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Buildings and their environment

INTRODUCTION

The purpose of this paper is to discuss some of the factors concerned in the relationship between buildings and the environment of which they form a part. As the paper is to be presented at a conference on Environmental Health Engineering in Hot Climates and Developing Countries, it seems appropriate to select for discussion the irrigated lands in the Republic of the Sudan, where the physical environment has been transformed from an almost uninhabited wilderness into a series of prosperous agricultural communities. This complicated and lengthy process has involved the activities of engineers of all kinds, agriculturalists, government administrators, businessmen, traders, tenant-farmers, their families and itinerant labourers.

Since a few years after the First World War when the Gezira scheme first got under way as a result of the construction of the Sennar Dam on the Blue Nile, many thousand settlements have grown or have been created to house the farming communities. The Gezira and the related Managil schemes are still being extended and produce the main export crop of the Sudan, high quality cotton, as well as several food crops for local consumption. The irrigated lands of the Gezira now extend from the Blue Nile westwards to the White Nile occupying the greater part of the land surface in the triangle bordered by the two Niles with Khartoum at the apex (Fig.1). The scheme has been successful but because it has been extended gradually has gained little international publicity. Its success has attracted population from other parts of the Sudan as well as itinerant labour from Nigeria (lying as it does on the

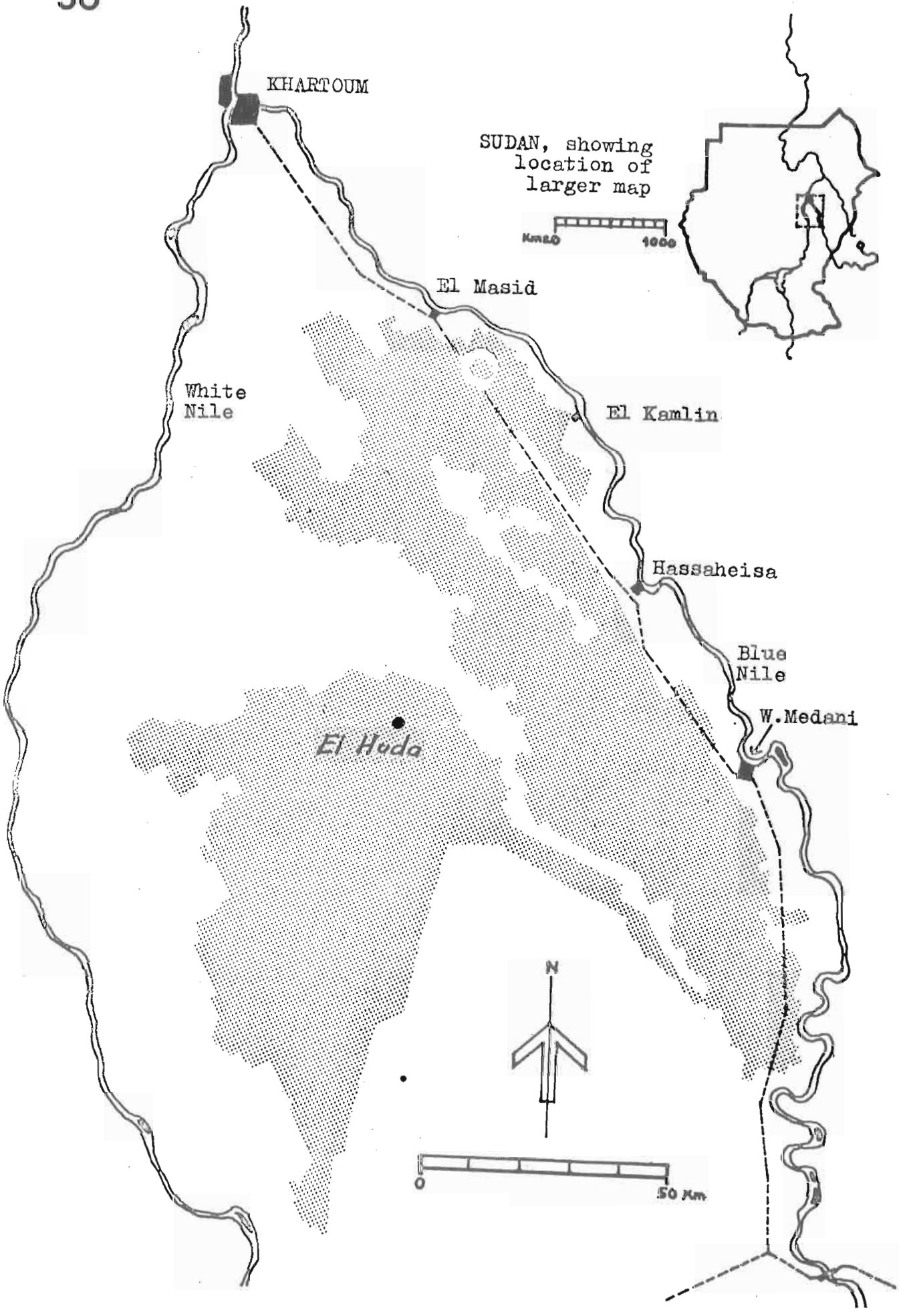


Figure 1 The Gezira Scheme including Managil Extension

route from Nigeria to Mecca). Settlements have grown spontaneously on sites convenient for the main occupation of agriculture, many of them enlargements of smaller settlements which were in existence before the irrigation canals were built. The pattern of activity then depended on rainland cultivation for three months of the year. The rains fall in June and July and dura was harvested in October. Most of these settlements were founded by nomads making a gradual break with pastoralism who followed a mixed system of agriculture depending on both stock-raising and cultivation. This system meant that at any time of difficulty such as political unrest, wars or exorbitant taxes, they could abandon settled cultivation and revert to nomadism. The areas of cultivation were usually not far from the Nile banks and during the troubled times of the 19thC those of the rainland inhabitants who did not wish to follow a nomadic life often retreated to the riverain villages where protection and cultivation were more certain.

At the beginning of the 20thC more settled conditions favoured the development of the rainland communities. The growth of the three Towns, (Khartoum, Omdurman and Khartoum North) provided urban markets for agricultural produce and the construction of the railway from Khartoum to Wad Medani (capital of the Blue Nile province) in turn made possible further economic development of the area. The Gezira scheme bringing gravity irrigation not only transformed agriculture but also had a most profound impact on the physical, social and economic conditions of every settlement within its boundaries. The irrigation network made possible a new flexible system of land use but in turn demanded a new agricultural routine. Instead of three months field work a year, a new timetable over eleven months of the year was necessary.

Irrigation requires a strict tempo of work and measures against disease and pests resulted in cotton sowing being concentrated into a short period. The farming year consists of four seasons (see Fig.2). The rainy season between July and October when crops are sown and established is followed by the winter season from October to December when a regular watering regime is introduced. The dura is harvested at this time but the cotton is not ready until January when the cotton picking season starts. Cotton picking lasts until April, the beginning of the summer season when the cotton stalks are pulled out and burned to eliminate pests and disease. This activity lasts until June or July when the rainy season or Kharif brings the beginning of a new farming year.

In order to maintain the high standard of cotton cultivation (Sudan Gezira cotton has a high quality reputation in world markets), a system of close supervision was developed. Administratively, the scheme was divided into units called blocks. Each block is controlled by an inspector employed by the Sudan Gezira Board and aided by two assistants. The inspector in turn is helped by village councils in the day to day running of the block.

The coming of irrigation changed radically land use and distribution in the area. A standard system of land allocation was adopted, each holding consisting of 40 feddans (4200 square meters) made up with a number of plots (hawasha) which may or may not be adjacent to one another. The usual pattern of crops is in the proportion of ten feddans of cotton, five of dura, lubia (fodder) on $2\frac{1}{2}$ and the remainder left fallow. Plots of vegetables, groundnuts and wheat also are frequently grown and to an increasing extent.

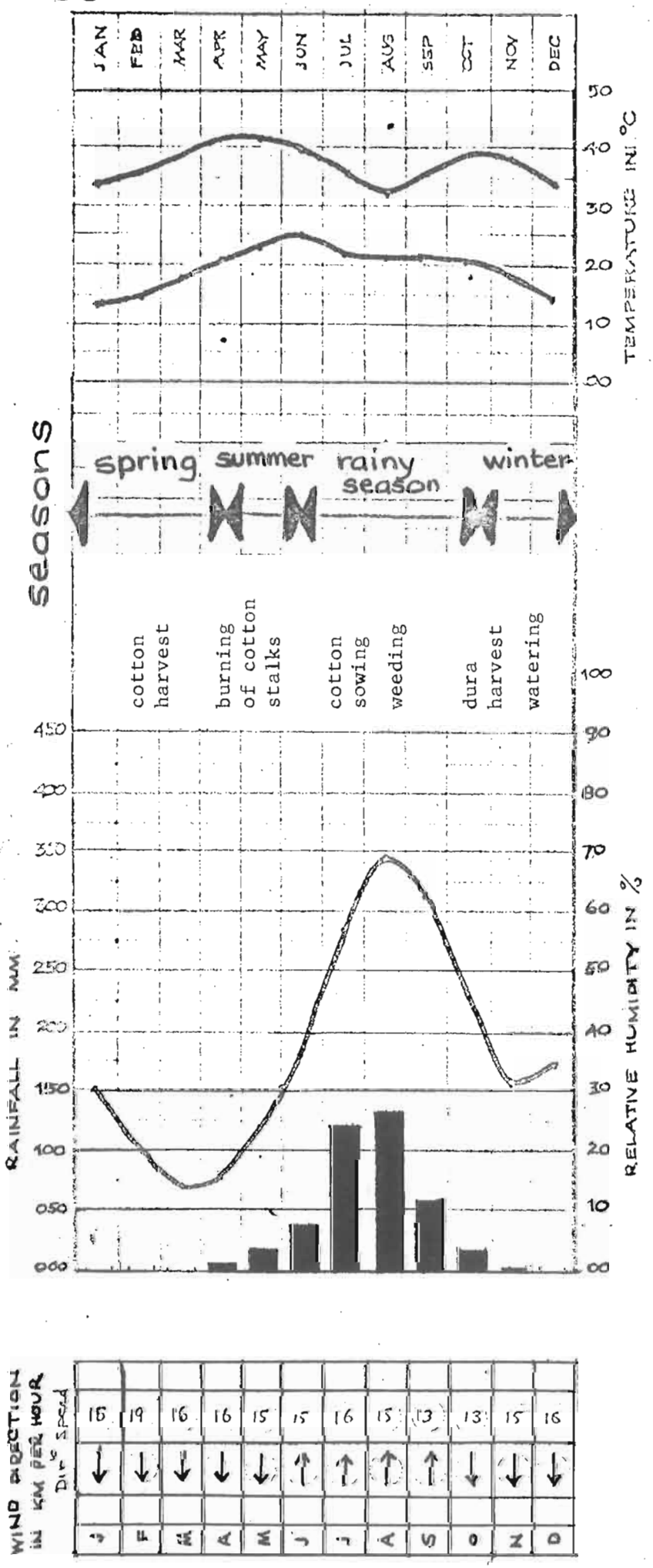


Figure 2 Seasons and Climatic Data - Gezira

COUNTRY: SUDAN
LOCATION: GEZIRA
ALTITUDE: 405 M.
LATITUDE: 14° 40'
LONGITUDE: 35° 60'

Notes

Actually the area is plain and flat.

