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of the two-day Conference
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environmental health engineering in hot climates and developing countries

edited by
JOHN PICKFORD

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environmental health engineering in hot climates and developing countries

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NEEDS AND PROBLEMS IN WATER SUPPLY IN DEVELOPPING COUNTRIES.
Summary of a paper submitted to the Conference on Environmental Health Engineering in Hot Climates and Developing Countries by I. M. G. van Damme [1]).
Loughborough University of Technology, September 1973; 12 pp. [2]).

The world's average man
He lives in a hut
He cannot read or write
His energy is sapped by disease
He labours fifteen hours a day
He works on land he does not own
He and his family are always hungry
He will die young
(From the Journal of Geography 1967)

Introduction

The variation in physical environment, culture and history in the part of the earth where poverty prevails, is considerable. It is not surprising, therefore, that between the three developing continents fundamental differences exist, both as to magnitude and character of the problems.

One of the problems affecting water supply is the fast increase of the population. An accelerated development — it will be evident to all — is necessary. In this development water will play a critical role. The development of the economy in the countries concerned can only then proceed, if an adequate water supply raises the public health to an appropriate level, sustains agriculture and industry and maintains a healthy environment. The Western countries will have to pay their contribution to this development, among other things by making their experiences available to the developing regions...

Following the introduction to the problem a review of water needs is given. To begin with one is reminded that a priority, which was mentioned in many of the 109 recommendations at the United Nations Conference on the Human Environment in Stockholm 1972, was the development and improvement of water supplies. "One of the aspects of the problem is illustrated by recent national studies in Africa which show that women in rural areas spend so much time carrying small amounts of water — often unsuitable for consumption — that they lack the necessary time and energy to care for their children or to educate themselves. It is not only the construction and exploitation of ponds, wells and other water sources which is at stake, but the basic education of populations in the least-developed parts of the world in the simple facts of hygiene and sanitation"... (p.3)

The author points out that besides basic constraints of the global progress in water supply there are many complicating factors which are of regional or local character. "Here sound information is rarely available and education lacks. In many cases the chlorinated water — unknown smelling — is being used for the washing of clothes, whereas the familiar brook, though polluted, continues to serve as a source of water — and as latrine. In certain areas in Asia the water of the river, used within living memory, will remain sacred, how dirty it may be.

In other places the problems are of political nature. Whereas in the country of Kenya rainwater is caught by way of roofs and stored in cisterns, in many other African countries individual solutions for the daily supply of water would be a reason for the government to refuse assistance in the future. For the Congo-project, plans are ready. Resulting from this project, enormous boundary-crossing Congo- and Chad-lakes would change the climate in Central Africa, fertilize parts of the Sahara-desert

[1]) Manager WHO/IRC, The Hague, former participant ICSE.
[2]) Free copies available on request from WHO/IRC, Parkweg 13, The Hague.

and solve water supply problems in surrounding areas. But due to political implications it is unlikely to become true.

As everywhere sly merchants take advantage of the needs of their fellow-men. In many countries the poor water situation gives them a safe income by asking exorbitant amounts for a few gallons of reliable water. Prices 5 to 50 times the cost that would be required to maintain a public, piped and heater water system, are paid to these vendors". (pp 4-5)

Approach

This part of the paper is devoted to the question of how to improve the existing situation Examples are given of successful moves taken in different parts of the world. It has been found that: ..."A greater effort should be made to tap financial sources within the country. The necessary external financial support will in general come available on the base of carefully planned "Bankable" projects. Without doubt the lack of training constitutes a serious shortcoming. Universities in most countries *educate engineers. In many cases the education is not problem-oriented, however,* in India, for instance, engineers are available in great numbers. Few of them have been educated in such a way that they can be used in those fields and at those places where the problems are that most serious. The greatest need concern the "non-professional" man for which training very often does not exist. Next to job-training, and training abroad, particularly instruction of instructors will lead to an acceleration of progress. Another category for which training is badly needed, is the managerial and administrative level." (p. 5). One of the basic shortcomings is the insufficient use of local material.

..."Simple solutions using home-made handpumps and bamboo pipes for the extraction and transport of water, coconut and rice husks as filter materials and coagulant aids from locally available materials can certainly contribute to an increased progress of water supplies. In many countries, however, where status is preferred above the unmeasurable impact of good water, simple solutions have not received much attention until today. Gradually, the application of such technologies is gaining interest and much work is being done in this field. Rather than construction of installations based on Western principles, transfer of knowledge and application of know-how adapted to prevailing circumstances will be able to bring about any acceleration of the solution of the vast problems"... (p. 6)

Further-on thoughts are given about water quality and quantity needs, water prices and facilitation of use.

When discussing the problem of motivation the author states the "The task of the water supply professional in the development countries is often difficult. Governments must be persuaded that, not only is water supply needed, but it can be designed constructed, operated and paid for successfully. By and large, this general acceptance of a principle is delayed considerably in urban areas, while in rural areas it is making its way at a snail's pace". (p. 7)

It is however encouraging that there are exceptions of this bad situation. In Venezuela for example it was decided, several decades ago, to improve the rural service, village by village. It now provides this amentity to some fifty per cent of the rural population.

..."The progress made should not only be related to the number of people benebitted or percentage of population covered but also to other aspects, such as the improvement of administration practices, the growing concern for water quality, the wider interest in programmes of technology transfer, the development of innovative and autochtonous technologies and, what is extremely important, the increasing recognition by the higher decision makers of the importance and priority of water supply in the overall process of social and economic development"... (p. 8).

The author concludes that the Western assistance to the developing countries with regard to water supply programmes will have to lead to self-activity. The responsability lies within the countries themselves.

The last part of the report summarizes the history and tasks of the WHO International Reference Centre for Community Water Supply (IRC) and related international network of collaborating institutions.

In April 1973 IRC convened a meeting of directors of Collaborating Institutions to outline a programme of specific activities directed to water supply problems. Out of the twenty-nine proposals brought forward, six were classed as high priority. It might be useful to quote below some of these main programmes of which the largest impact can be expected.

— "Application of appropriate technologies" which aims at identification of successful simple, lowcost and labour intensive technologies, used in industrialized and developing countries, and at investigation of the practicability of using such technologies, particularly in rural areas.

— "Slow sand filtration in developing countries", which concerns the encouragement of the use of slow sand filters for treatment of drinking water in developing countries and the development of design criteria appropriate for tropical and semi-tropical countries.

— "Health effects of water re-use", aiming at experimental evaluation of the long term effects of consuming renovated water, and establishment of the safe limits of concentration of organics in renovated waste water for drinking water purposes.

— "Impact of community water supply", by which an attempt will be made to evaluate the impact of community water supply and sanitation projects on community health and on the socio-economic life in a community......

STATISTICAL DATA

Participants of the International Courses in Hydraulic and Sanitary Engineering (1957-1973) classified by region and by country

Used abbreviations: ICHE-International Course in Hydraulic Engineering
ICHy-International Course for Hydrologists
ICSE-International Courses in Sanitary Engineering I and II
ICEST: International Course in Environmental Science and Technology

AFRICA

course / country	ICHE since 1957	ICHy since 1966	ICSE I/II since 1960	ICEST since 1971	Total
Algeria			1		1
Angola	1				1
Cameroon	1				1
Ethiopia	2		2		4
Ghana	15	1	3		19
Kenya	2	2	4		8
Mauritius		1			1
Mozambique			1		1
Nigeria	16	2	17	1	36
Sierra Leone		1			1
Somalia		1			1
South Africa	10		1		11
Sudan	16	13	17	2	48
Tanzania		1	2		3
Togo	1				1
Uganda	2				2
Zambia		1			1
Total	66	23	48	3	140

J M G VAN DAMME

Needs and problems in water supply in developing countries

The world's average man

He lives in a hut
He cannot read or write
His energy is sapped by disease
He labors fifteen hours a day
He works on land he does not own
He and his family are always hungry
He will die young

From: Journal of Geography, 1967

INTRODUCTION

The variation in physical environment, culture and history in the part of the earth where poverty prevails is considerable. It is not surprising, therefore, that between the three developing continents (fig. 1) fundamental differences exist, both as to magnitude and character of the problems.

One of the problems affecting water supply is the fast increase of the population. Fig. 2 and 3 elucidate the population problem. Fig. 2 gives the increase of total population per region; fig. 3 shows the world population from data of the UN Dept of Economics and Social Affairs and other sources. An accelerated development - it will be evident to all - is necessary. In this development water will play a critical role. The development of the economy in the countries concerned can only then proceed, if an adequate water

INDUSTRIALIZED AND DEVELOPING REGIONS

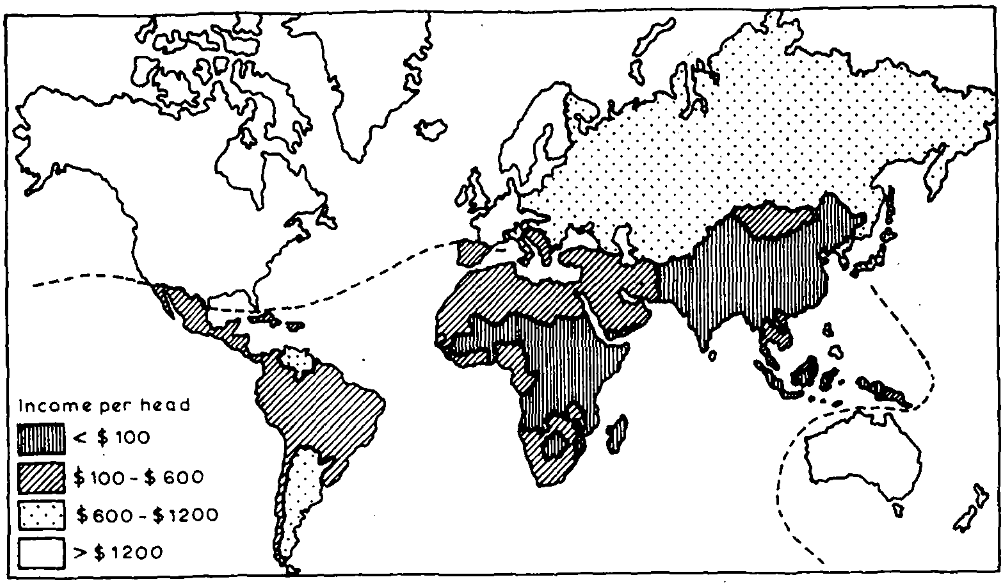


Figure 1 - Industrialized and developing regions

supply raises the public health to an appropriate level, sustains agriculture and industry, and maintains a healthy environment. The Western countries will have to pay their contribution to this development, among other things by making their experience available to the developing regions.

The report of the Club of Rome states in the concluding section that world equilibrium can only become a reality if the situation of the so-called developing countries in an important measure is improved, both in absolute sense, and as compared to the industrialized countries. One of the messages in the report is that improvement can only be achieved by a global strategy.

WATER NEEDS

A priority which was mentioned in many of the 109 recommendations at the U.N. Conference on the Human Environment in Stockholm 1972 was the development and improvement of water supplies. Indeed, next to hunger and growth of population the shortage of water forms a characteristic of the situation in the third world.

Fig. 4 shows the water supply situation in 1970 (deduced from a report of the Director General of the WHO to the Twenty-third World Health Assembly (1)). Fig. 5 gives the same, divided into urban and rural situations. This figure shows that most people without safe water live under rural circumstances, and that most people in rural circumstances live without safe water.

