floating prefabrication plants for operation along the coastline is recommended. Such floating concrete and precast r.c. member factories are completely self-contained production units, independent of all external installations and, at the same time, mobile. Such floating plants are always ready to be put into operation and, after having produced the prefabricated elements required at one construction site, they can be towed to a new location without being dismantled. In this way the whole coastal region of the country could be supplied with prefabricated housing. Supply of sand, gravel, cement and steel is easily solved by local coastal seafreight. In co-operation with a supplier of prefabrication plant equipment, the shipyard at Antseranana (Diego Suarez) could build such mobile floating prefabrication plants.

3 GHANA

In 1960 there were 98 towns in Ghana with a population of 1,555,174 constituting 23.1% of the total population. By 1970, the number of towns increased to 135 with a population of 2,472,456. The increase in total population of Ghana during this period was 27%, but in urban areas it was 60%. This shows a constant drift of population from rural to the urban areas. This trend has to be checked by providing more work opportunities in the rural areas.

A major problem of the economy is the soaring cost of house construction over the last five years. The cost of building materials has been increasing by leaps and bounds and it is incumbent upon the economy to pay more attention to the development of building materials.

In Ghana, 54% of the houses are built with mud and 38% with cement concrete blocks as walling materials. In some urban regions like Accra 60% of the houses are made with cement concrete blocks. In the rural areas houses are mainly constructed with mud, and the percentage of cement concrete houses is much lower than on the national average.

The roofing material mainly consists of reinforced concrete and zinc sheets. Both the raw materials, cement and zinc sheets have to be imported and are in short supply due to an extreme shortage of foreign exchange. Hence there is the need for the manufacture of building materials which can be indigenously made without complicated machinery and with little capital investment.

The housing needs in the country are great. In an urban housing survey report, it was estimated for 1977 that about 160,000 rooms should be constructed annually to house the increasing population and replace obsolete buildings. In calculating this figure decrowding has not been taken into consideration. No systematic survey of the housing need in the rural areas has been carried out.

However, in the last decade there has been a serious drift of population from rural to urban areas. In order to stop this inflow, integrated rural development programmes have been installed. The Programme

of the House of Chiefs of the Brong Ahafo Region, initiated a few years ago, consists of two parts, industry and agriculture, with emphasis on the manufacture of bricks and tiles for the construction of houses on a co-operative basis.

Similar programmes have been initiated in other regions, but they all suffer from the limited availability of durable building materials. There are a number of mechanized brick and tile manufactures in the country and more are under construction in recognition of the potential importance of this type of indigenous products. They are, however, all located in bigger towns and are not in a position to supply the rural areas to any appreciable extent. Furthermore, they are hampered in their operation by a severe lack of spare parts and maintenance facilities and the prices of their products generally bring these out of reach of the major part of the population.

A decentralized manufacture of bricks and tiles utilizing non-mechanized technologies seems to be an appropriate way of tackling these problems. An approach of this type is favoured by the widespread distribution of clays and fuel resources and the desirability of producing durable building materials as close as possible to the consumer - ideally with the active participation of the user himself.

In the execution of the UNIDO assisted programme for promotion of rural brick and tile industries valuable support in terms of infrastnucture, administration and overall motivation of the participating village co-operative is received from the Regional Development Corporations, the Regional Offices of the Ministry of Industries, Science and Technology and the Rural Service Centres which are being established by the Ministry of Rural Development and Co-operatives.

As a consequence of the limited resources initially available to the project it concentrates its activities to one region and will only at a later stage move into other regions. The ultimate objective is to spread the promotion of appropriate building materials technology to all parts of the country, including the Accra/Tema area with or without external assistance.

4 GAMBIA

The Gambia has only few exploitable natural resources of which, besides ilmenitic sands examined in another context, various deposits of kaolinitic and other plastic clays have been explored and assessed with UNDP and UNIDO assistance. Following laboratory investigations of local raw materials and bodies based thereon the technical feasibility of local manufacture of, inter alia, bricks, wall and floor tiles, stone ware pipes and earthenware was established.

Given a certain domestic market for structural clay products, which would replace part of the presently used sand-cement blocks, the Government had decided to pursue the introduction of clay bricks and related products in the country. Following initial studies of the matter and considering the almost entirely missing tradition for brick manufacture and consumption in the country the plans aim at the utilization of a labour-intensive technology with a relatively low yearly output.

Previous studies have recommended the start of rural manual brick production units, serving only a limited local market, supplemented or followed after a few years of increasing interest in output of 2 - 3 million bricks. Three manual brick making units are already operating in Brikama, Mansakonko and Kerewan, with a production of about 1000 pcs/day.

The success of the small units has strengthened the Government in its preference for a labour-intensive co-operative type production and a strong interest has been expressed in continuing the project with Chinese assistance.

The Chinese authorities, on their side, have accepted the idea to assist in the establishment of a small semi-mechanized brick making plant and have suggested to carry out, as a first phase, a thorough feasibility study. The execution of this study and the planning of the actual plant establishment (phase II) are the activities encompassed by a second UNIDO project.

The project is in the specific interest of the lower levels of the population to whom new job opportunities will become available and who benefit from the availability of good quality structural clay products.