Maximum day rain is 270 mm.

Maximum day-temperature is 42°C

Minimum day-temperature is 13°C.

There are frequently dusty wind "Haboob" Usually in July.

Highest relative humidity is 70%

There is some evaporation, the highest in the hotest day in May — 23 mm.

On receiving a tenancy, each tenant becomes a partner in the Scheme with the Government of the Republic of the Sudan and the Sudan Gezira Board with rights and responsibilities defined by law. The ownership of the land is vested in the Government and every tenant is a sub-tenant of the Government but pays no land or water rent on condition that he provides labour for cotton production. He receives a 46% share of the profits from cotton production and the full returns from all other crops. The Government (Ministry of Irrigation) supplies water by means of the irrigation works which it operates and maintains while the Sudan Gezira Board is responsible for the management of the Scheme and marketing of the cotton. The Board also promotes and finances research towards increased productivity and together with local government it promotes the social development of the area.

The size of a holding is too large for the tenant and his family to perform all agricultural operations themselves. This particularly applies to weeding and harvesting. Therefore from the very beginning of the scheme there has been a need for a hired labour force. Labourers immigrated to the area from many parts of Africa, (particularly the west of the Sudan, Nigeria, Niger and Chad) and were encouraged to settle in small villages scattered throughout the irrigated areas to provide readily available labour.

The demand for labour throughout the year is not uniform but is at its highest during the rainy season when a serious growth of weeds have to be cleared from the fields and the irrigation channels. Extra labour is also needed during the harvesting of the cotton crop. The settlements in this way vary in size and in the mix of population between the tenant farmers, the labourers and their respective families.

The villages have grown in a haphazard way on land not allocated to agriculture. An aerial view reveals a strong contrast between the informal layout of the village and the rigid geometrical arrangement of canals and plots. To understand the sub-division of space within the village between public and private, it is necessary to understand the attitude to privacy resulting from the Muslim religion and the extended family system. Public space finishes at the entrance door to the walled courtyard of the dwelling. This courtyard is known as the 'hosh'.

There are usually separate entrances and quarters for men and women. Male visitors are only allowed to the reception room or diwan where they may only meet the male members of the family. Similarly female visitors are only allowed access to the women's quarters maintaining strict segregation of the sexes at all times. The female members of the tenants' families are not permitted to work in the fields in case they come into contact with strangers particularly the immigrant labourers.

Public space is in the form of a network of narrow lanes between the hosh walls, occasionally opening into small rectangular spaces with a tree now and again to give shade. This network is informal and never involves the use of the surveyor's straight line (see Fig. 3). It is related to the scale of the pedestrian and the donkey which is the main form of personal transport. In most villages few of the lanes can accommodate motor vehicles which have only recently been used for transport of goods and cotton. Personal motor transport is rare and usually confined to Gezira Board and Government officials and wealthy merchants. There are

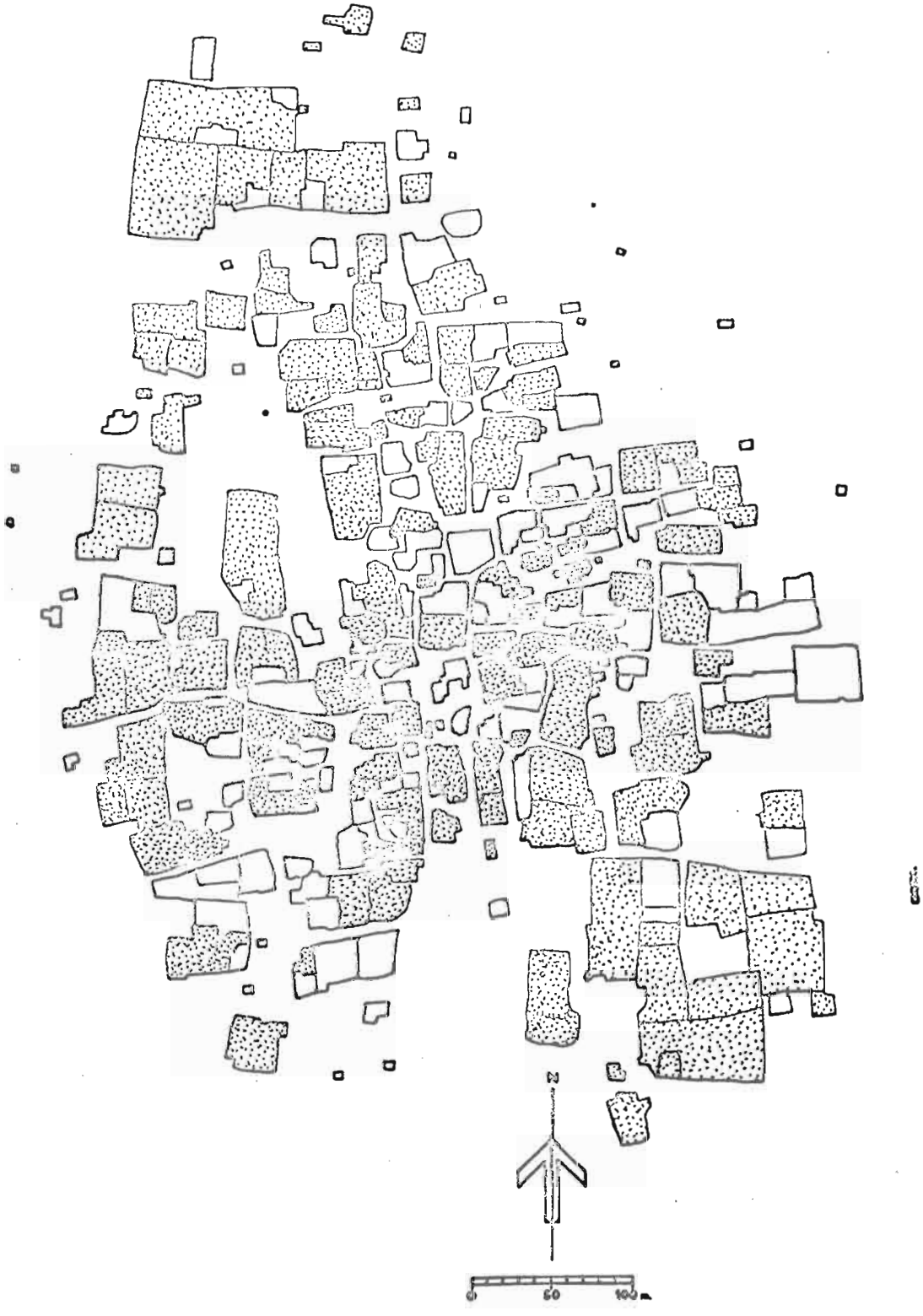


Figure 3 Plan of Gezira village (Udeid El Bashagra)
tenant households shown dotted

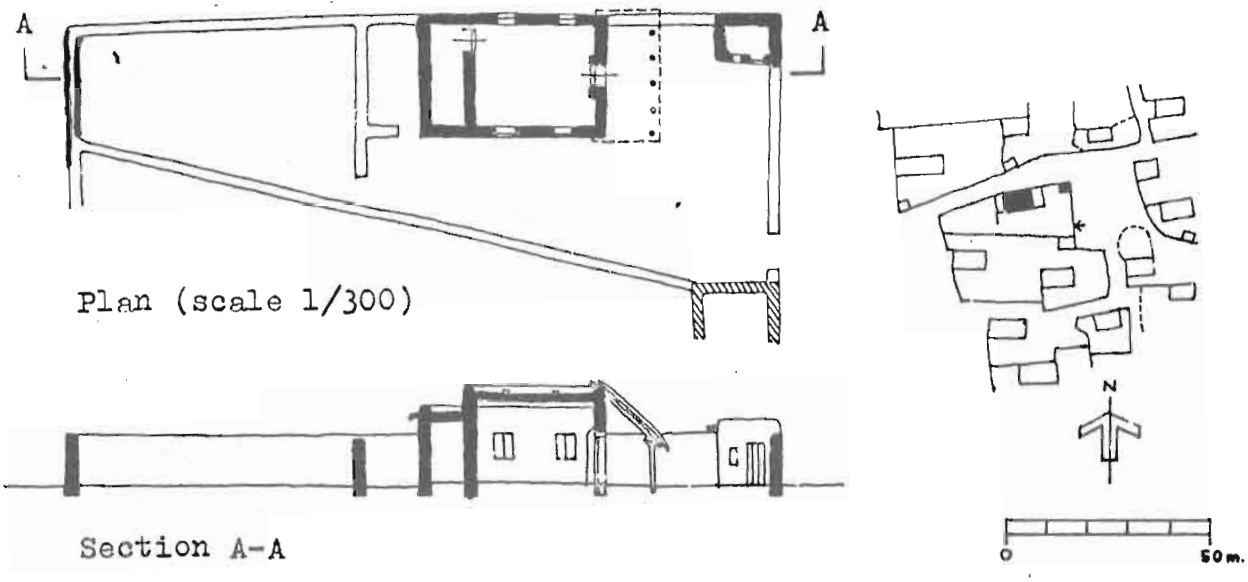
no tarmac roads except for the main road from Khartoum to Wad Medanî, the remaining roads are usually tracks following the pattern of canals and as the soil is predominantly of the black cotton type, they are impassable during the rainy season; even four wheel drive vehicles have considerable difficulty at this time.

Once the boundaries of a building site have been settled, it is customary to enclose it with a mud wall to form the hosh. A house is then built by constructing room units within the hosh as and when required according to the needs of the family. Before the Gezîra scheme, rooms were commonly built to a circular plan of approx. 3 meters internal diameter to the mud walls which supported a conical thatched roof. This form of construction is common throughout Africa and is still found in the more remote areas of the Sudan (the West and the South). After irrigation was established, the circular plan form began to be superseded by a room unit of a square plan with a flat roof, similar in construction to the houses in Omdurman and Nubia. This type of house has a more urban character and is typical of hot-dry climates with little or no rainfall.

The square plan provides a room of approximately 4.60 meters square usually with one door and four windows. Rooms of this type became very popular in the 1940's and soon replaced all those of a circular plan. The walls are built of mud and timbers support thin branches which in turn carry a layer of straw and earth to form the flat roof. Other classes of room have also been used including a store room (4.60 meters by one meter) often attached to the west end of a room unit (see Figs. 4 and 5).

Sunshading elements are also very common. A sloping lean-to roof is often attached to the east end of a room in the form of a frame-work of rough timbers supporting straw or dura stems. This provides shade like a verandah and is called a 'Kashasha' (see Fig. 4). Another method of providing shade is to construct an independent frame-work of poles supporting a horizontal cover of straw or dura stems. This is called a rakuba.