Fig. 6 gives a comparison between the situations at the beginning and at the end of the development decades. Situation 1962 has been based on several different data and the expected situation 1980 has been taken from the results of a WHO-questionnaire in 90 countries, published in the progress report by the Director-General of the WHO to the Twenty-fifth World Health Assembly (2). It can be concluded that from 1962 to 1970 a considerable progress has been booked, especially in the cities. Yet, due to increase of population the development shows a backtrend: also totals not-served still grow. To-day 250 million citizens and more than

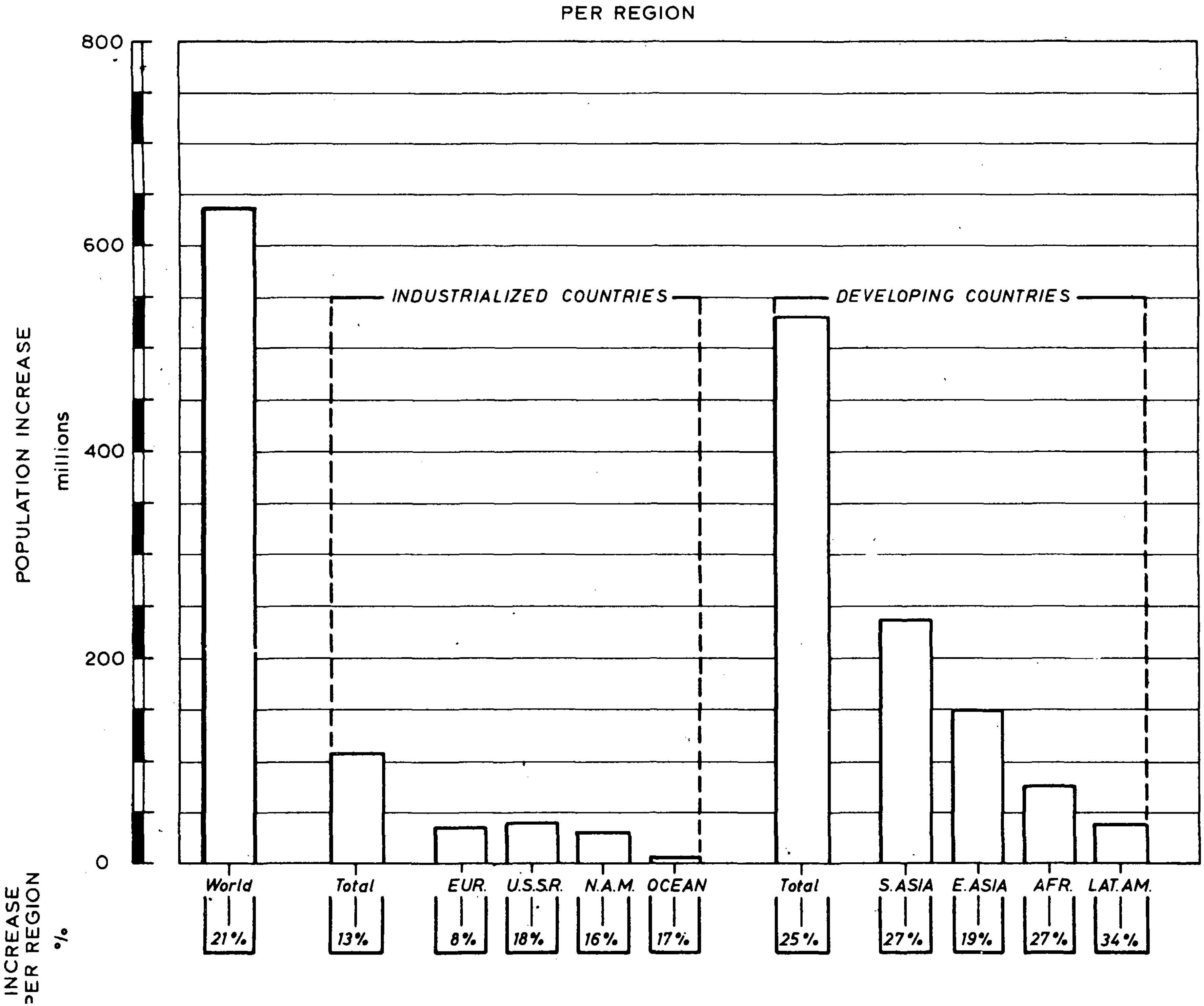
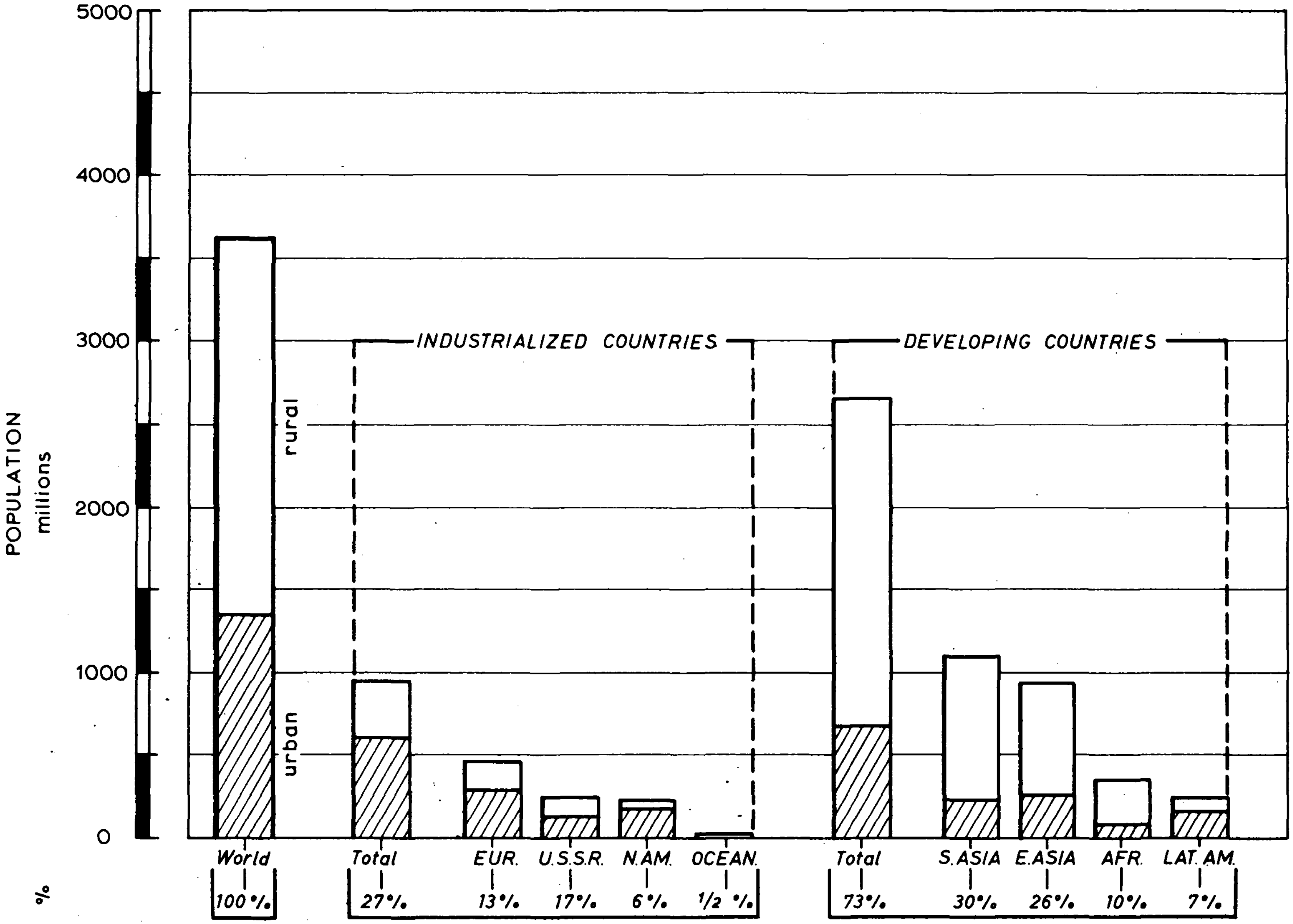