There are, of course, many variations in the combination of these elements. A study carried out by students of the University of Khartoum in 1963 on a group of villages known as Beshagra revealed seven basic types of room arrangement. The majority of rooms belonged to the first four types but a tendency to change to the remaining three types was noticed for new construction. Diwans (or guest rooms) in particular tended to fall into the last two categories. Wealthy villagers only can usually afford to devote one room for the reception of guests and their building habits probably represent the socially 'ideal' form. Some of the prominent sheikhs have built more elaborate diwans using more expensive modes of construction. Whereas there is some degree of standardisation in the plan arrangement and construction of room units, there is none in the approach to the dispositions of these room units within the hosh. The principle of forming semi-private areas and the isolation of male guests from the women of the family, is always maintained but there are limitless variations to the spatial arrangements of the hosh. All domestic activities take place here. Cooking takes place out of doors usually under a rakuba or kashasha where water storage jars (called zeers) are also kept. Sub-areas of the hosh are also used as outdoor sleeping spaces for much of the year. In some households farm animals are



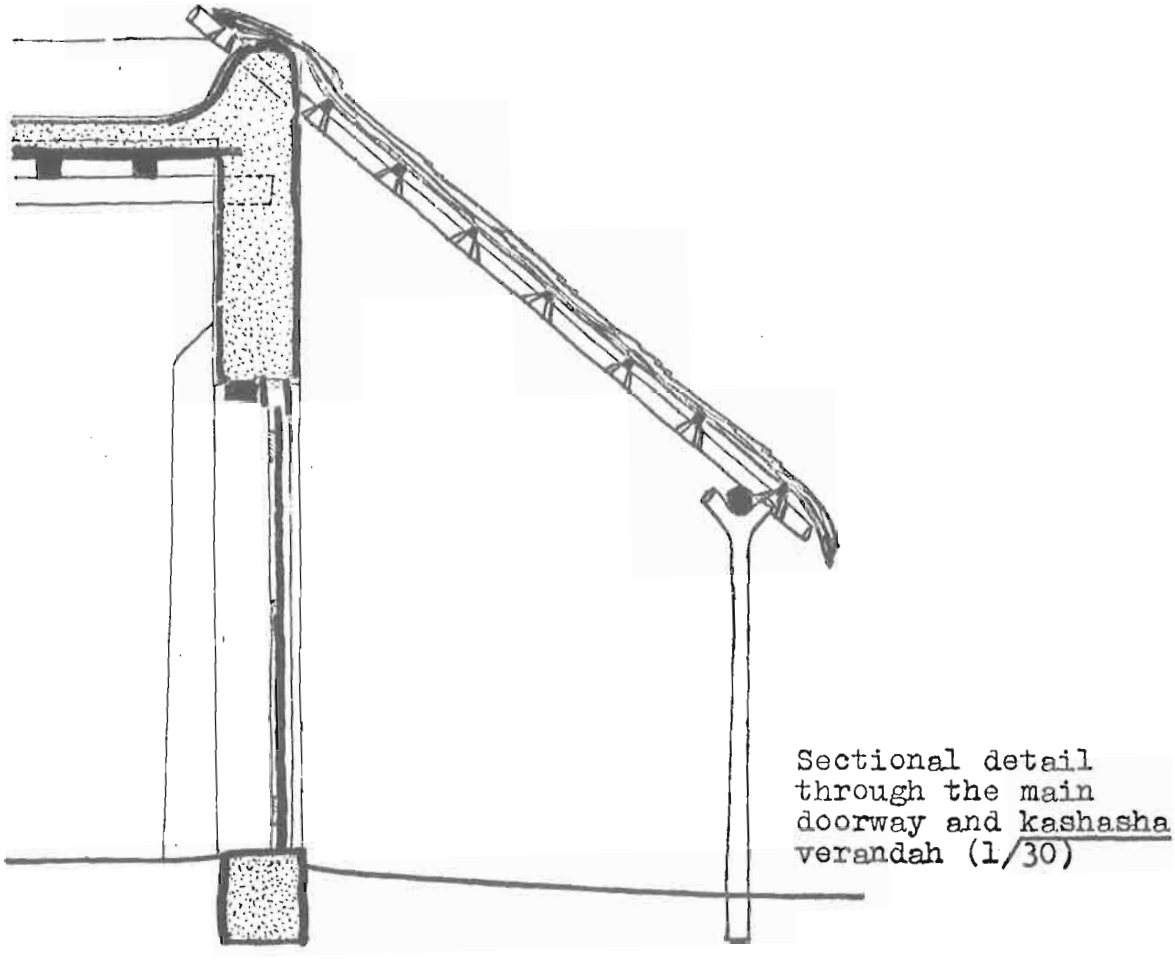
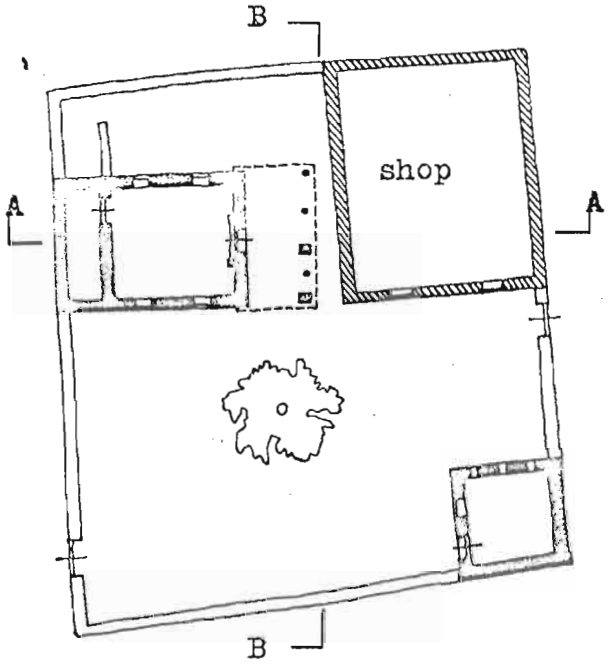
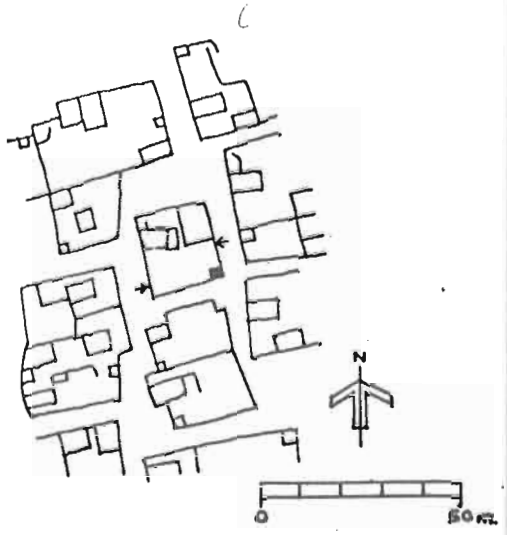
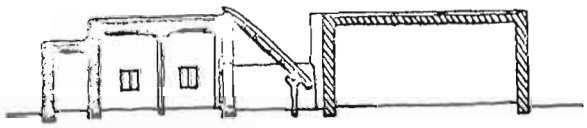


Figure 4 Typical dwelling of Jalous construction

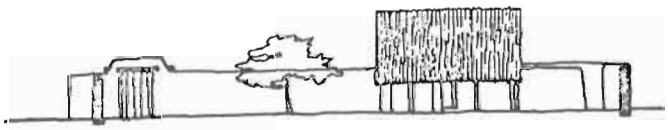


Plan (scale 1/300)

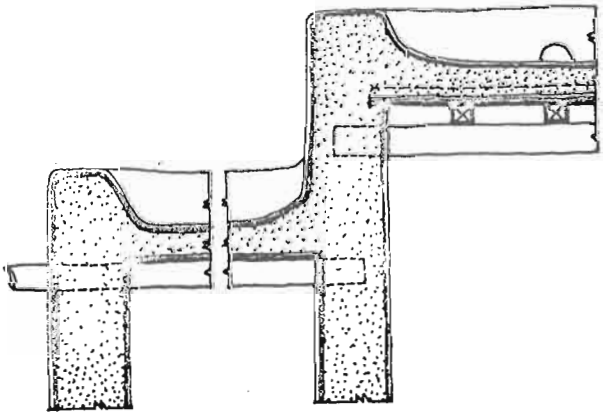




Section A-A



Section B-B



Sectional detail through the roofs of living room and storeroom. (1/30)

Figure 5 Typical dwelling in Gezira village (Wad Lemeid)

kept in sub-divisions formed by mud walls or thon fences, known as zeribas. Domestic sanitation is usually by means of the pit latrine placed at a far corner of the hosh with its own screen walls. Hens and other domestic animals are accommodated in some narrow space behind the latrine or other room unit.

Some households have a separate kitchen room which is used mainly for storing food, utensils and fuel and in a few cases, food is prepared indoors on a permanent stove with smoke and fumes finding their way out through holes in the wall. It is more usual for the cooking to be done on braziers in the shade of the hosh wall or kashasha. The latrine is often placed for convenient use by guests and is a deep pit about 1.50 meters square which is dug deep enough to act as a soakaway in the sandy layers below the clay soil. It is then covered with a platform of branches and earth supported on timber rafters. There is the necessary hole in the centre and the latrine is screened from view by screen walls or other rooms. It is usually without a roof. Washrooms are sometimes provided for private washing from jugs or bowls of water. These together with zeerhouses are sited for the convenience of guests rather than the family.

The sharing of the household amenities and diwans often occurs between related families. The family hosh in this way becomes part of a group of linked domestic yards forming a multi-dwelling group. This multi-dwelling is very difficult to recognise or chart unless one is aware of the family relationships and the historical development of the arrangement of rooms. As the family develops with the passage of time, there obviously occurs a lack of space for the addition of further rooms because the family hosh is surrounded by others in a similar state of growth. At this point it becomes necessary to continue development in the outskirts of the village on fresh land often already in use for animal enclosures (zeribas).

House building is normally undertaken during December and January as farm work is less demanding at this time, the cooler temperature makes mixing and other building operations easier and the dry weather means that the construction is not liable to rain damage. Most houses are built from mud which is used either in situ as a homogeneous wall or in the form of bricks moulded by hand which are sun-dried and bonded with mortar of the same material. The former method is known as jalous and is gradually being replaced by mud bricks. Jalous walling is made in horizontal layers and each layer must dry out before it can support the next. Mud brick, on the other hand, can be used continuously and therefore building operations take less time although more preparation is needed beforehand.

There are many difficulties involved in mud construction and the average life of jalous is about ten years although in exceptional cases such buildings can last up to 25 years. As these buildings usually have no foundations of any kind, they are vulnerable to ground movement in the black cotton soil particularly in the rainy season when upthrust occurs because of the expansion of the soil by saturation. Cracks occur in the walls, allowing rain to penetrate, particularly at the junction of roof and parapet walls. The wall base can also be undermined by rain and standing water.