Figure 2 Population increase 1960 - 1970

Figure 3 Population 1970

POPULATION 1970
PER REGION



WATER SUPPLY SITUATION 1970

DEVELOPING COUNTRIES WHO MEMBER STATES

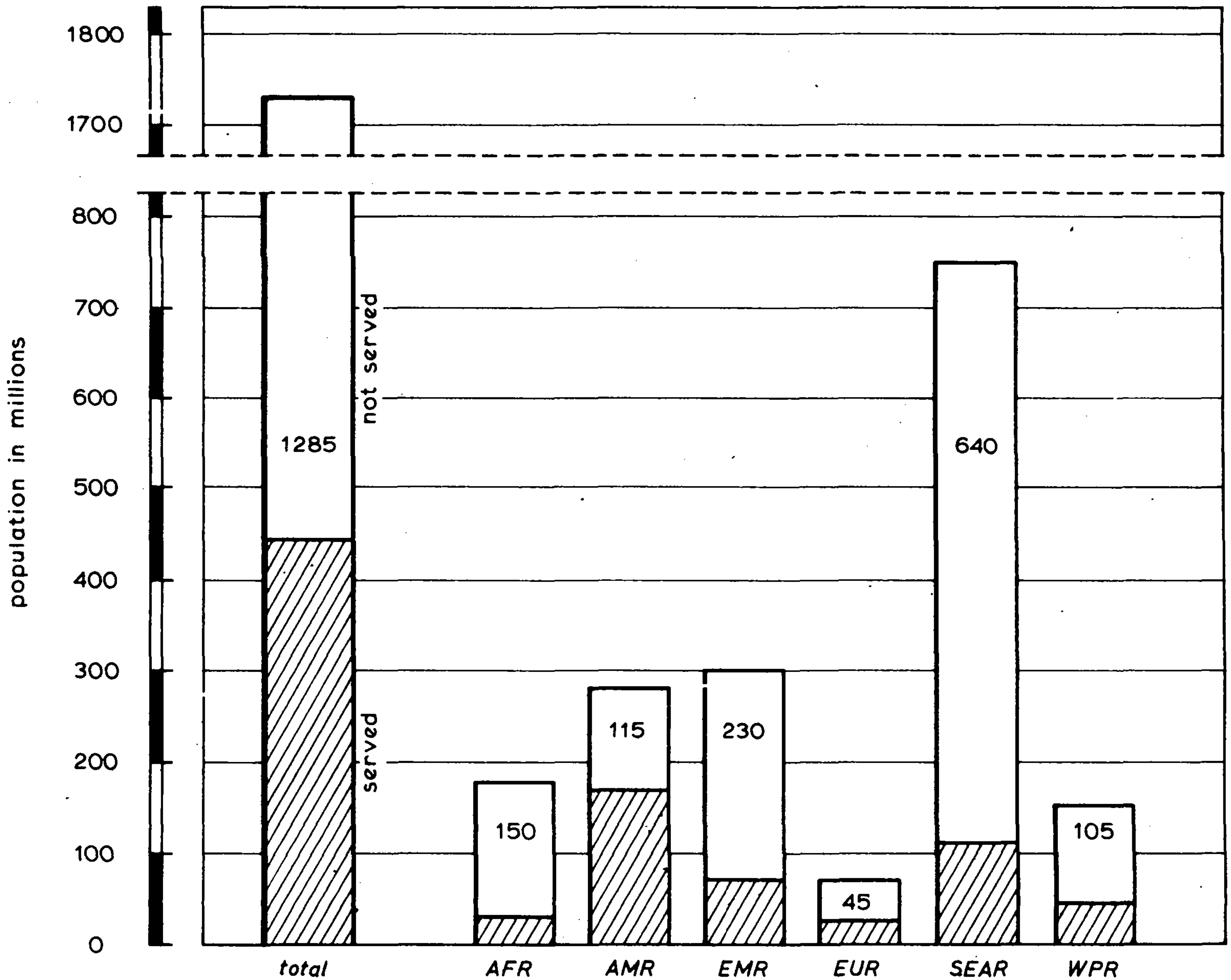


Figure 4 Water supply situation 1970

WATER SUPPLY SITUATION 1970

DEVELOPING COUNTRIES WHO MEMBER STATES

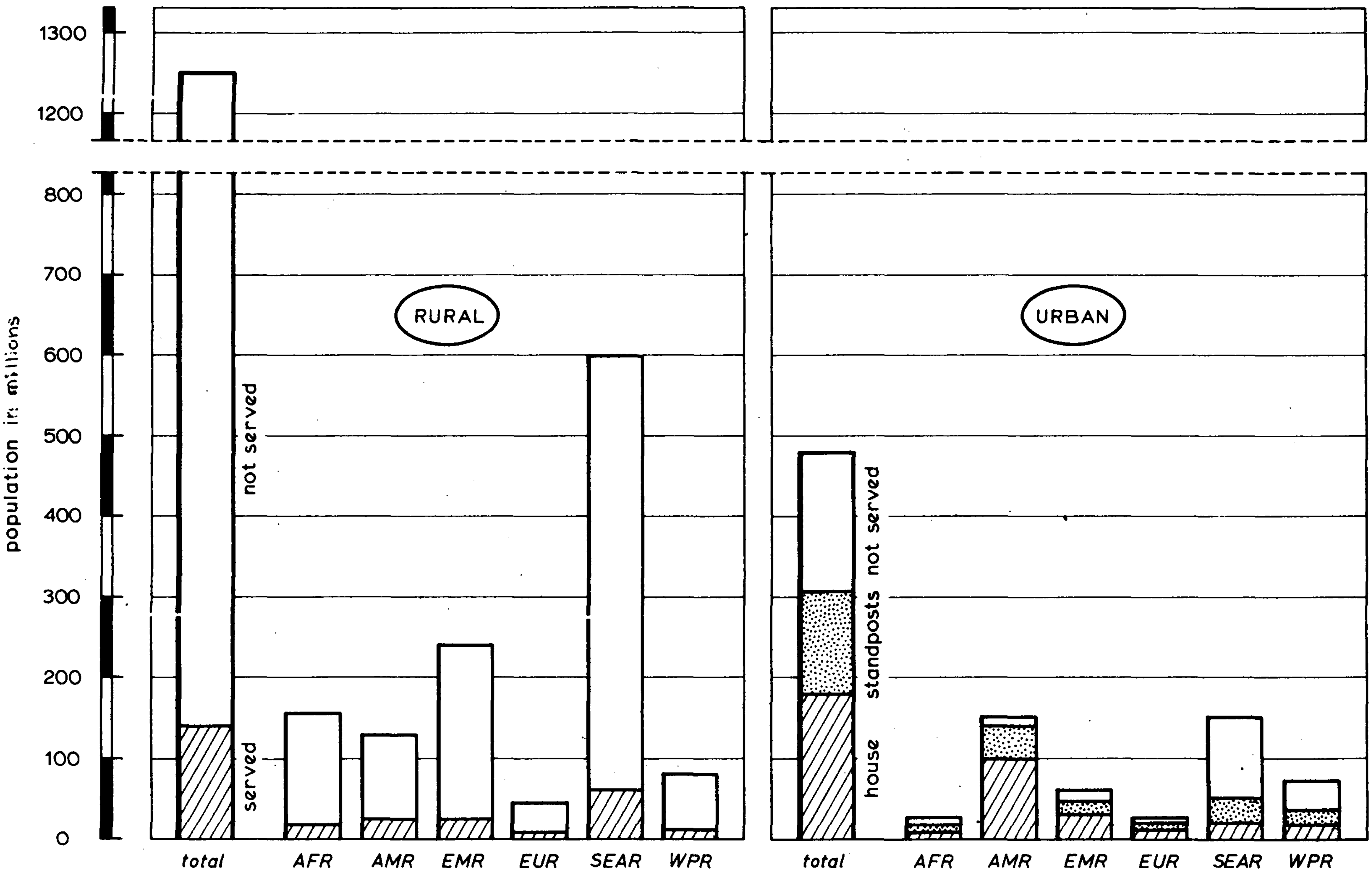


Figure 5 Water supply situation 1970 divided into urban and rural situations.

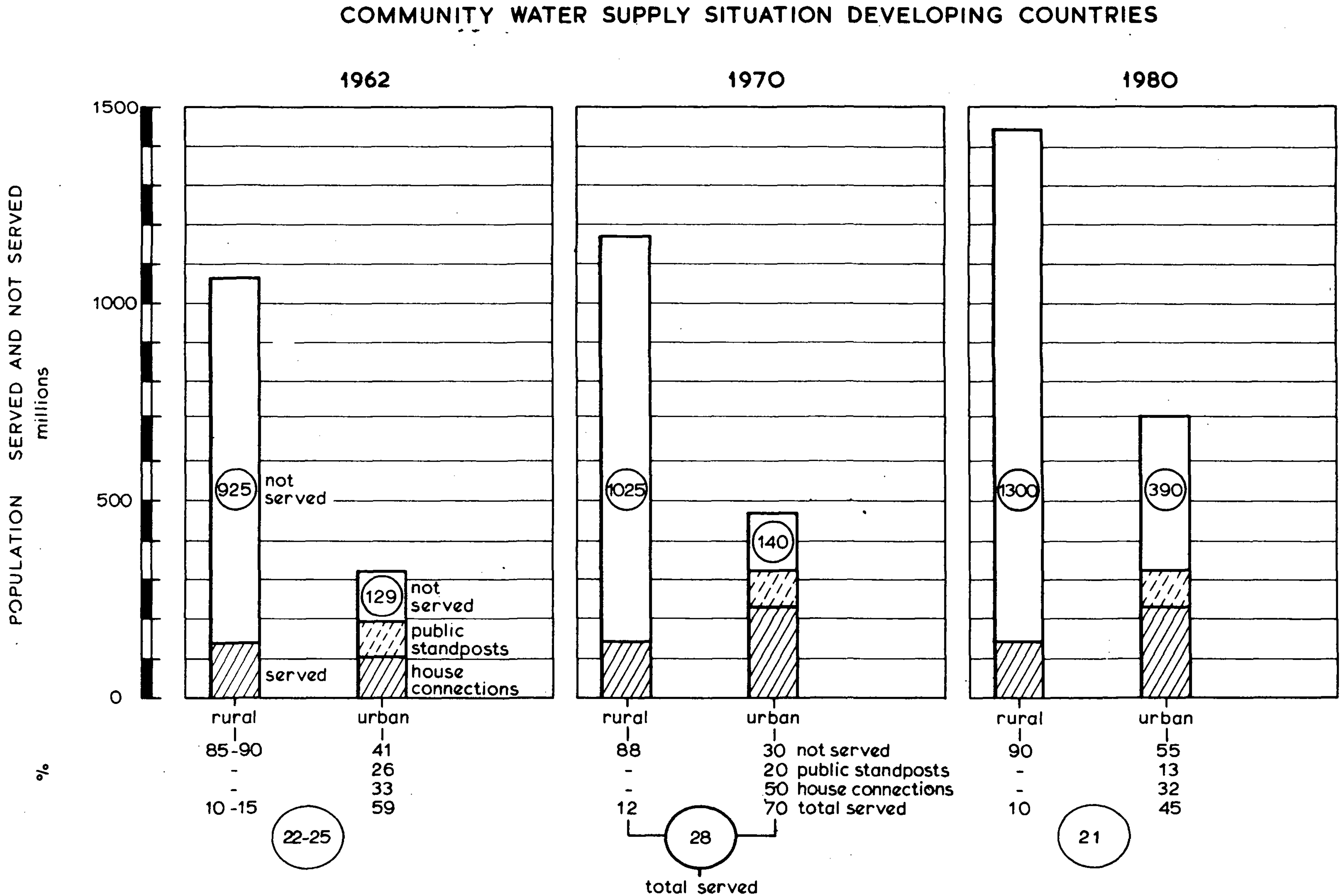


Figure 6 Community water supply in developing countries.

1000 million rurals are waiting for adequate water supplies.

Maurice Strong, Secretary General of the Conference on the Human Environment stated on water supply two years ago: "A shortage of drinking water threatens to make life in many cities in developing countries impossible. In many cases the problem of shortage of drinking water is much greater than that of shortage of food".

The consequences of a lack of water supply services can indeed be disastrous. It is now universally accepted that by providing a community with safe water, epidemics of water-borne diseases such as cholera and typhoid fever can be prevented, and incidence of these diseases can often be considerably reduced. Other water-borne diseases include dysentry, paratyphoid fever, infectious hepatitis, hookworm, etc.

The possible implications of water-shortages as described above can be illustrated by the consequences of the great outbreak of cholera epidemics in 1867. The disease spread via Canada to Argentina and other parts of the world. As stated by M. G. Candau, Director of WHO (1967), in that outbreak 50 000 people died in Argentina, 130 000 in European Russia, 190 000 in Hungary, 90 000 in Japan and many others elsewhere whose deaths were not recorded. It is estimated that five million people die every year from infectious diseases contracted through water. Dramatic examples of epidemics caused by water show that there is no frontier to stop circulation of water and that its properties must be studied on an international scale as well as a subject of international cooperation.

A result of good water supply is shown in fig. 7 (3).

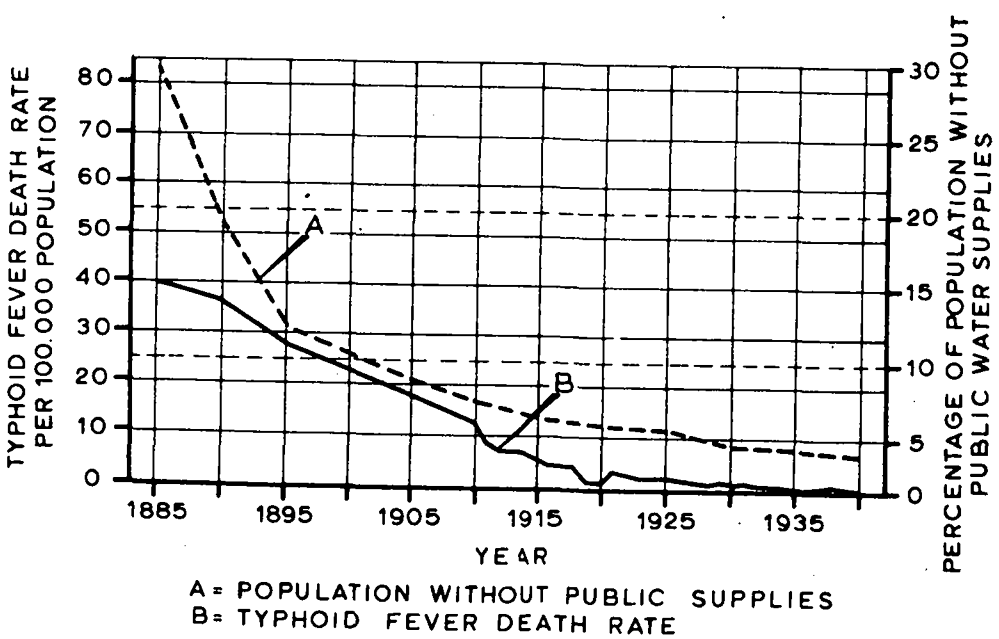


Figure 7. Relation of typhoid fever death rate to percentage of population without public water supplies in the State of Massachusetts, USA

Another aspect of the problem is illustrated by recent national studies in Africa which show that women in rural areas spend so much time carrying small amounts of water - often unsuitable for consumption - that they lack the necessary time and energy to care for their children or to educate themselves. It is not only the construction and exploitation of ponds, wells and other water sources which is at stake, but the basic education of populations in the least-developed parts of the world in the simple facts of hygiene and sanitation.

In order to stimulate an accelerated progress in community water supply during the UN Second Development Decade (1971-1980), WHO proposed the adoption of global targets. Towards 1980 it is attempted to arrive at water supplies for the entire urban world population and for 25% of the rural population. This implies additional water supplies for 500 million urbans and 200 million rurals is 1980. This also implies a total amount of US$13 200 million, based on the assumption that costs of house connections are approx. US$38.- and public stand pipes US$15.- per capita.

In the Third World the history of the West is repeated. Perforced by circumstances, however, a much shorter space of time is available. The water need of the developing countries asks for assistance by the industrialized countries. This means an enormous challenge to the Western world in general and to the water supply in particular.

The task should be a rewarding one. As Dr Jenney states in his terminal report of a mission in Brazil (4): "In the complicated network of economic deficiencies (in the developing areas), the improvement of a man's health is an achievement that will neither create a new need, nor in turn depend upon another capital investment for its success. It is unique in that it is a successful end in itself, economically basic, politically unquestionable, and in most cases technically negotiable. Sometimes, as in eradication of a disease, it is a single investment, ended forever, a paid-up endowment for the infinite future. In the Western world we are living on such an endowment; the developing areas are not, and this most acute difference is reflected in every facet of economic and cultural contrast".

Which, then, are the constraints of a rapid progress in water supply and how far will a different approach to that during the last decades be required? The governments of the countries concerned have in answer to the afore mentioned WHO-questionnaire characterized the lacks which in their opinion cause a meagre progress(2):

- insufficient finances (both internal and external inappropriate financial frameworks;
- lack of trained personnel;
- inappropriate administrative structure and in many cases an inadequate or outmoded legal framework;
- insufficient production and use of local material.

Connected with these basic constraints are many complicating factors which are of regional or local character. Some examples may elucidate the diverging nature of these problems. As in many countries, the groundwater in North-Cameroon remains unattainable for the inhabitants who every day have to walk many miles in order to secure their water supply. Reasons are insufficient geological insight, a dry climate and impassable roads.

Problems are often connected with town and country planning. In the interior of Brazil the scattered population makes an adequate provision of water unpayable. In many developing countries the "bidonvilles" form an infra-structure in which the construction of supplies is impossible.

In the rural areas, social and psychological problems play their role. Here sound information is rarely available and education lacks. In many cases the chlorinated water - unknown smelling - is being used for the washing of clothes, whereas the familiar brook, though polluted, continues to serve as a source of water - and as latrine. In certain areas in Asia the water of the river, used throughout living memory, will remain sacred, however dirty it may be.

In other places the problems are of political nature. Whereas in the country of Kenya rainwater is caught by way of roofs and stored in cisterns, in may other African countries it disappears unused into the soil, as the construction of preliminary facilities would be a reason for the government to refuse assistance in the future.

For the Congo-project, plans are ready. Resulting from this project, enormous boundary-crossing Congo- and Tsaad-lakes would change the climate in Central-Africa, fertilize parts of the Sahara-desert and solve water supply problems in surrounding areas. But due to political implications this is unlikely to come about.

As everywhere sly merchants take advantage of the needs of their fellow-men. In many countries the poor water situation gives them a safe income by asking exorbitant amounts for a few gallons of unreliable water. Prices 5 to 50 times the cost that would be required to maintain a public, piped and treated water system, are paid to these vendors.

APPROACH

Of great importance is the question of how to improve this poor situation. One of the prime constraints might be the lack of decisive governmental intent. Of equal importance, however, is the recognition by the officials of the governments canvassed by the earlier mentioned WHO questionnaire that the number one constraint is the insufficiency of internal financing. This leads all other retardants, such as lack of trained personnel, inappropriate administrative structures, lack of external money, insufficient production of local materials, or inadequate or outmoded legal framework.

Undoubtedly, part of the deficiency exemplified in lack of internal money is bound up with the failure to develop fiscal resources and machinery to reduce, if not eliminate, this financial restraint. Successful moves in this direction are already underway in many developing countries, such as Brazil, Guatemal, Ghana, Tanzania and Israel. The means of introducing these aspects into country campaigns are perhaps the keys to successful implementation (5). A greater effort should be made to tap financial sources within the country. The necessary external financial support will in general come available on the base of carefully planned "bankable" projects. Without doubt the lack of training constitutes a serious shortcoming. Universities in most countries educate engineers. In many cases the education is not problem oriented,

COMMUNITY WATER SUPPLY: TRAINING NEEDS, 1972-1976

Region	WHO-sponsored fellows, 1971	No. of staff requiring training,[1] 1972-1976											
		Professionals						Non-professionals					
		Managers	Financial personnel	Engineers	Chemists, biologists	Other	Total	Allied health professions	Well drillers	Supervisors	Special artesans	Special clerical	Total
AFR	41	57	64	272	63	74	530	187	170	290	350	200	1197
AMR	85	187	127	204	79	97	694	298	248	266	1207	25	2044
EMR	33	119	137	228	134	64	682	226	127	275	676	170	1474
EUR	49	-	6	24	6	-		36	-	-	-	-	-
SEAR	23	57	31	170	2505	12	2775	760	40	275	100	100	1275
WPR	12	289	407	607	158	157	1618	558	402	2000	4004	3820	10784
Total	243	709	772	1505	2945	404	6335	2029	987	3106	6337	4315	16774

[1] For whom training facilities are not now available in their countries

Table 1
Community water supply
training needs 1972-1976

however. In India, for instance, engineers are available in great numbers. Few of them have been educated in such a way that they can be used in those fields and at those places where the problems are the most serious. Table 1 shows training needs in the period 1972-1976 (2). The greatest need concerns the "non-professional" man for whom training very often does not exist. Next to job-training, and training abroad, instruction of instructors will particularly lead to an acceleration of progress. Another category for which training is badly needed is the managerial and administrative level, which has constituted the limiting factor in Latin-America. Without managerial machinery, the introduction of water supply, either locally, regionally or centrally, is improbable. Time and again physical facilities have been built by one or another of external agents, who then desert the site. Before long, these deteriorate, through lack of maintenance and repair and increasingly fail of their purpose or function. More emphasis on training of this category, through courses and seminars, will undoubtedly contribute to a faster solution of the problem.

At many conferences the insufficient use of local material has been mentioned as one of the basic shortcomings in many regions. Simple solutions using home-made handpumps and bamboo pipes for the extraction and transport of water, coconut and rice husks as filter materials and coagulant aids from locally available materials can certainly contribute to an increased progress of water supplies. In many countries, however, where status is preferred above the unmeasurable impact of good water, simple solutions have not received much attention until today. Gradually, the application of such technologies is gaining interest and much work is being done in this field. Rather than construction of installations based on Western principles, transfer of knowledge and application of know-how adapted to prevailing circumstances will be able to bring about an acceleration of the solution of the vast problems.

Much can be said in this connection on how much water is needed per capita and what its quality should be. Design criteria for water quantity in developing countries vary from 25 l/c.d. to 100 l/c.d. in larger villages. Textbooks often mention 400 l/c.d. In large cities in industrialized regions figures of 800 and more l/c.d. are used. Even in tropical areas people will seldom have a consumption of more than 5 l/d, however.

If, according to D.T. Lauria, the problem of concern is how to allocate scarce resources so as to maximise the number of people served with piped water, then "quantity" is no more important than, say, the design period since both these factors affect system scale which is, after all, the principal determinant of cost. Also, quantity seems to be no more important than "meters" or "public fountains" or "piped house services". The essential trade off is not between quantity and quality but between quality of service and quality of product where quality of service includes the amount of water to be supplied as well as distribution considerations.

It should be recommended also that water demand will depend mainly on the price of water, facilitation of its use, and per capita incomes. Two of these factors, namely price and facilitation of use, can be manipulated by the water supply authority, and hence the per capita requirement is, in fact, a partially controlable variable.

Quality standards are given in (6). It can be questioned if lower standards will indeed have the large impact on progress as many claim. Unwanted effects may in the long run not be counterbalanced by the larger number that could be supplied with water. Low standards may ultimately lead to undermining of the motivation to pay for piped water supplies or even to want piped water at all. And besides, as H. R. Shipman states(7), those who argue the cause of reduced biological, chemical or radiological standards for water should recognize at the outset the seriousness of the implications. Advocates of solving the water supply financial problems by reducing safety standards champion a cause which few people in any country could accept. Of special note to the economist is the fact that the savings in costs which could be achieved by reducing the margin of safety usually built into the quality standards will be likely to prove negligible. The principal points to be stressed concern good engineering, good planning, good operation, good financial policy, and good management.

MOTIVATION

The task of the water supply professional in the developing countries is often difficult. Governments must be persuaded that, not only is water supply needed, but it can be designed, constructed, operated and paid for successfully. By and large, this general acceptance of a principle is delayed considerably in urban areas, while in rural areas it is making its way at a snail's pace. An example from Central and South America, where progress in rural water service has been considerable: the available data on the water supply situation in Latin-America and the Caribbean countries show that by the end of 1971 some 152 million of the Region's 287 million inhabitants had piped water supply. In urban areas more than 120 million people, or approximately 78 per cent (vs 59% in 1960) were provided with water supply service either through house connections or public hydrants. The rural population benefited was estimated at 31 million or 24 per cent of the total (vs 8% in 1960).

A comparison of the situation at the beginning and at the end of the last decade demonstrates that many countries of the Region have reached and surpassed the "Punta del Este" goal of supplying water to 70% of the urban population. One country, Venezuela, decided already several decades ago to step up rural service, village by village. It now provides this amenity to some 50 per cent of the rural inhabitants.

The progress made should not only be related to the number of persons benefited or percentage of population covered but also to other aspects, such as the improvement of administration practices, the growing concern for water quality, the wider interest in progress of technology transfer, the development of innovative and autochthonous technologies and, what is extremely important, the increasing recognition by the higher decision makers of the importance and priority of water supply in the overall process of social and economic development. Awareness of the importance for the search of new sources and ways for the financing of water supply works has led to inventive approaches which permitted a new dimension to the water supply programs in some countries. Thus, a new group of capable executives emerged, the ones responsible for the water supply undertakings. Some of the huge water supply entities, which only a few years ago were beset by grave financial troubles and that due to innumerous constraints gave way to serious criticism as to the quality of service offered, have changed or are now rapidly changing into sound and efficient enterprises.

The achievements of the last decade were the result of the considerable efforts of the countries and demonstrated the willingness of the responsible authorities to cope with the water supply problem showing also their decision to meet the challenge that is envisaged for the years to come. Here the motivation was high.

With the same motivation the countries in Africa and Asia will have to develop their water supply program. Only then can technical and financial support be successful. The responsibility lies with the countries themselves, however. The role to be played by the Western world is not that of help from above. The assistance will have to lead to self-activity in the countries concerned.

IRC

The World Health Organization (WHO), the U.N.-organization that among other things is concerned with water supply, has long ago understood that only through cooperation and through use of existing facilities and expertise available in many countries can the problems be solved. Since 1968 a world wide network of Collaborating Institutions is in development of which the WHO International Reference Centre for Community Water Suppyy (IRC) forms the nexus. The IRC, within this International Network for Community Water Supply, has in principle three tasks:

- documentation, and exchange and transfer of technical and scientific knowledge and information;
- initiation, coordination and conduct of research and development programmes;
- organization and conduct of training programmes and of exchange of personnel.

Because of the serious needs in water supply in developing countries the emphasis of the activities tends to be on problems prevailing there. Nevertheless the Centre has also to play a coordinative role in research and development work in the industrialized world.