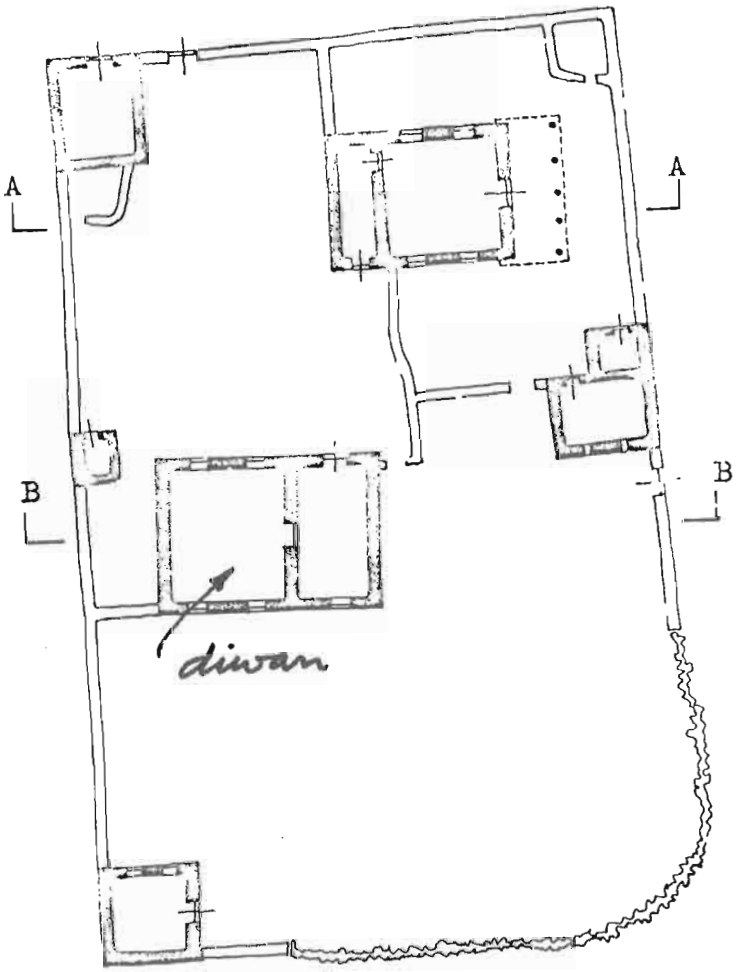
The basic material for the walls (both jalous and mudbrick) is usually made in the Gezira from a mixture of two kinds of earth,

red and black. Suitable earth is often obtained a few kilometers distant from the building site and the mix depends on the availability of the two kinds of earth. The jalous or mud brick walls and roofs are rendered externally with a fermented mixture of mud and dung (donkey mainly) known as zibala, which is water-proof and has good thermal qualities. It has a very pleasant texture giving a consistent visual character to the village, but a combination of extreme heat and heavy seasonal rain is extremely destructive and leads to flaking of the zibala. Constant maintenance is therefore necessary and is usually carried out in June and July, just before the rainy season. Emergency repairs caused by heavy rains are made in August and September.

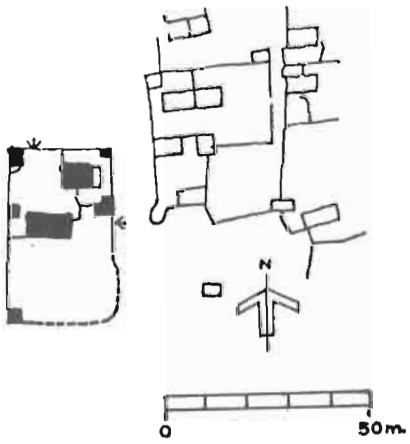
An alternative and more durable method of house construction has been developed but unfortunately it is rather more costly than jalous or mud brick. This method is known as Gishra and is a combination of mud bricks and burnt bricks. The burnt bricks are used as external facing and for the parapet walls to resist erosion from the rains. Foundations to the wall are also built from burnt bricks. The flat roof is constructed in the same manner described for the jalous houses. The small scale contractors and bricks for gishra work normally come from villages on the banks of the Nile, where the kilns and fuel are available. As yet, gishra houses are few and usually confined to the diwans of the wealthier farmers or merchants (see Figs. 6 and 7). Gishra construction, however, is commonly used for shops and community buildings, like clubrooms, Khalwas (religious schools) and mosques. As a result the gishra buildings stand out in contrast to the general background of jalous and have attained a 'prestige' standing in the community. Public and community buildings are thus distinguishable from the rest because of the external use of burnt brick. Shops, for example, consist usually of a combination of one room for storage, one for sales plus a verandah of some kind. These are usually in one building but occasionally the store may be separate. If money is available, the roofing material may be more permanent. For example, a double-pitched roof of galvanised corrugated iron sheets supported on timber purlins and rafters or trusses is commonly used on clinics, clubrooms or schools built with funds provided by the villagers and the local council.

Buildings built mainly from Government sources, like schools and houses for officials and teachers, are built with solid burnt brick walls (one and a half bricks thick) laid in sand cement mortar with roofs of G.C.I. These are the most permanent buildings in the Gezira and are usually built by contractors from standard plans supplied by the relevant Government Ministry. The mosque is always placed on a prominent site, often the centre of the village and is at least of gishra construction. In some of the wealthier villages it may be of quite elaborate construction with decorative brickwork with the use of bright coloured paints. Government or semi-government buildings are usually sited on the periphery of the village as is the butchers shop and the borehole stand pipe for fresh water that most Gezira villages possess. Shops, however, are fairly evenly distributed throughout the village.

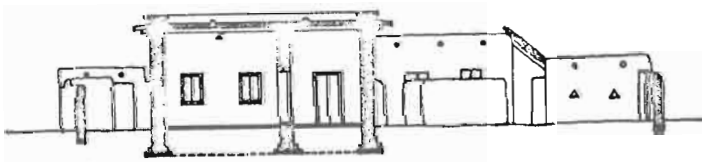
The haphazard development of villages followed by the growing demand for services provided by the Government, such as water, education and health services has created many problems. As funds are not sufficient for every village to have its own school and clinic, it is difficult to decide which villages should have priority. Indeed many villages are too small to possibly justify



Plan (scale 1/300)

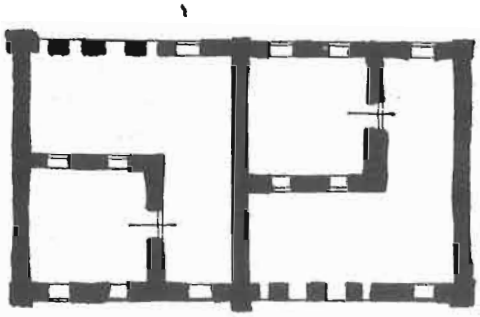


Section A-A (jalous)



Section B-B (gishra)

Figure 6 Plan showing dwelling with diwan in gishra construction



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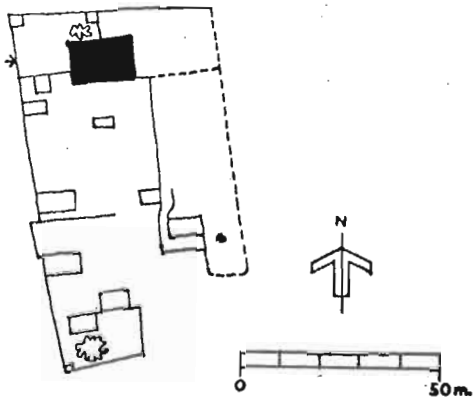
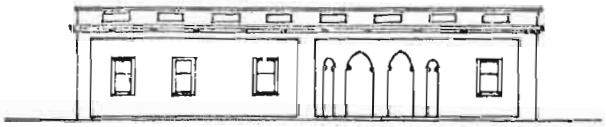
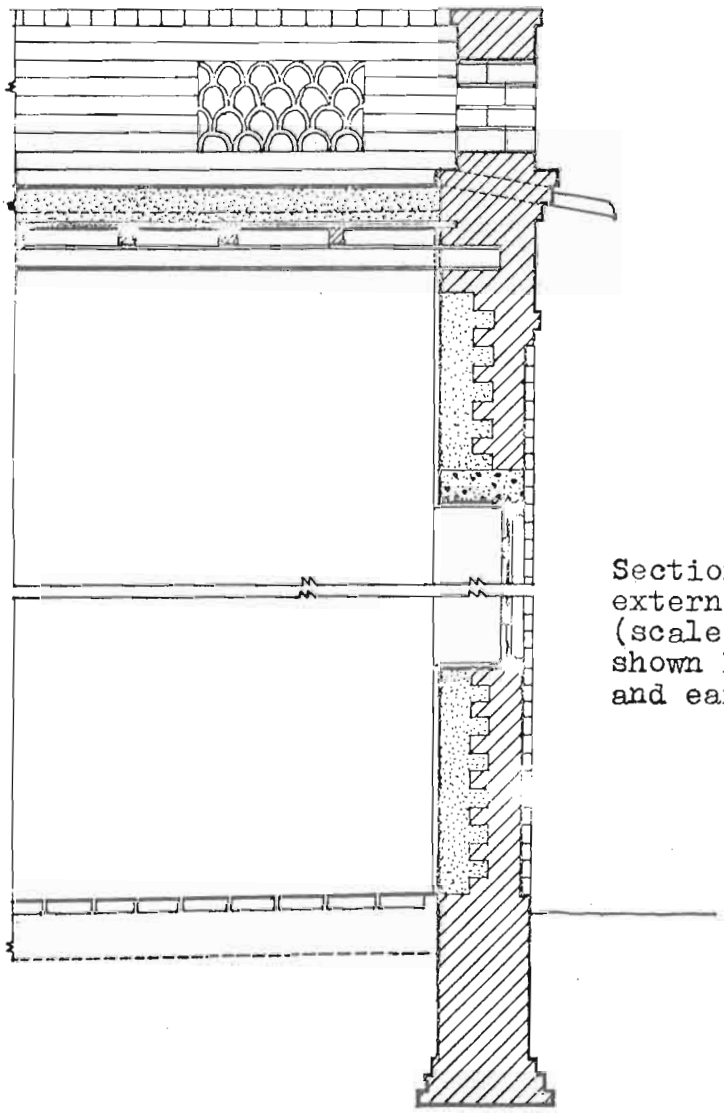




South Elevation



Sectional detail through external wall of Guestroom (scale 1/30). Redbrick is shown hatched, mudbrick and earth roofing dotted.

Figure 7 Plan showing Sheikh's guestroom (Wad Lemeid - Gezira)

the cost of a clinic or school. For some time, at least, many children must travel to other villages to attend school. In the same way, sick people may need to travel some way to attend a clinic elsewhere. These needs for communication coupled with the expansion of trade mean that people travel out of the village more than in the past. Often they find the direct route to another village may be blocked by an irrigation canal and have to travel out of their way to cross it at the nearest available bridge. Bridges are expensive and have not been provided on a large scale. The irrigation network was designed as a result of the needs of gravity and agriculture and is frequently in conflict with a desirable communication network of paths and roads between villages. It is now Government policy to try to link neighbouring villages in groups for purposes of providing schools, clinics and communication and to try and encourage future expansion in this rational way.

Great progress has already been made with provision of fresh water for drinking purposes and nearly all villages have a borewell with raised storage tanks and a wind driven propeller pump. The presence of stand pipes accessible to all villagers has reduced the former tendency to use water from the irrigation channels which harbour bilhazia snails and other sources of infection.

The basic problems of the built environment in the Gezira are thus presently at two levels. Firstly, at the detailed level of house construction methods and secondly the planning level relating to future expansion of the settlements and the siting of new facilities such as roads, schools and clinics.