In collaboration with WHO, the IRC endeavours to pay a contribution to building up of an infra-structure of knowledge and expertise, with the help of which implementation of works will be facilitated. The objective comprises all those activities which precede actual implementation of water supplies. Next comes the collection of existing information and the development of new knowledge in an adapted and usable form to those persons who actually need it.

The purpose of the International Network for Community Water Supply (fig. 9) in its entirety will be able to provide an invaluable support to the countries. It is expected that Regional Reference Centres and Collaborating Institutions will indeed maintain continuous and close contact with the International Reference Centre in such a way as to constitute a system which will make available multi-disciplinary knowledge and expertise in the field of water supply to developed and developing countries. The whole Network should develop a catalytic action, promoting and supporting activities related to the provision of selected information, research capability and manpower education and training.

After the initial stage of building up and consolidation of this Network, the IRC convened in April 1973 a meeting of directors of Collaborating Institutions, the purpose of which was to delineate a programme of specific activities directed to water supply problems (9). At the Conference 31 participants from internationally operating organizations and institutions discussed existing needs and programmes to be developed. 29 proposals for specific projects were brought forward, of which 6 were ranked with highest priority. These 29 projects, in fact, represent the main areas of needed activities and the 6 highest priority ones indicate programmes from the results of which the largest impact can be expected. These 6 projects are:

- "Application of appropriate technologies", which aims at identification of successful simple, low cost and labour intensive technologies, used in industrialized and developing countries, and at investigation of the practicability of using such technologies, particularly in rural areas.
- "Slow sand filtration in developing countries", which concerns the encouragement of the use of slow sand filters for treatment of drinking water in developing countries and the development of design criteria appropriate for tropical and semi-tropical countries.
- "Health effects of water re-use", aiming at experimental evaluation of the long term effects of consuming renovated water, and establishment of the safe limits of concentration of organics in renovated waste water for drinking water purposes.
- "Impact of community water supply", by which an attempt will be made to evaluate the impact of community water supply and sanitation projects on community health and on the socio-economic life in a community.
- "Development and implementation of systematic training programmes in community water supply", which is directed to the development of specific training projects, based on an identification of the manpower situation in the water supply field in developing countries and of existing capabilities and programmes.
- "Health effects of trace elements in water", comprising the evaluation of an experimental project.

This last project will have the most immediate impact in industrialized countries.

Although the Centre is young, several activities have gained wide interest. A monthly Newsletter gives short reviews of relevant internationally scoped activities and research results. Publications have been issued on the use of iodine as disinfectant, the establishment of a "potential pollution index" of rivers, water supplies for small households, and a reference paper on plastic pipes, and several bulletins with information on current research, and education programmes were compiled. An expert meeting on health aspects of the use of uPVC pipes and polyelectrolytes in community water supply organized by the IRC, has given valuable results and has pointed out new directions for further investigations.

With these and other studies and projects listed in the annual reports, the IRC endeavours to sustain the targets of the United Nations Second Development Decade, thus contributing to an accelerated implementation of water supplies to millions of people unserved today.

CONCLUSION

Many organizational aspects in the countries concerned will have to be improved, if the above goals are to be reached. As conclusive contribution, the IRC uses its 'transferring capacity' to take from the report of a WHO expert committee five points for discussion:

Water quality standards are essential for the purposes of surveillance, both in the interests of public health and for operational control. Existing international and regional standards provide a basis for national standards, which should reflect the stage of development of the country. In framing these national standards, limits for bacteriological and toxic substances cannot be sacrificed, but it is recognized that local situations may demand some relaxation of certain chemical and physical requirements. At all times, however, drinking water standards must be adequate for safety and their application must be simple to supervise:

The development of professional societies and waterworks associations at the national and international level is highly desirable since, among other functions, they can bring pressure to bear for the benefit of community water supply development. It is important also not to overlook the encouragement of community interest at the local level that these sources can provide:

There would be undoubted advantages if research institutions and universities interested themselves in the water supply problems of their respective countries. A close liaison between such institutions and the operative departments responsible for water supplies would be mutually valuable and should be encouraged:

Promotion of community interest and participation is essential for the initial and continuing success of any community water supply programme:

The construction, management, operation and surveillance of water supplies demands the services of trained and experienced personnel, professional and sub-professional, if the large investments made in these facilities are to be protected. International assistance has been, and should continue to be, of value to governments in the training of these men. In view of the large numbers of personnel and diversity of disciplines required, however, and to ensure effectiveness, the bulk of training should be carried out within the country concerned.

Many disciplines must be applied to fight against the thirst of the world. Proper management is one of them. Technology is another.

The need for technology is still there. Most of the world's population is on the edge of starvation despite today's science and technology. These human problems must be faced. The problem for management is how to advance science and technology, how to apply them, and how to apply them with compassion and attention to the human consequence.

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THE INTERNATIONAL NETWORK FOR COMMUNITY WATER SUPPLY

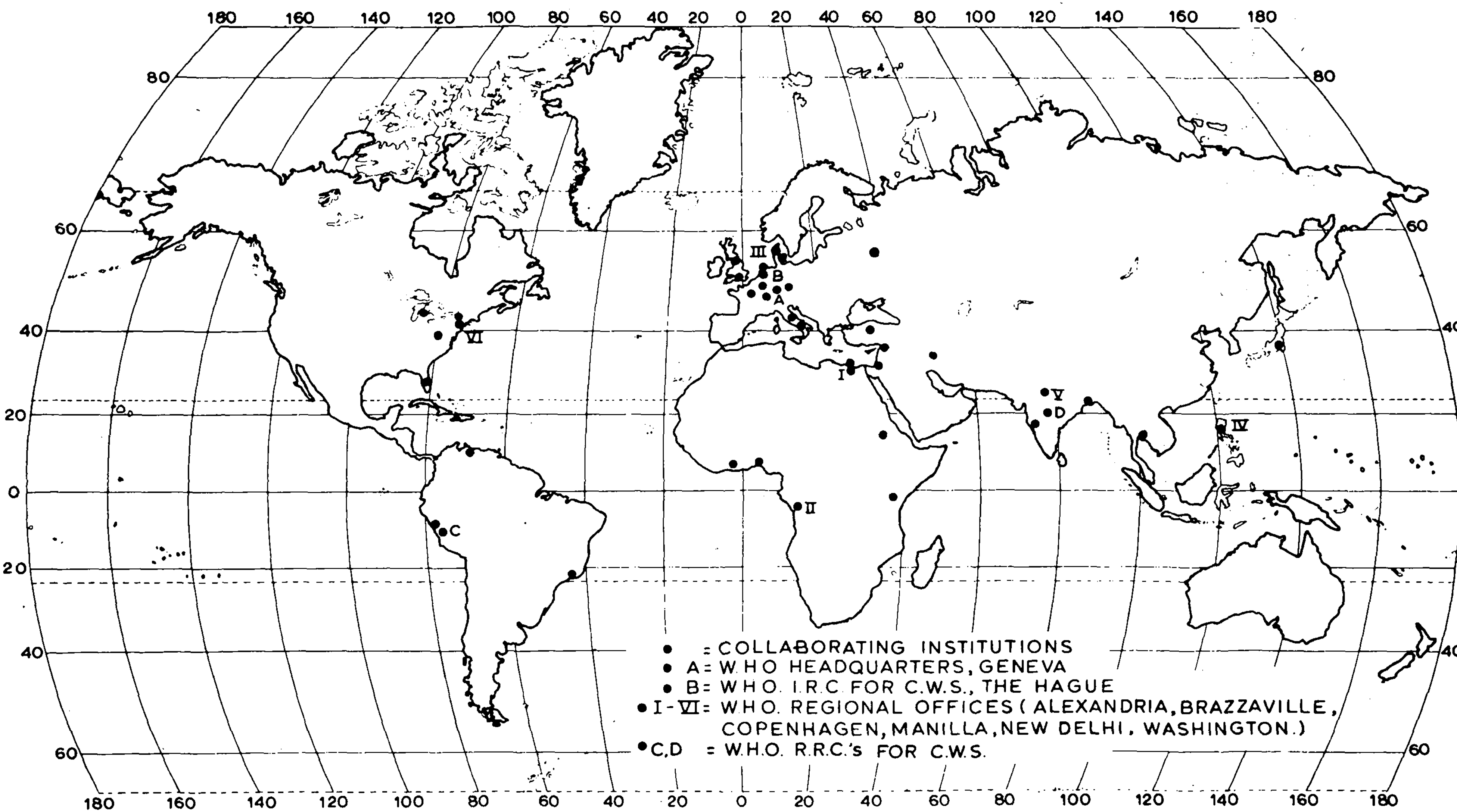


Figure 9 The international network for community water supply

discussion

CHAIRMAN: R. G. ALLEN, BSc, PhD,
Director, Water Research Association

Dr ALLEN introduced the first paper on the Needs and Problems in Water Supply in Developing Countries. There was not anybody better able to lead this than Mr VAN DAMME, as he was in the centre of things as the Manager of the International Reference Centre for Community Water Supply, a unit set up in partnership between the World Health Organisation and the Dutch Government with its headquarters in The Hague. It was a young organisation, which held great promise for the future.

2. Mr J. M. G. VAN DAMME said that in spite of ingenuity in the last century as to the provision of alternatives for all kinds of means to survive, we had not been inventive enough to find a replacement for water to stay alive, and still needed a couple of litres a day to go on living.

3. People who were not served with a piped supply of pure water resorted to other sources such as pools containing poor quality water; others had to walk very long distances with all kinds of possibilities of pollution. Also many vendors were making misuse of the situation by asking for a lot of money for water at prices from 1 dollar to 4 dollars per cubic metre, for instance, in cities like Istanbul, Dakar and Kampala. It was no wonder that water supply had become a critical factor in public health and environmental hygiene, and in economical development. Less water was available because of the tremendous pollution and the amount needed was one of the biggest problems for water supply and solving water supply problems was not only a question of technology; there were many more complicating factors.

4. Mr VAN DAMME showed slides of the figures in his paper. In 1980 the world population would be one and a half times as much as in 1960, and the increase would be largest in developing countries. South Asia was the region with the largest problems in this respect, although the largest percentage of growth was in Latin America. In general relative urban growth was much larger than relative rural growth.

5. As regards water supply, it was quite astonishing how many people did not have good water available and the problems were largest in South East Asia, Eastern Mediterranean and a little less in Africa and America. The situation in rural circumstances was much worse than in urban circumstances. Altogether almost thirteen hundred million did not have water available. There had been considerable progress between 1962 and 1970 but on the other hand the people not served grew because of the increase in population.

6. The problems had been listed: no money, no skills, no use of local labour and materials, inappropriate laws, inappropriate administrative structure etc. Mr VAN DAMME showed slides to give an impression of the problems. In Caracas it would be completely impossible to make any network. In the fringe areas of Rio de Janeiro they were busy building flats for the people and that was one of the solutions; it was necessary to do something about infrastructure before supplying water. Another solution was villagization, but the problem was often who would pay for this solution. Another problem was illustrated by a slide of a bucket next to a well in a highly polluted area with cows walking around and children playing. When the bucket went into the well the water was polluted, and all kinds of diseases could result.

7. What could be done about this situation? The schemes being carried out by WHO, UNICEF etc were extensive but were not numerous enough to cope with the problems. At the International Seminar on Technology Transfer in New Delhi in 1972, Mr Abdel-Rahman, Executive Director of UNIDO stated that in the developing countries most attention was given to investment in equipment and buildings, less to the training of workers and managers and least to the development of technological capacity and appropriate designs.