With relation to house construction methods, an experiment was financed by the Sudan Gezira Board in 1963/64 at a village called El Huda in the Manaqil extension of the Gezira scheme. El Huda was designated as a centre for public service for the surrounding district and as a result had grown in population from 500 in 1958 to about 3,000 in 1963, the new residents were tenant and labourer families drawn from other parts of the Gezira. A large number of houses were obviously required in a very short time and the situation was worsened by the fact that little money could be spared for building expenditure, as the farming community was still struggling to establish itself on the smaller tenancies of 15 feddans (as opposed to the 40 feddan tenancies in the older scheme) with a consequent low income. The soil was of the difficult black cotton variety which was far from ideal for building purposes. It was decided to initiate a group of trial houses involving the use of a variety of 'improved' mud-building methods. The help of a group of specialists from W.H.O., U.N.E.S.C.O. and the University of Khartoum was enlisted in the design of the houses. Preliminary discussions had produced the proposal to carry out tests on earth/cement blocks made on site but all of them proved negative whatever mix was used with or without the addition of sand. The blocks were made with a landcrete machine, suffered from shrinkage cracks and were too weak for walling purposes. It was then decided to concentrate on measures aimed at increasing the durability of existing building construction by improving wall foundations and roof water-proofing. The depth of ground most affected by seasonal moisture movement appeared to be 1.50 meters, so two types of foundation were suggested, both of burnt bricks. One to the depth of 1.70 meters including 20 cms of wall above gound and the other with a depth of 1.00 meter also including 20 cms of wall base but in this case to be built on a 10 cm layer of dry sand filling on either side to absorb movement of the surrounding ground. The use of both mud and cement mortar was suggested as

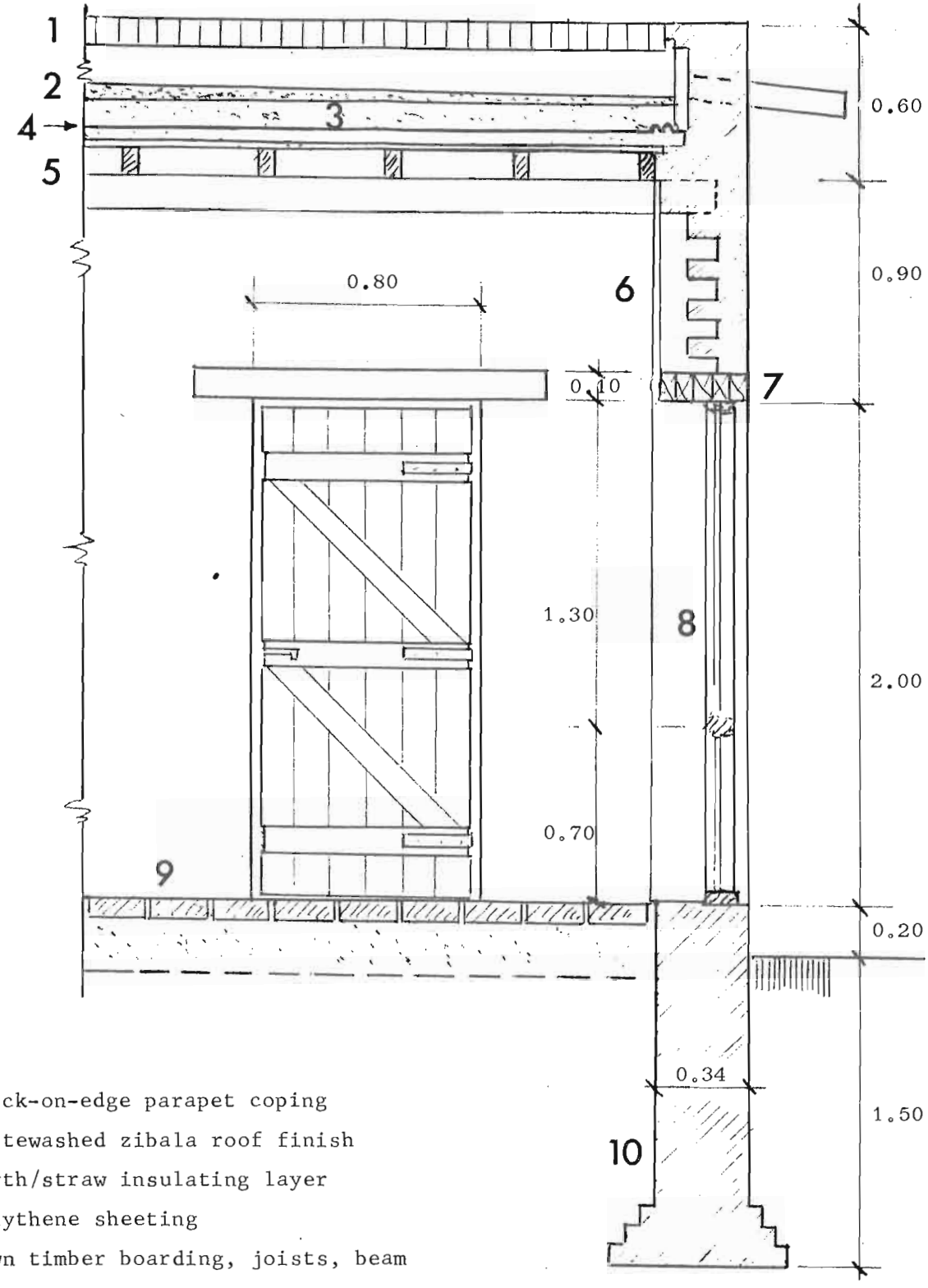
well as the possible use of a polythene apron at 20 cms below ground level to reduce saturation in the outer face of the foundation. The purpose of a 20 cm wall base was to protect the wall from erosion by splashing and standing water. Only one change was suggested to the traditional walling methods, in the case of gishra, cement and sand pointing to protect the mud mortar from erosion by rain and dust storms.

The traditional flat roof gives good heat insulation at low cost but with a fair amount of leakage during the rainy season. It was proposed to make this type of roofing waterproof by introducing a membrane of polythene sheeting with the earth layer. The top layer of earth was rendered with zibala and then painted with limewash to act as a heat reflector.

The houses were built to two specifications of construction. Type 'A' was upgraded gishra with deep foundations (see Fig. 8) and type 'B' was improved jalous with foundations one meter deep on sand (see Fig. 9). Hosh walls were jalous without foundations and rendered with zibala. All doors and windows were made locally of imported softwood timber, the windows consisted of frames and shutters only. The room layout of the houses was very carefully considered and was designed so that a house could be built in four stages as funds became available (see Fig.10). The first stage consisted of a family/guest room (6 x 4 meters), fodder store, kitchen store, latrine and washroom. At the second stage a family verandah and cooking verandah would be added (in type 'B' construction the verandah would be made of two layers of woven grass brush matting on bamboo and timber framing, while type 'A' would have flat roofing as already described on brick piers and arches). Another family room size 4 x 5 meters would be added at the third stage, the hosh size allowing for the addition of another family room in the fourth and final stages. The plan arrangement allows for the sub-division of the hosh into two main male and female areas for outdoor sleeping with a smaller space, directly accessible to the guest room or diwan and another enclosed space for domestic animals (zeriba). There are also two separate entrances to the hosh which has an area of 20 meters square. The prevailing winds in the Gezira are north/south and as we have seen the traditional Gezira room unit has the windows placed on the east and west walls to get maximum through draught when needed. The shutters are used to exclude the outside air at certain times of the day during the hot season and during dust storms (haboobs). (For a detailed description of the traditional method of controlling the internal environment in this way, see 'The Design of Buildings in Hot-Dry Climates and the Internal Environment' - Miles Danby - Build International (6) 1973.)

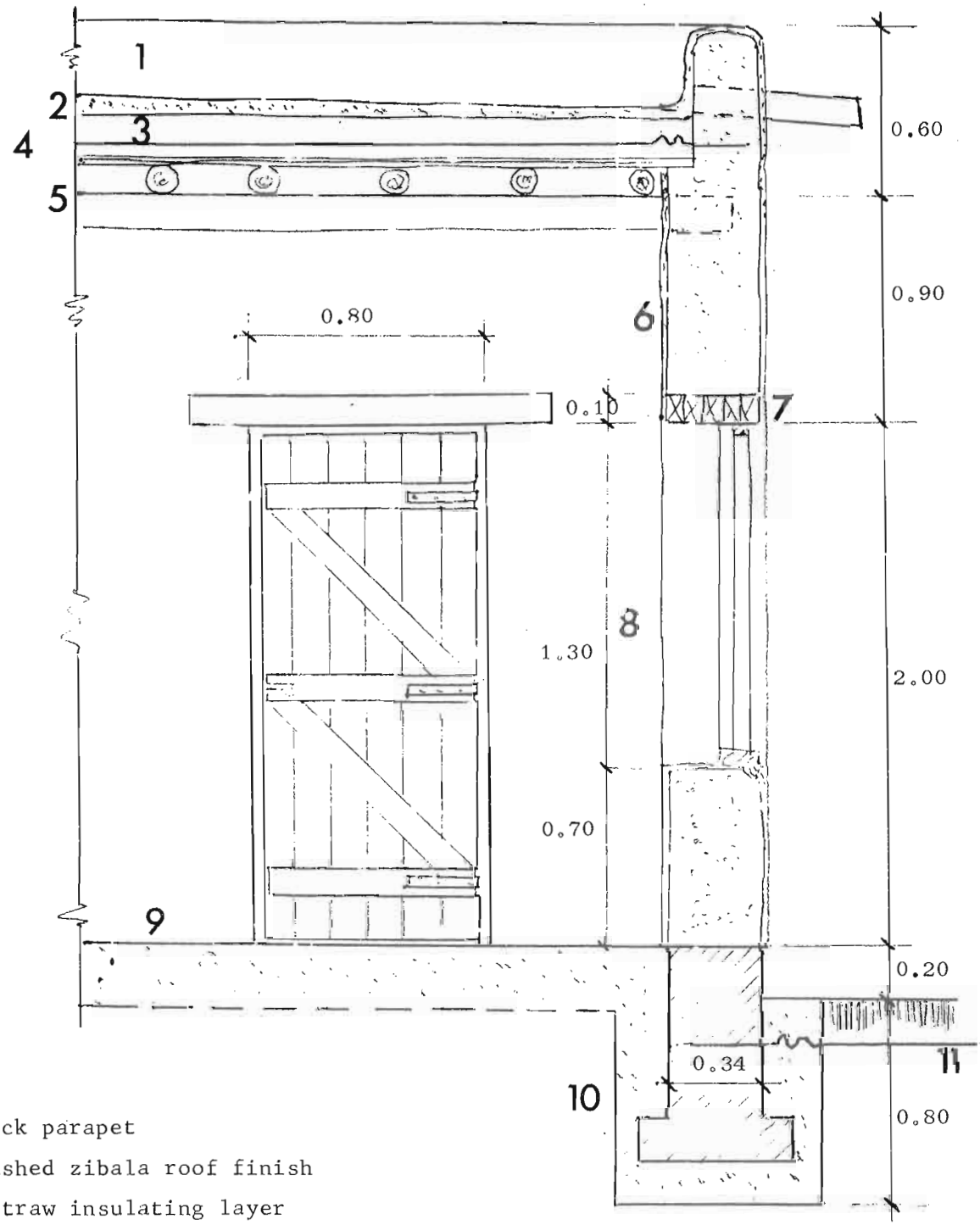
The trial houses were built to the same orientation with family verandah placed to obtain optimum through ventilation and shading by its roof and adjacent room from the south-westerly sun as it is used mainly during afternoons and evenings. The stores, latrines and washrooms were placed against the hosh walls so that when used in a grid iron layout some economic advantage can be gained from the sharing of party walls.

The main improvements that these houses offered over normal conditions in the Gezira were in the provision of food preparation and sanitary accommodation. The cooking arrangements consist of a platform 30 cms above the ground shaded by the verandah roof with direct access to an enclosed kitchen store for food and utensils.



1. Brick-on-edge parapet coping
2. Whitewashed zibala roof finish
3. Earth/straw insulating layer
4. Polythene sheeting
5. Sawn timber boarding, joists, beam
6. Gishra walling rendered internally
7. Made-up lintel of sawn timber
8. Timber shuttered window
9. Red brick floor finish (guestroom only)
10. Red brick wall footing

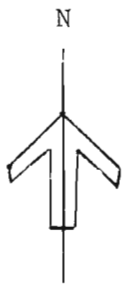
Figure 8 TYPE 'A' CONSTRUCTION
Typical Section Scale 1/25



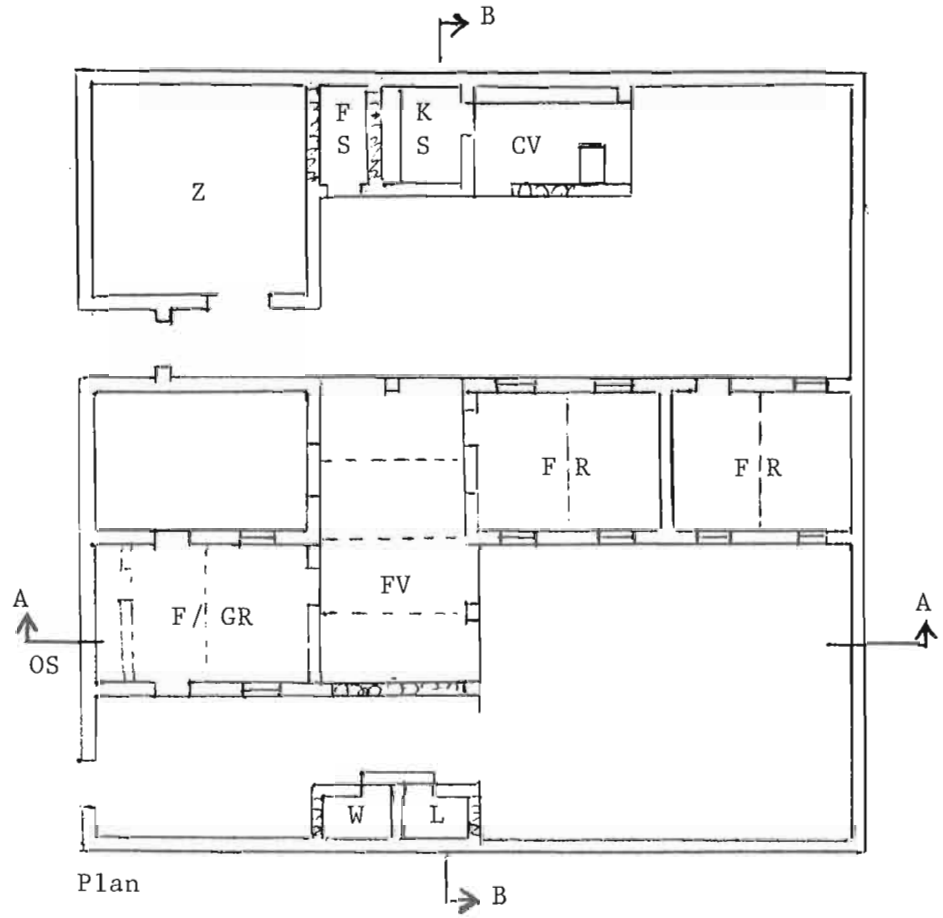
1. Mud-brick parapet
2. Whitewashed zibala roof finish
3. Earth/straw insulating layer
4. Polythene sheeting
5. Bamboo/gareed, local timber joists and beam
6. Thurab mud-brick walling, zibala external rendering
7. Made-up lintel of sawn timber
8. Timber shuttered window
9. Compacted sand/earth floor
10. Red brick footing with dry sand infill
11. Polythene apron waterproofing

Figure 9 TYPE 'B' CONSTRUCTION
Typical Section Scale 1/25

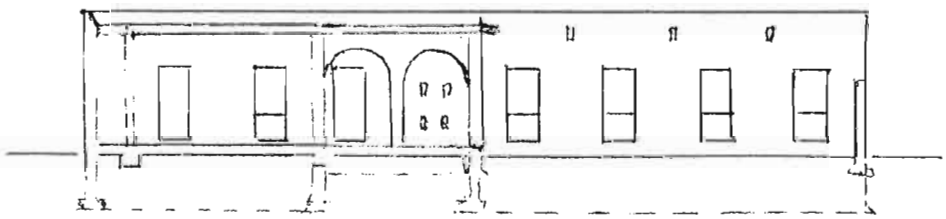
F/GR Family/Guest Room
FV Family Verandah
FR Family Room
FS Fodder Store
KS Kitchen Store
CV Cooking Verandah
W Washroom
L Latrine
OS Optional Store
Z Animal Zeriba



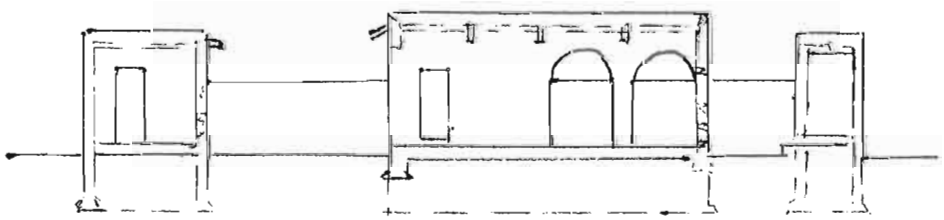
Scale 1/200



Plan



Section AA



Section BB

Figure 10 HOUSE PLAN WITH TYPE 'A' CONSTRUCTION
Scale 1/200
All stages shown completed

The pit latrine has a water seal formed in a pre-cast reinforced concrete slab of special design. It can be flushed with a minimum of water.

It is extremely difficult to get accurate information about costs of traditional building or improved traditional building as carried out at El Huda. Any economic assessment would need to relate to annual household expenditure to initial cost of a building which in turn must be related to cost of maintenance and the degree to which this is effected by durability which again is a function of initial cost. These are a series of very complicated and subtle economic relationships which are very difficult to chart even in developed countries where there are more relevant statistics. What does seem clear is that no physical improvement to dwellings can be achieved without either a dramatic increase in incomes or some improved form of borrowing facilities. It is unlikely that this could come from Government as their funds are barely enough to cope with the need for increased public services. It is only in very exceptional circumstances that Government money is used to finance such housing direct. One such example in the Sudan is the Khashm-El-Girba resettlement and irrigation scheme.

The construction of the Aswan High Dam in Egypt meant that the majority of the inhabitants of Wadi Falfa in Nubia (Northern Sudan) would be displaced from their homes by the rising waters behind the Dam. The Sudan Government decided that these people should be resettled in new irrigated lands made possible by the construction of a new dam across the Atbara river at Khashm-El-Girba. As this migration naturally had to be effected at short notice and at one time it was felt that houses should be built by Government ready to receive settlers on arrival. Unlike the Gezira, here was an opportunity to plan the layout of the villages from the outset.

The villages were incorporated into the network of irrigation canals with the aim of distributing them evenly over the irrigated area to give easy access to the fields (see Fig. 11). As a result, all the settlements are more or less the same size with 600-700 houses and a population of between 3500-4000 inhabitants.

The total scheme involved 32 villages with one new town called New Halfa as a commercial and administrative centre. A settlement of this size, however, involves some of the inhabitants with long journeys by donkey to their plots and also means that each village is about 8-12 kms from the next, discouraging any social life among different settlements.

The village layouts were planned on a standard grid iron layout with 15-20 meter wide streets separating blocks of houses 120 meters by 80 meters (see Fig. 12). There is no differentiation between main and secondary streets and no differentiation between pedestrian, animal and motor traffic. As a result, all streets are used for all purposes, and they are so wide that they cannot be kept in a reasonable condition and have become dusty and dirty spaces exposed to the sun. Each village is assumed to be a single unit, and the centre is planned symmetrically around a site for a mosque. Large areas are allocated for schools, sport, reserve park and public buildings but the areas are so large and unrealistic that for years each village will have a large dusty wilderness in the centre as it is so far from the nearest irrigation ditch there is little hope for any vegetation or shade from trees.