8. This order of priority should be reversed, to lead to the gradual introduction of locally produced equipment instead of imported items and to the development and modification of technology that would be incorporated in the further expansion of industry. In approaching the problems there should be four obvious basic starting points. Firstly, the people themselves must want the water; this was obvious but very often they did not realise that they needed really pure water to survive. Secondly, Governments must be persuaded that water supply was necessary and could be designed, constructed and paid for successfully. Thirdly, in the building of water supplies local skills must be used as much as possible. Fourthly, once the plant was ready the local people must be able to run it.

9. Mr VAN DAMME told about the rural town of Jatijoso in Eastern Java, Indonesia. The twenty-five hundred inhabitants formerly obtained their water from a brook in the valley some ten to fifteen kilometres away. It was generally felt that the situation needed improvement and so they decided to organise a team to see if there were any other sources of water. Another source was soon found up in the mountains, 60 metres high and a distance of around eight kilometres. Some money was brought together but it was soon evident that it was not possible to build a steel pipeline with the money they had and they decided to use bamboo pipes. Seven permanent labourers were employed and around 3000 people gave unpaid help. A mountainous path had to be cleared to the source by exploding large rocks with kerosene; bamboo bridges were built over the ravines, and masonry cisterns had to be built. After one year and a half the whole thing was ready but the only way of checking it was to see if actually water came out of the end. It looked very beautiful going over the gullies high in the mountain but after all only a quarter of a litre per second came out - hardly enough for three hundred people. However this scheme of self help attracted the attention of the local government and it was soon decided that a second pipeline should be built. This time the expertise of the university in the area was asked. To be sure of the cooperation of the villagers it was decided to make a regional supply which was enough for ten villages and two towns in the neighbourhood. This added an advantage that illegal consumption was avoided and breakdowns would be reported immediately.

10. There were various ways of jointing bamboo pipes. The flow could practically be predicted by using well-known formula with an adjusted roughness coefficient. At Jatijoso the pipes were laid 150 mm below the surface which was enough to avoid breakdown because of local traffic, atmospheric weathering and attack of insects. The joints proved to be the weakest point in the whole system and it was not possible to have pressure higher than 10 metres of water so masonry cisters had to be built as pressure relief. Another problem with bamboo pipes was that they seem to consume chlorine so a long contact time between the chlorine and water was needed.

11. The reasons for the success of the scheme were obvious. Firstly, the decision of the community concerned to have water and to do it themselves. Secondly, the choice of the bamboo which made them independent of foreign countries and from import restrictions. Thirdly, the system chosen was simple - masonry cisterns, bamboo bridges, bamboo pipes and rock breaking by kerosene.

12. Mr VAN DAMME next spoke about the International Network for Community Water Supply, and particularly to the meeting of Directors of Collaborating Institutions in April 1973. One of the main tasks of this meeting was to plan a programme of international activity. Several proposals were brought forward, one of which was the application of appropriate technology. Many years ago industrial countries had good solutions which were still in existence and which were very good, but often this was not realised and people looked for new solutions which were not always necessary. And also in the industrialised countries we have managed to do things which are considered to be old fashioned but which can be very useful in developing countries. Unfortunately some engineers had not considered those solutions and consulting firms should have an open eye for these solutions for developing countries and draw attention to these solutions, which might solve many problems of foreign currency, import restrictions, etc. One of the problems was that engineers were not usually educated in that way.

13. The International Network for Community Water Supply should make such information available as widely as possible, evaluate new ideas, collect old ones, and stimulate and carry out investigations as well as training in this field. In general the Network would set up an infrastructure of

knowledge and experience as a basis for implementation. There was also a Network for Waste Disposal of the WHO of which the International Reference Centre was situated in Zurich, Switzerland. An example of a project was then given which was in development at the moment.

14. This project which was presumably going to be financed by the Dutch Government was about slow sand filtration, which was widely thought to have vast advantages in developing countries. The project aimed to give more emphasis to this system and if possible to bring it to wider application. Several plants in different parts of the world would be investigated and then a standard design of experimental full scale filter would be developed and built in villages, so that after the experiment they could be transferred to the local governments. Investigations would concern several aspects, taking into account local conditions, climate, quality of the raw water, use of locally available filter media, and pre-treatment. Mechanical equipment to clean the filter sand would be developed. If possible, at each location there would be two filters, one control filter and the other operated with different media, filter rates, etc. Then it was intended to organise training courses and seminars so that the filter could be run properly afterwards and the use of slow sand filtration in the region could be encouraged.

15. The International Reference Centre also had projects for developed countries one of which was the health aspects of water re-use; it was hoped that work on this would be carried out by several collaborating institutions.

16. Another project was in the field of training: it was proposed to select a number of countries, and to assess the training needs there on the base of existing facilities and programmes. A pool of regional instructors would then be set up to instruct national instructors, who could take over the job, using training manuals in their own language.

17. Mr VAN DAMME drew attention to the points of discussion on the last page of his paper. Construction, management and operation of water supplies all demanded the services of trained and experienced personnel, professional and sub-professional. To ensure effectiveness the bulk of training should be carried out within the countries concerned, and consulting firms could do a great deal about this. In Holland contracts were being prepared with training courses as follow-up. The firm involved had asked the I.R.C.'s advice as they were not trainers themselves. I.R.C. had agreed to co-operate in building up a twinning relationship between a water supply organisation in the developing country and a company in an industrialised country. There were already two such contracts in Holland. The water supply companies were very enthusiastic; they could keep their good men because they could let them widen their scope in developing countries from time to time, and it was good for people working in other water supply organizations to widen their scope occasionally.

18. Another point for possible discussion had been illustrated by the bamboo pipe case: the promotion of community interests and participation was essential for the initial and continuing success of any community water supply programme.

19. Standards were often being discussed. Did they serve their purposes or were they constraints on further development of water supply? Often the word itself was misleading; perhaps "recommendations" would be better. Low standards would increase the risks of diseases quite considerably.

20. Mr VAN DAMME referred to the recommendations of the WHO Expert Committee that there would be undoubted advantages if research institutions and universities interested themselves in the water supply problems of their own countries, and established a close liaison with the operating department responsible for water supplies. This was the basis of the International Network for Community Water Supply. The last point for discussion was professional societies and water works associations, which should be set up where they did not exist as they could emphasize the advantages of community water supply development. They could promote long term development programmes, organise regional conferences and seminars, and stimulate training courses.

21. Finally, Mr VAN DAMME said it was clear that the goals set by the United Nations would be empty figures unless they converted to short and long range national goals, which should be an integral part of national economic development programmes. An interesting example of this was the Israel National Water System which Mr VAN DAMME described.

22. The CHAIRMAN thanked Mr Van Damme for providing a backcloth on which to hang the discussions. He had referred to almost all of the facets which came into play when trying to increase water supplies in developing countries.

23. Mr W. S. MOFFAT congratulated Mr Van Damme on his presentation. There was one point he would like to emphasize: ground water, which had only been mentioned in relation to Israel, which was not related to rural supply.

Mr MOFFAT suggested that ground water ought to be considered in a developing country for any sized scheme whether it was rural or urban town. A town or large rural supply required a fairly major aquifer, but there were very few rocks which could not produce sufficient water to supply a small community. This had many advantages over a small surface water supply. It was necessary to drill a borehole and seal it properly so that surface water could not enter, with the casing brought above ground level and a concrete apron around it, and a pump fitted correctly. The pump should be carefully chosen to be fairly maintenance free. Then a satisfactory bacteriologically-free supply of water would be available. The chemical quality would depend on the basic ground water chemical quality but would remain fairly constant. The drilling of the hole required very little technical skill apart from somebody to site the hole and supervise the work. Mr MOFFAT contended that surface water should not be considered for a rural water supply until the ground water had been thoroughly investigated.

24. The CHAIRMAN said it was clear that borehole supplies in various parts of the world were the key factor and could be numbered in tens of thousands. Expertise in hydro-geology was required. In some cases ground water was heavily mineralised and not easy to use. Four to five thousand parts per million of sulphate was common in some parts of the world and a research problem was how to purify that kind of water cheaply.

25. Mr J. C. HOWARD said that it was difficult to obtain a simple robust hand-pump or a hand-screwed auger in western countries or elsewhere. There was a whole area of technology in which engineers had failed the developing countries; they needed to re-think how a local community could assess its soil and ground-water potential and decide where it would be best to dig and to produce simple machines to dig and get water from the ground.

26. The CHAIRMAN said he had visited West Bengal to see a project for the improvement of an ordinary hand pump locally manufactured for 4 dollars; however, it was rather unreliable. A hand pump made with modern materials had been designed by the Batelle Institute in America, using a neoprene diaphragm as a flap valve, and the cost was about 180 dollars in America. However, all that was really necessary to improve the locally-made pumps in West Bengal was for the Indian Standards Institution to draw up a proper specification so that the pumps would be made with proper tolerances.

27. Dr ALLEN suggested that before going to modern sophisticated technology there was a need to help the people on the ground to produce a slightly better product by giving them management and engineering techniques which would not cost too much money. In the case of the Jabco Pump made in Bengal the cast iron had a high sulphur content but merely by machining to better tolerances a life of about ten years could be obtained. Around the world certainly there were plenty of local manufacturing units which could produce this kind of pump, and a British Standard covered a pump almost exactly the same as that used in West Bengal.

28. Mr Simon WATT had been investigating hand pumps, and was compiling a list of pumps which could be bought. He was looking at the use of alternative materials such as cement, wood and timber, and different forms of bearings such as oil-soaked wood. Often a small improvement of a certain component made a pump quite viable in comparison with a machine shop produced pump.

29. Mr P. K. JAIN suggested that for countries such as India 20 to 40 litres of water per capita was a reasonable basis for design, which was accepted by the World Health Organization. The period of design could be reduced to between five and ten years rather than a longer period.

30. Slow sand filters were not old-fashioned even in Britain, and were useful for developing countries because of their simplicity and their bacterial quality. During the past century little research had been done on slow sand filters; investigation would be useful especially in three fields. First was an understanding of organic degradation. Secondly, the relation between filtration rate and depth. Thirdly, there was the rate of filtration itself; up to what limit could the rate of flow be increased?

31. Mr T. CALCUTT thought that for slow sand filters the rate was irrelevant in many of the developing countries because land and cheap labour was often freely available. The object was not to build the most precisely optimised system but to produce some water that people could use.

32. Dr G. J. MOHANRAO agreed in part with Mr Calcutt regarding land requirements but there were other problems to be taken into consideration. For example loss of water by evaporation was important in hot climates. In certain towns in India such as Madras it had been found that some slow sand filters cause hydrogen sulphide problems. There was often a certain amount of eutrophication in surface waters which could cause trouble in a slow sand filter.

33. Dr MOHANRAO supported Mr Moffat that ground water should be used wherever possible.

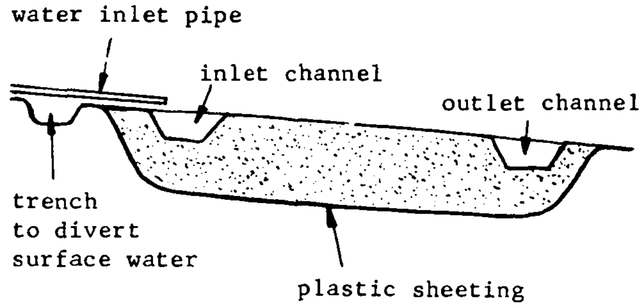
In many areas in India most of the surface waters were highly contaminated so there was a strong reason to look deeper. Ground water had some basic advantages: it had storage where there is no evaporation, and gave free filtration. There was a need to protect the water from contamination from above.
Mr Moffat assumed that casing was well done and the pump was fitted well, but in developing countries anything and everything could go wrong.