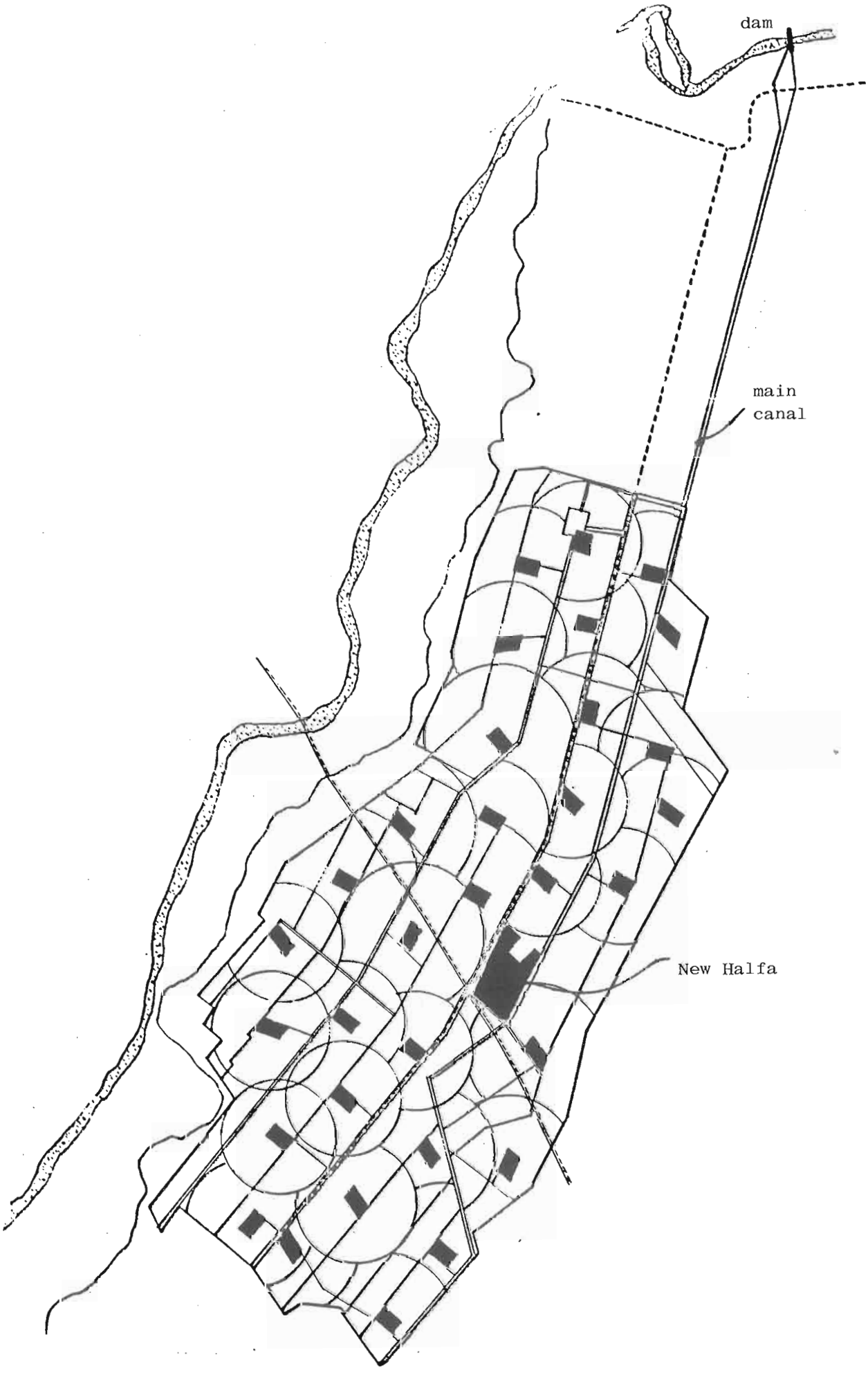


Figure 11 Layout of Khashm El Girba showing villages as built

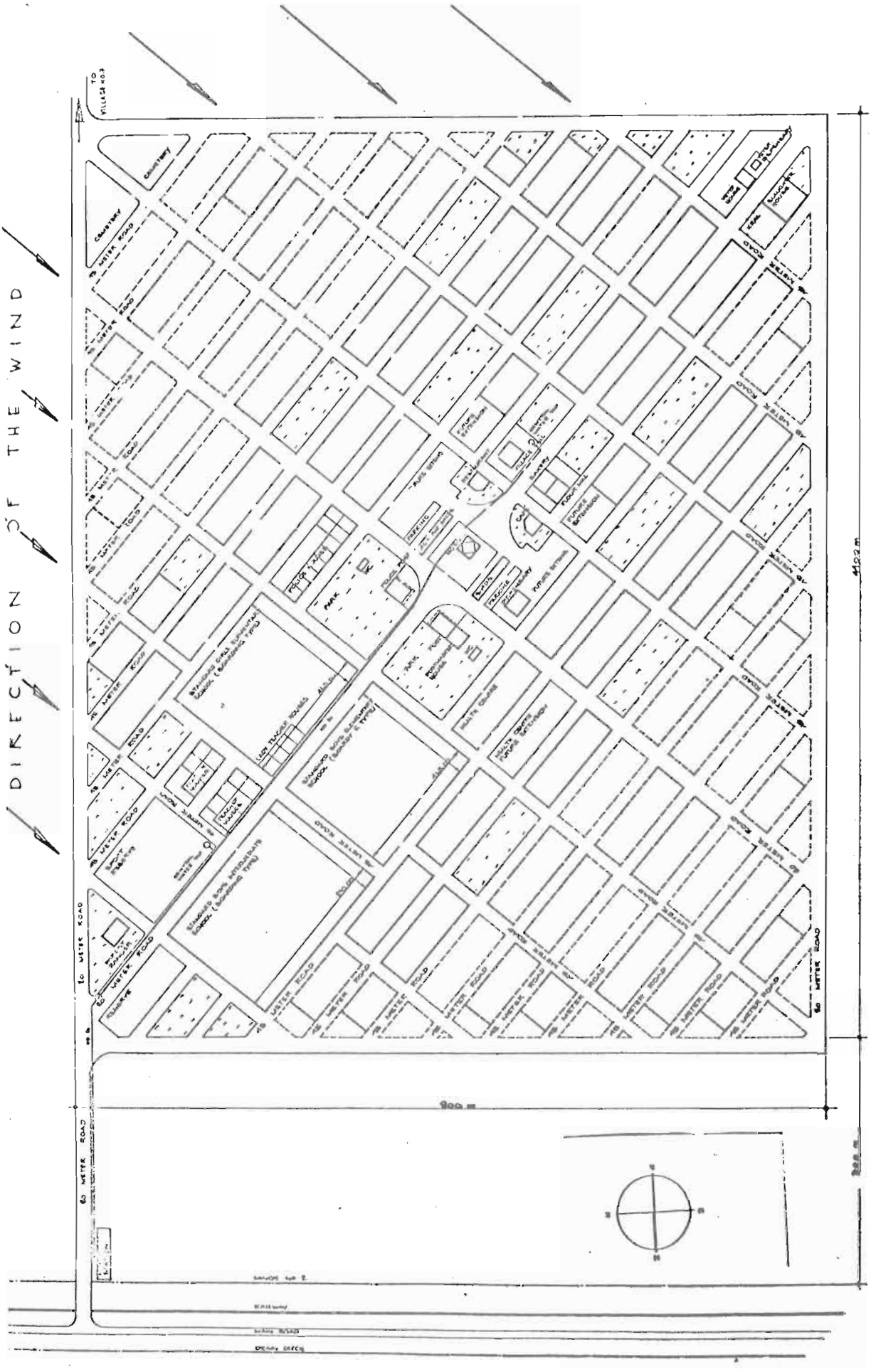


Figure 12 layout of typical village
Khashm El Girba Scheme

The size of each settlement is such that the distance from the farthest house to the school or the shop is from 1100 - 1300 meters which is too far for small children and the aged to walk through the shadeless and dusty streets.

The houses are built with concrete block walls, metal windows and shutters and a roof of corrugated asbestos sheets on timber purlins with no insulation. Each house has its own hosh enclosed with walls of pre-cast concrete planks. A typical house has four rooms, one of which was intended as a kitchen plus a family verandah and a latrine. There is no separate provision for animals or gardens. The resulting environment is monotonous and inhuman. The houses are less satisfactory thermally than traditional mud construction would have been and several times more expensive than the El Huda type of construction. Fortunately, the Nubian inhabitants having a tradition of decorating their houses have already tried to give some humanity to their new houses by decorating the entrances and by painting murals within their homes. Many of these murals express homesickness for the Nile and the date palms of Wadi Halfa. Also many inhabitants have made their own additions and adaptations.

When the author visited one of these villages a few years ago, he could not find one of the rooms designated as kitchens on the plans being used as such. Cooking was always done in the open, often quite elaborate mud ovens and shelters had been erected in the yard. A tremendous investment of Government resources has been made in the construction of very expensive and unsatisfactory housing, an investment that could, with the benefit of hindsight, have been better allocated to building community buildings in the first stage of construction and to the allocation of professional advice, building materials and craftsmen to help the settlers to build their own houses. One cannot escape the feeling that the Gezira settlers left to their own devices had produced a better built environment and at a fraction of the cost, although at nothing like the speed.

A counter argument could be made that these houses have an expected life of at least thirty years and could be considerably improved by the occupants with the addition of ceilings for example. The maintenance problem is also considerably less and the need for emergency repairs after the rains has been completely eliminated. Whether one agrees that such a high investment in house construction is justified or not, there can be little doubt that the layout fails to show any understanding of the needs of a rural community of this kind.

Professor Kadic has suggested that in future layouts of rural housing of this kind, the three basic parts of a farmstead should be identified and carefully planned. First, the residential part with a house consisting of rooms arranged to give sex segregation, shaded verandah, yard divided into areas for family, guests, cooking and a flower garden. Orientation to wind and sun must be carefully considered. Secondly, animal accommodation with a specially designed shed or yard for cattle, sheep, goats and donkeys (even camels in the case of nomads). This should include a feed store and manure heap. There also should be a shed and yard for poultry with easy access to the kitchen yard. The animal accommodation must be situated to prevent nuisance by smell (accent on wind direction) and insects to the house or neighbouring houses and should have a direct and separate access to a road for motor transport and animal traffic. Thirdly, the vegetable garden

and orchard should be accessible to both of the first two parts of the farmstead. Vegetables would be needed for the kitchen or market and the manure for the vegetable garden. Allowance should be made in the original total plan for irrigation to the vegetable and flower gardens and orchards within the house plots.

Kadic has made several tentative layouts involving a residential pedestrian street at one end of the plot with a road for animals and motor traffic together with an irrigation trench at the other (see Fig. 13). The need for flower gardens and shade trees to improve the micro-climate in the Sudan is very great, apart from the universal desire to grow flowers for their beauty. Some of the residents at El Huda were able to grow impressive gardens of canna lilies with the aid of waste water only.

When planning new irrigated lands, the total environment should be considered from the start. It is not enough to design a satisfactory network of irrigation channels making the most of the contours to provide a given number of agricultural plots of a certain size and then to leave the rest of the built environment to be fitted in somehow by other authorities and the settlers. A hierarchy of settlements should be sited in relation to agricultural lands, a communication network, schools, clinics and public services. Kadic has suggested that rather than a number of uniform sized large settlements as at Khashm-El-Girba, it would be better to plan a number of small villages (700-1000 inhabitants) with better access to the fields (see Fig. 14) and at the same time provided with basic facilities as a water-well, shops for everyday requirements, elementary school, mosque and playground. A number of these settlements could form a cluster around a nucleus of a larger village which would have more public services, health clinic, secondary school, cinema, police station, market, workshops and a co-operative centre.

Having settled the strategic planning, there is still the controversial question of housing. The amount of investment available and the relative roles of Government and settlers must be decided upon. It does not seem likely that in the foreseeable future that there will be sufficient public funds to subsidise the construction of houses. The cost of housing as mentioned before must be related to the income of the occupant. An assessment of how this affects the type of construction has been made by Dr. Bedri Elias (see Fig. 15). Starting from the essential of a minimum amount of enclosed space, he has compared the cost of this for four types of construction against incomes in urban areas of Central Sudan, and finds that only 55% of families could afford the minimum standard of space in red bricks with cement mortar (similar to type 'A' in the El Huda experiment). As incomes are considerably lower for the majority in the rural areas, they could afford to build at most with improved mudbrick and new settlers would in addition need help in the form of a low interest loan from Government or private sources. There is, therefore, an urgent need for more experiments in rural housing on the lines of the one described at El Huda and further studies are being initiated by the Ministry of Housing.

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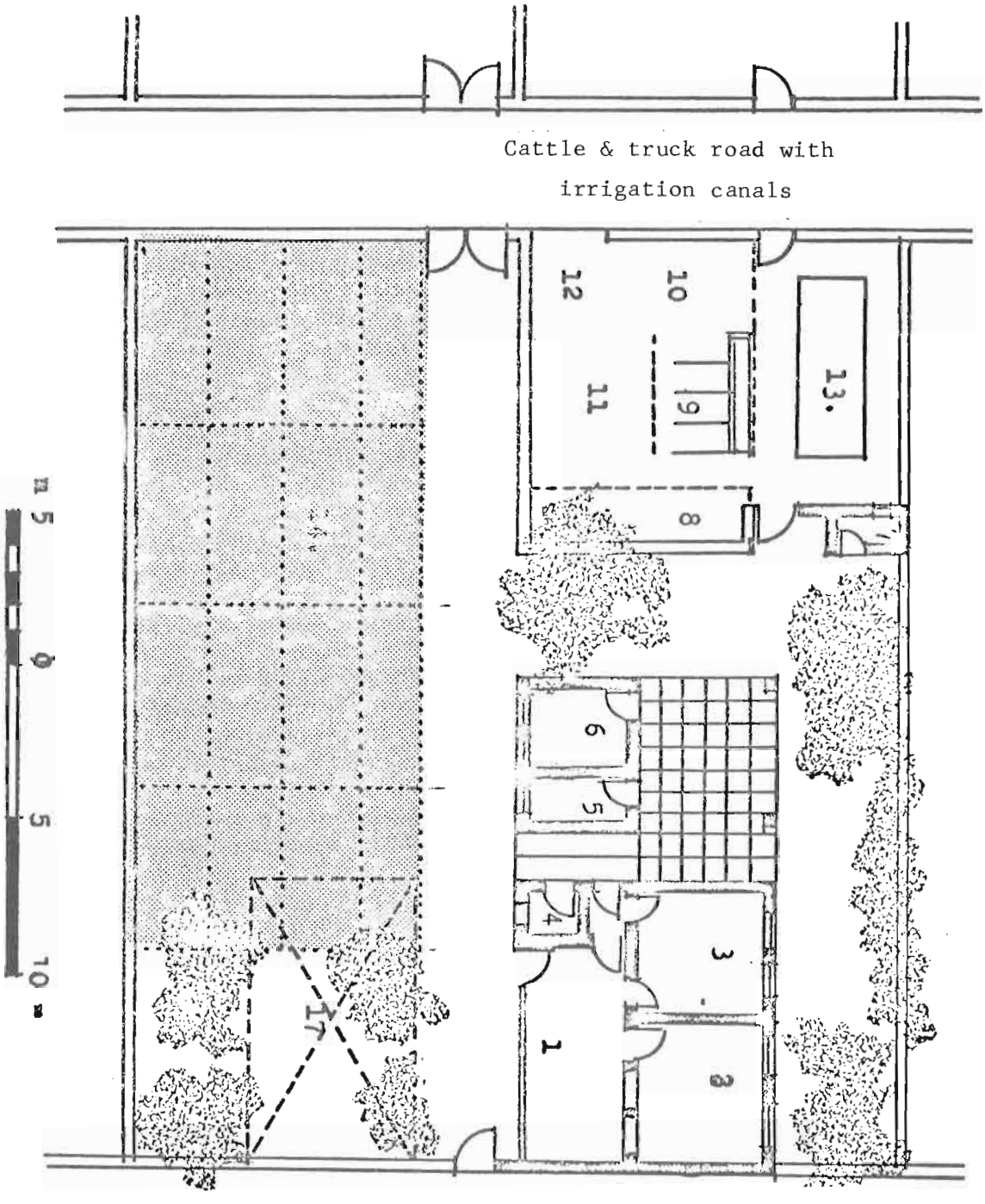


1 - varrandah
2 & 3 - rooms
4 - washing
5 - store
6 - kitchen
7 - lavatory
8 - cattle fodder
9 - cows & donkey shed
10 - goats' shed
11 - cattle yard
12 - manure heap
13 - poultry shed
14 - vegetable garden
15 - flower garden
16 - poultry yard
17 - future extension

Figure 13 Suggested Farmstead Layout (Kadic)

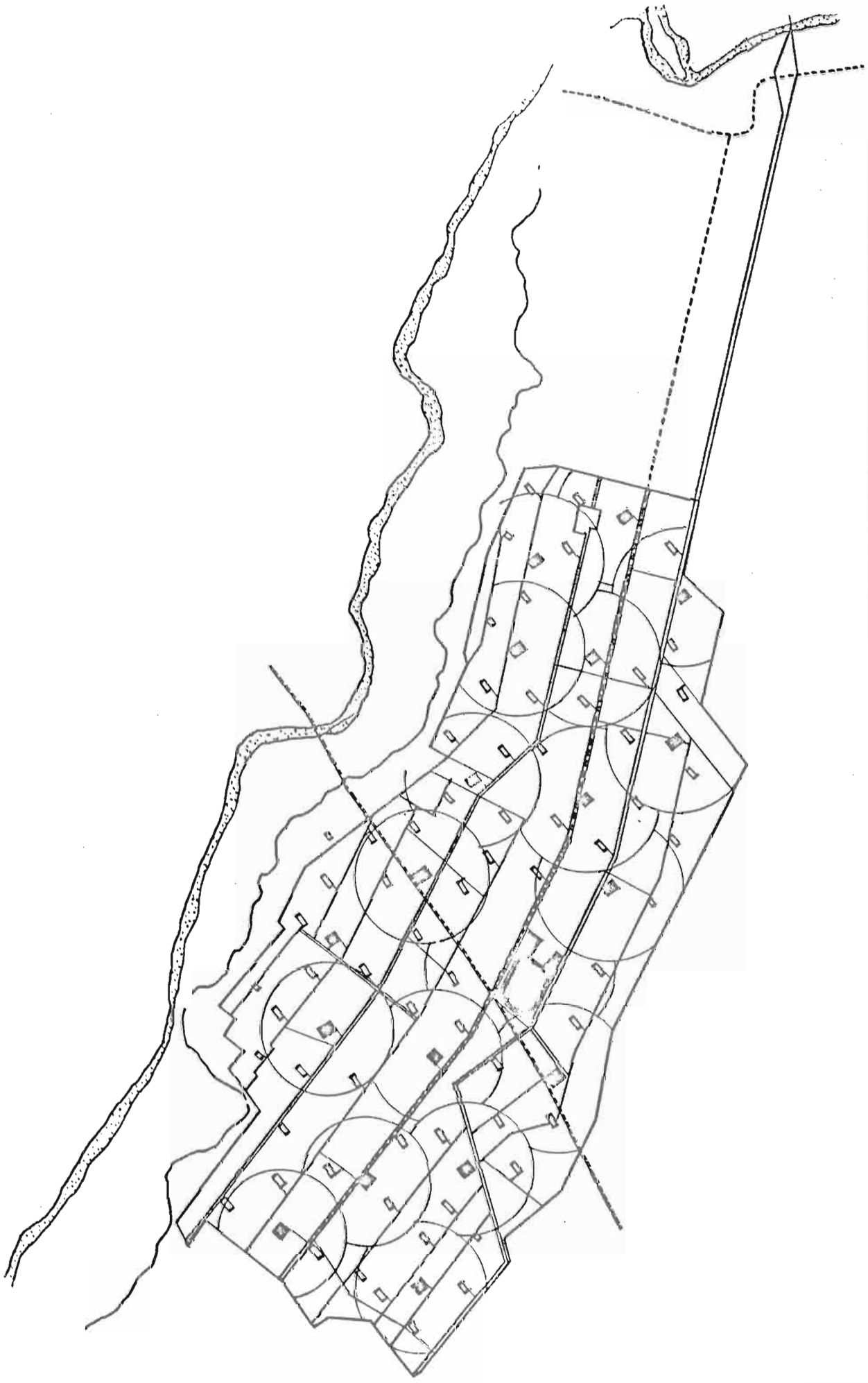
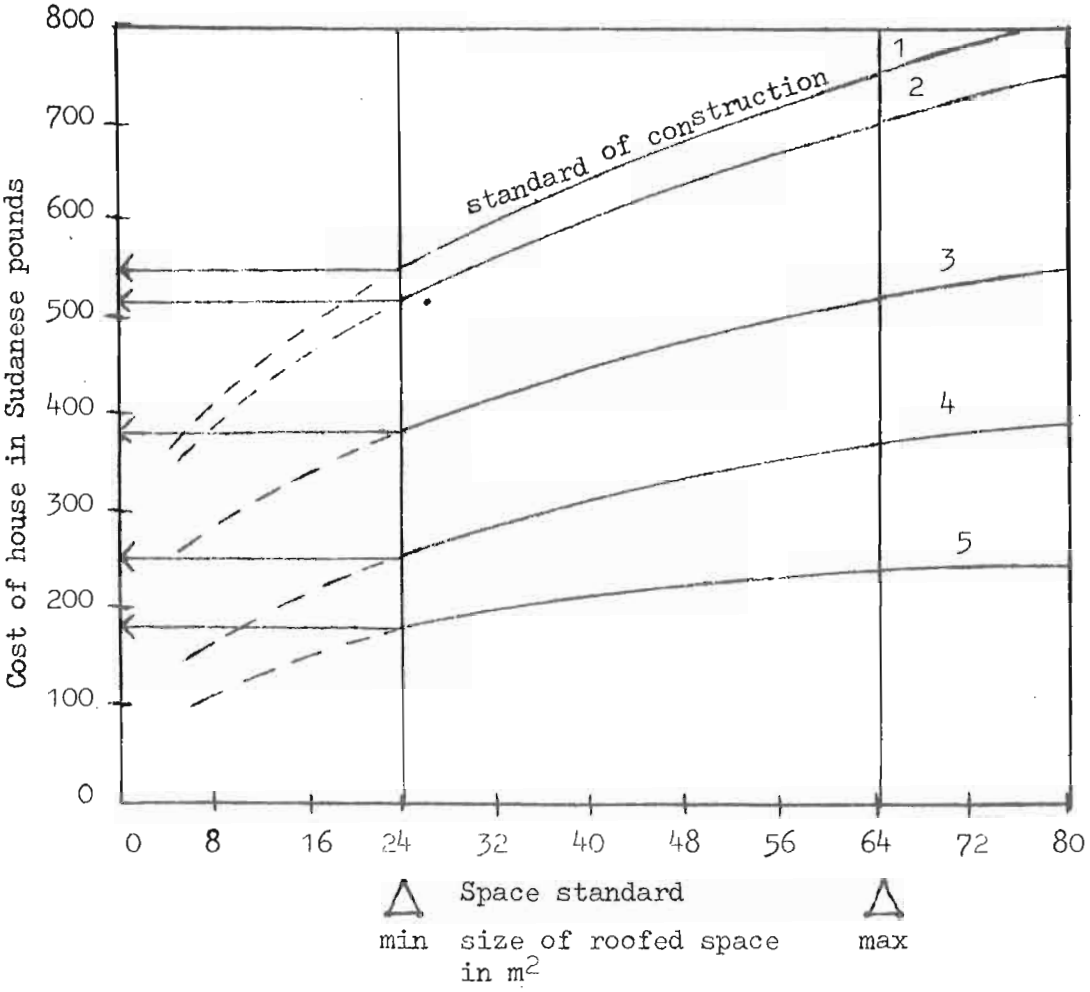


Figure 14 Khashm El Girba Scheme - suggested layout by Kadic



Standard of construction	Description	Percentage of families who can afford minimum standard
1	Hollow blocks	52
2	Redbricks in cement mortar	55
3	Improved mud bricks	75
4	Mud bricks	85
5	Mud layer (jalous)	92

Figure 15 Percentage of households who can afford the cost of recommended space standards at different standards of construction

(from "Space standards in low cost housing, with special reference to urban areas of central Sudan", PhD thesis, El Bedri Omer Elias, University of Edinburgh)

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