34. Mr M. A. ACHESON said that one of the problems with slow sand filters in some parts of the world was that suitable sand was not available. An interesting technique was being developed in Thailand, using other materials than sand for the slow filter.
In the Asian Institute of Technology laboratories a roughing filter had been made out of shredded coconut fibre which was readily available at very low cost. This was followed by a polishing filter of burnt rice husks, of which great mounds could be seen near rice mills. Filters were being developed at village and family scales with these two materials and using surface water for producing a very clear and relatively pure effluent.

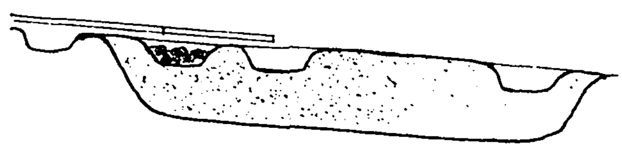
35. The CHAIRMAN agreed that in the slow sand filter there was nothing unique about the sand, but thought that removal of the top layers at regular intervals might present difficulties with rice husks and similar materials.
Mr ACHESON replied that these materials were so cheap, that when the loss of head reached a certain depth the whole media was thrown away and replaced at little cost; it was a labour-intensive operation and no chemicals were involved.

36. The CHAIRMAN suggested that many people working in the developing country areas did not appreciate that many of the major cities in the industrialised countries used slow sand filters for their supplies and were continuing to build them. It was thought to be a preferred technique, producing better quality water than chemical coagulation except in cold weather. For example the whole of London was supplied by slow sand filters. Mr VAN DAMME added that in the biggest harbour in the world, Rotterdam, slow sand filters still formed an essential part of the treatment system.

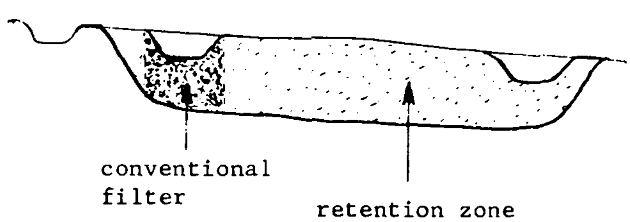
37. Mr H. T. MANN described a horizontal sand filter which he had constructed, which was of this form:



The loading rate was calculated in terms of retention time to provide 100% security against the spread of Bilhazia circasia, which must find a host within 36 hours of being released by the snail. This gave a flow rate of about 0.25 cubic metres per day/cubic metre of sand, compared with about 1.0 cubic metres per day for a conventional slow sand filter. However, where there was plenty of space efficiency was less important than effectiveness; this sort of filter was easy for people to build and produced a very considerable improvement in turbidity, in the concentration of organic matter and in bacterial protection. The filter could easily be cleaned by digging a temporary second inflow channel a few feet below the first channel, and it was then not necessary to stop the flow at all.



38. The CHAIRMAN suggested that this type of filter might consist of a conventional slow sand filter followed by a retention zone:



Mr MANN said that biological action occurred in the entire bed of sand. The structure was simpler and required no under-drains. There were two experimental filters of this type still in position and two quite large ones constructed to deal with something like 2000 gallons an hour. In reply to a question by Mr MOFFAT, Mr MANN said there was a very small surface available for evaporation and the mosquito breeding risk was smaller.

39. Dr MOHANRAO thought the idea was excellent except for the polythene which was very expensive in developing countries and easily torn. There were other ways of making the filter impervious, such as puddled clay.

40. Mr W. STEWART turned the discussion back to Mr Van Damme who had dealt with water on a global scale. A series of photographs in one of the Sunday Magazines recently showed earth satellite photographs of pollution and Mr STEWART wondered whether photographs such as this could be used to pin-point sources of water in developing countries. Mr VAN DAMME replied that this system was being investigated by UNESCO.

41. Dr MOHANRAO said that the majority of the Indian population obtained their drinking water from shallow dug wells which were contaminated bacteriologically but otherwise were reasonably palatable in most places. He asked for comments on how to disinfect such water. The traditional method was chlorination, but new methods of adding the chlorine were required. Villagers and town people who had not been used to drinking chlorinated water did not enjoy the taste of chlorine so did not like much chlorine residual in it. The chlorine had to be added from some gadget which was easy to operate, which could be changed once a week or once a month and which was not easily stolen.

42. The CHAIRMAN knew of developments using porous pots lowered down wells, and in some parts of the world iodine was available which could be used very well.

43. Mr VAN DAMME posed another question, especially to consulting engineers. Did they think it feasible to use low cost or appropriate technologies? These were often discussed, but nobody seemed to build them. The CHAIRMAN also wondered how many consulting firms designed on the basis of simplicity: the use of local materials and simple design.

44. Mr P. I. HELMORE said that in his paper for Session 4 of the Conference he had drawn attention to the requirements to use local materials and simple methods. However, a consultant was designing for a client and it was the client's attitudes which partly conditioned what could be done. Those attitudes often stemmed from the education of the client. It was very gratifying that at Loughborough University there was accent on simplicity and things that could be achieved in simple ways. It is essential that people who would control the work in developing countries should not be instilled with learning from textbooks where sophisticated methods were put in the fore, and the old-fashioned methods such as highly efficient slow sand filters were put in a less attractive way. Mr HELMORE had put forward simple designs only to be told, "Oh, we don't want this old-fashioned type of thing". No consultant who had worked overseas for long would put forward complicated systems, as they soon fail through lack of maintenance or spares or operational skills.

45. Mr A. EL-HINGARI suggested that if any one wanted a simple design he would not hire a consultant, and Mr P. G. STANLEY suggested that the discussion referred to the level of do-it-yourself, self-help, minimum cost, local materials, where the consultant was not usually brought in. His involvement tended to be with larger regional or urban problems.

46. The CHAIRMAN suggested that a great deal of difficulty was related to the sheer magnitude of the task of expanding supplies in countries which had few resources. This meant that those countries had very few 'wise men', as it took a long time to train a 'wise man', who could look over a bridge and see sewage fungus on the bed and say "Ah, yes, now this is a polluted stream". So many people working in that kind of area wanted a pH meter and to measure the COD or the BOD of the stream before announcing that it had any pollution in it.

47. Everyone was clamouring for standards so they could send out a man from an office in London or Amsterdam with a set of rules and tell him to go to Bangladesh and when he found that the pH was 7.5 he was to discard the use of iron coagulant! Standards would enable an inferior man to be sent out where really a wise man should go. A wise man would look all around and take an evaluation of all of the circumstances in the area including the availability of iron as a coagulant, or aluminium, or no coagulant at all, and make a wise decision as to how to deal with that project on the spot. Dr ALLEN believed that this was a key factor in the whole philosophy of this problem.

48. There were some consultants who went out on do-it-yourself missions. One had a bright idea for producing water-retaining structures using polythene sausages filled with a mixture of sand and cement to build, say, an underground water tank. The polythene was pierced and the sausages watered so that the whole structure set solid without any formwork. This was an excellent idea and its introduction was a planned operation; FAO were involved and selected certain places in the Sudan for demonstrations of this technique. The local people gathered round to see the wonders of the white men who came to fill these sausages and sprinkle them with water. Three years after it had been completed the whole place was deserted with no water in any of these water-retaining structures. Nobody had any interest because there was a Rural Water

Supply Development Commission which was charged with the job of providing rural water supplies and they did not think much of the idea. The lesson here for the do-it-yourself engineer was to first sell the idea to the organization which was locally responsible.

49. Mr T. J. LEONARD suggested that if a consultant tried to sell an idea like this the local people would say "Can you guarantee it?" If the consultant could not, they said "Well, you ought to be able to, so we won't buy it!"

50. Dr MOHANRAO suggested that in developing countries only the application of know-how adapted to prevailing circumstances would bring about any acceleration of the solution of the vast problem. In India a number of slow sand filters were being converted to rapid sand filters because cities wanted to expand their water capacities as their demands were increasing. Water works were originally outside the cities but later were well within the cities and the space available was limited. Equipment manufacturers pushed their equipment, and many new water and sewage treatment plants needed sophisticated equipment which were beautiful for the first six months. After that they did not work as well, since the personnel to keep the simple but sophisticated equipment going were not available. In developing countries highly trained engineers and scientists were present on one hand and the highly unskilled labour in millions on the other, but the intermediate technician who could repair the machine was missing, at least in the numbers required. The simple rule was to keep machinery to the minimum, to keep it as simple as possible and before leaving the place to train people to handle it.

51. Mr CALCUTT agreed with Dr Mohanrao about the unsuitability of sophisticated equipment, but thought that the situation could not be overcome by training alone. His experience of a training scheme in Ceylon was that the major obstacle was not to find people to train and then to train them, but to get senior managers within the organization concerned to demand better performance at the local level. Training had to be used as a tool of management and not to replace non-existent or poor management. In Ceylon he had found that the senior engineers responsible had only agreed that improvement really was necessary by showing them lots of chlorinators that were not working, and it was then agreed that a number of people should be trained to repair and maintain them. When told that it would not be possible to carry out the training until there were some spares this was viewed with absolute horror: "Why do you need spares; You've got the training; isn't that enough?"

52. Mr EL-HINGARI said that an additional problem was the low salaries paid to engineers and managers for work in rural areas, so they went to industrial countries where they could get more money and a better life. The CHAIRMAN suggested this highlighted the need for in-country training.

53. The CHAIRMAN suggested that water could be provided for a much larger number of people by investing in an urban community rather than in low density rural communities who had never had any water. Why could they not wait a bit longer? There was often talk of the poor women, having to walk four miles for water; if they had it nearby, what else would they do with their time?

54. Mr HOWARD thought that a rural community had as much right to water as the town-dweller. In India, there were something like a million open wells, where three to four hundred million people drew their water every day. A pound spent for a village well might be much better value than in an urban community with sophisticated engineering, pumping with various pressure mains and high powered pumps.

55. In his paper Mr Van Damme mentioned that promotion of community interest and participation was essential for the continuing success of any community water supply programme. This was not true in industrial countries, so why was the onus for rural water supply in the Third World laid on every member of the community?

56. The CHAIRMAN believed that the clamour for water did not exist. The clamour was for a higher standard of living, and a higher standard of living meant first industrial development in the developing countries. If an industrialist, maybe only on a simple scale, moved in then it would be possible for the community to have work and some money. With the money they could buy clothes; the clothes get dirty and then they want a water supply. The only way for water supplies to come to the developing countries was by raising their economic standard of living so that they could have some of the minor sophistications of the modern world, which demand that they have water for washing.

57. Mr HOWARD thought that in many places a good water supply was the only way to increase income. The CHAIRMAN said there was a need for more case histories of that. Then the governments of developing countries could be persuaded to invest in water supply.

58. Mr D. ROTHWELL suggested that instead of seeking material wealth through industrial development there should initially be two objectives: to develop the economy based upon farming using traditional skills, and to give

the people a good basic standard of living involving sanitation and supplies of pure water. The CHAIRMAN said they might not want pure water and Mr ROTHWELL replied that education was required.

59. Mr S. WATT said that case histories regarding East African people's demands for water had been reported by White, Bradley and White (1972). The people there had very definite criteria for choosing their sources of water supply, which were based on their own ideas of economics and hygiene. These might be mistaken from a European viewpoint, but they should not be ignored.

60. Mr MOFFAT described how he sited boreholes, using other than geological means. He walked round the village and looked at all the existing wells scattered around to find out the most convenient place to put a borehole for the nucleus of the village. He then carried out a resistivity survey to find whether a borehole at that site would have any success. A few hundred gallons an hour at a convenient place was much better than 20 000 gallons an hour somewhere over the hill where no-one would go. As a result most of the boreholes he put down were used quite extensively. Frequently they were near the market place or in the vicinity of the chief's residence. When boreholes were put in markets they tended to improve and the number of people attending increased in a short time.

61. Mr EL-HINGARI said that sometimes the water already available in the village was the best because the people were used to it, even if it was polluted. If an outsider came to their village he might become ill by drinking it, but the villagers usually did not want any other water. Some water had as much as 2000 mg/l dissolved solids.

62. Mr ROTHWELL commented on criticism of public standpipes, saying it was better to have such a system than to rely upon a river polluted by people using it as a latrine. Where there was a limited supply of money the public standpoint was not as good as a supply in each home but at least it provided the first stage, a pure supply of water.

63. Dr MOHANRAO agreed that water inside the house from a tap would be worthwhile, but when money was short perhaps the second alternative was the public standpipe. Although it was not enough to have clean well water when there was a chance of its getting contaminated between the standpipe and the home it was sometimes possible to put groundwater into the houses through pipes. In ancient days most Indians used to carry drinking water in copper urns, which partially disinfected the water.

64. Mr P. K. JAIN said that Indian villages' uneducated masses did have a concern for their water; sometimes they even worshipped wells. There were people who strained water for drinking all their lives and pitchers were never touched without washing hands. The water obtained from a shallow village well had deteriorated during the past fifty years and villagers did not readily accept that the quality had deteriorated bacterially.

65. Mr VAN DAMME wondered whether technology was not important at all. Should WHO continue organising expert meetings so that the technology was further developed, or go more in the direction of sociology and promoting associations and societies? Was it important to erect pilot plants with education courses and seminars so that everybody could see their value.

66. Mr ACHESON said that the technologies for dealing with these matters were known but the basic problem was making the people accept technologies which were available. An incremental approach towards acceptance of these technologies was needed, involving four steps. First, develop means for rural people to express their choice regarding improvements; secondly, allow initial steps towards the improvement without the commitment of heavy investment on their behalf; thirdly, permit the village communities to develop their operational capacities to use the installations and to appreciate the benefits from them; and fourthly identify areas where technological research and development could continue for the improvement of these water supplies. A balance had to be made between access to really safe water and merely providing greater access to safer water than people had now.

67. Mr EL-HINGARI suggested that since the effect of polluted water was usually long term, it was very difficult to justify to the people why they should or should not drink this or that water. Most experts in undeveloped countries did not know how to communicate with the villagers, who normally did not listen to what their government said. The CHAIRMAN suggested that in Libya for example, the quality of the water that was supplied was probably decided more by the influence of tourism than local demands.

68. Mr JAIN emphasized the valuable work done by the World Health Organization and the CHAIRMAN thought WHO believed that the raising of economic standards was the first thing to strive for. For a long time it was WHO policy that a water supply and a sewage scheme should be provided at the same time, but they had been forced by economic circumstances to accept that water

supply should go in first. However, possibly damage to the population from not having a decent sewage disposal scheme was greater than that from inadequate water supply.

69. Mr D. BELCHER wondered whether engineers had taken over the role of the medical missionary of a hundred years ago. The medical missionary took in a social side as well as medicine; a course in Sociology as well as Public Health Engineering was required so that the engineer could deal with people in Governments and at local levels.

70. However as a consultant he found great difficulty in using local materials for specific jobs. He found great difficulty in any country in finding what was available. It seemed that many solutions had been suggested, but the available information was not getting down to the grass roots, not to the people who were making the profits. Institutes such as Loughborough University had technological information about new ideas, but it was necessary to pass this on to the World Bank and the British Government who were providing money. It seemed to be a lack of communication between the people who were thinking of new ideas and the consultants who were having to put them into regular use. The CHAIRMAN added that one of the essential functions of the International Reference Centre was to inculcate the idea at least in the universities in the developing countries that there were problems in the local community water supply, so that graduates would think of using local materials and would develop appropriate technology.

71. Mr BELCHER thought that many consultants had information which they did not pass on, possibly because of their profit motive. Individual consultants had learned by making the same mistakes as others before them. The Chairman again referred to the International Reference Centre and added that Loughborough University was becoming a clearing house for information of this kind. Mr BELCHER thought engineers needed a greater sense of vocation when working abroad.

72. The CHAIRMAN said that it seemed the last speaker was orientated in the way intended for the Conference - looking at the broader picture as well as the detail. He congratulated participants on the discussion which was based upon Mr Van Damme's excellent paper.

MILES DANBY

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

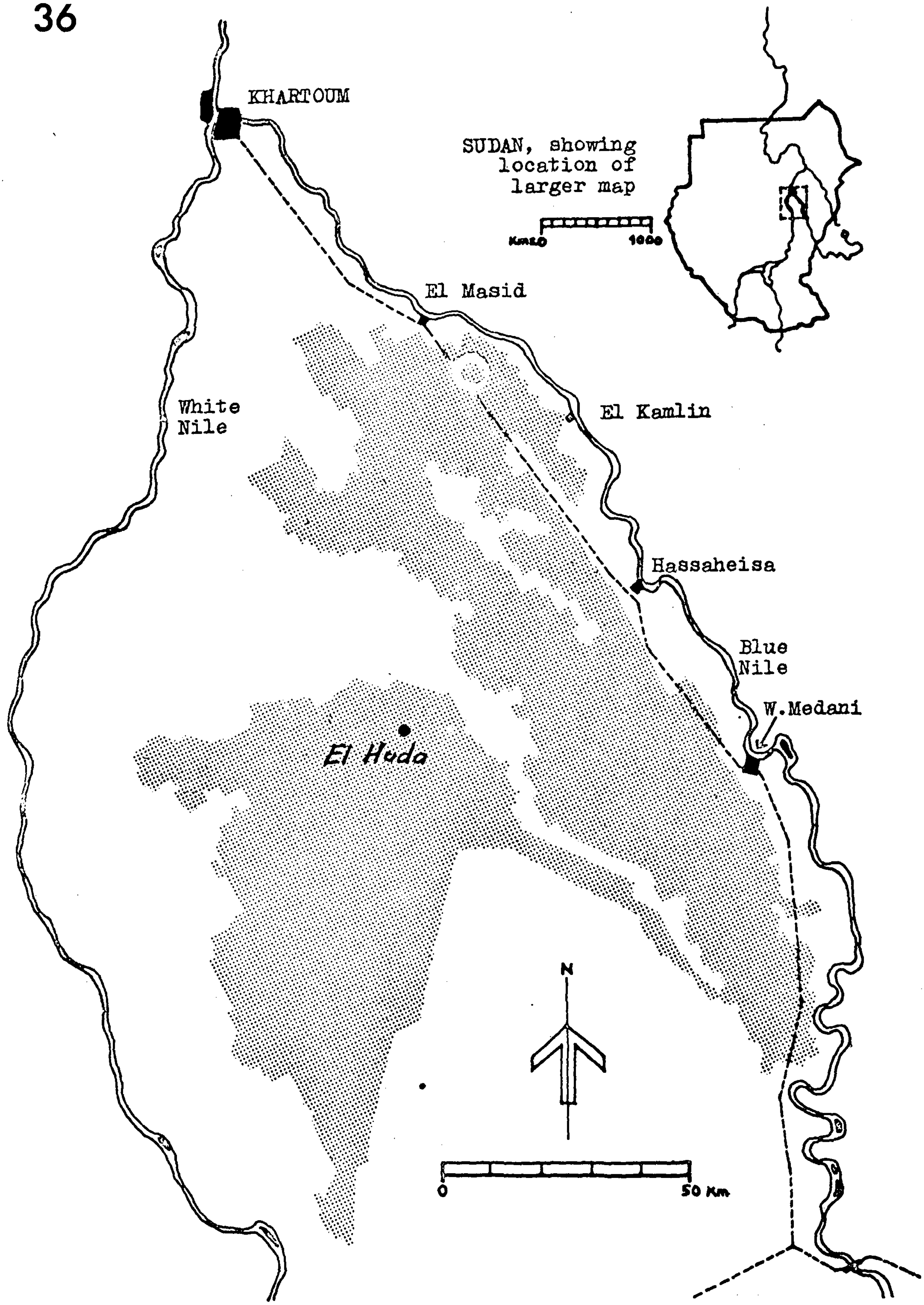


Figure 1 The Gezira Scheme including Managil Extension

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 2½ and the remainder left fallow. Plots of vegetables, groundnuts and wheat also are frequently grown and to an increasing extent.

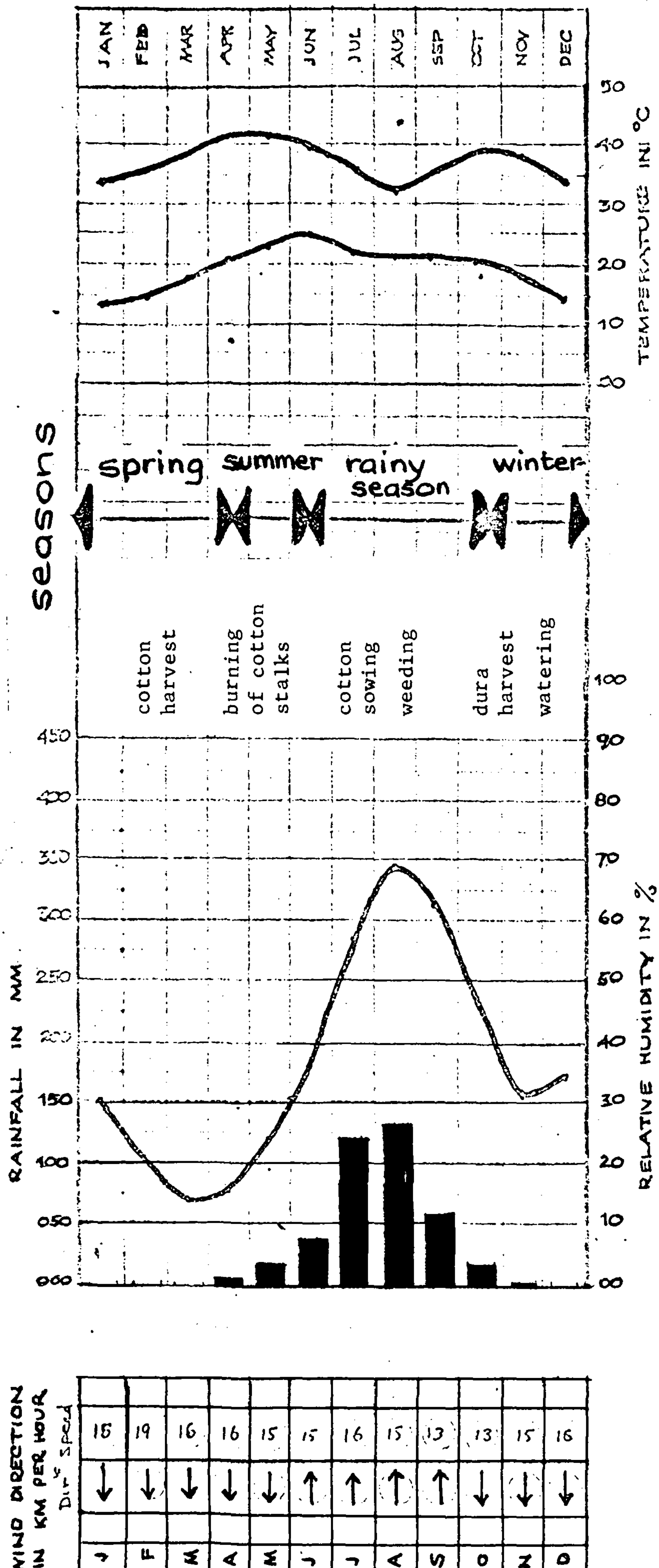


Figure 2 Seasons and Climatic Data - Gezira

COUNTRY: SUDAN
LOCATION: GEZIRA
ALTITUDE: 405 M.
LATITUDE: 14° 40'
LONGITUDE: 33° 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

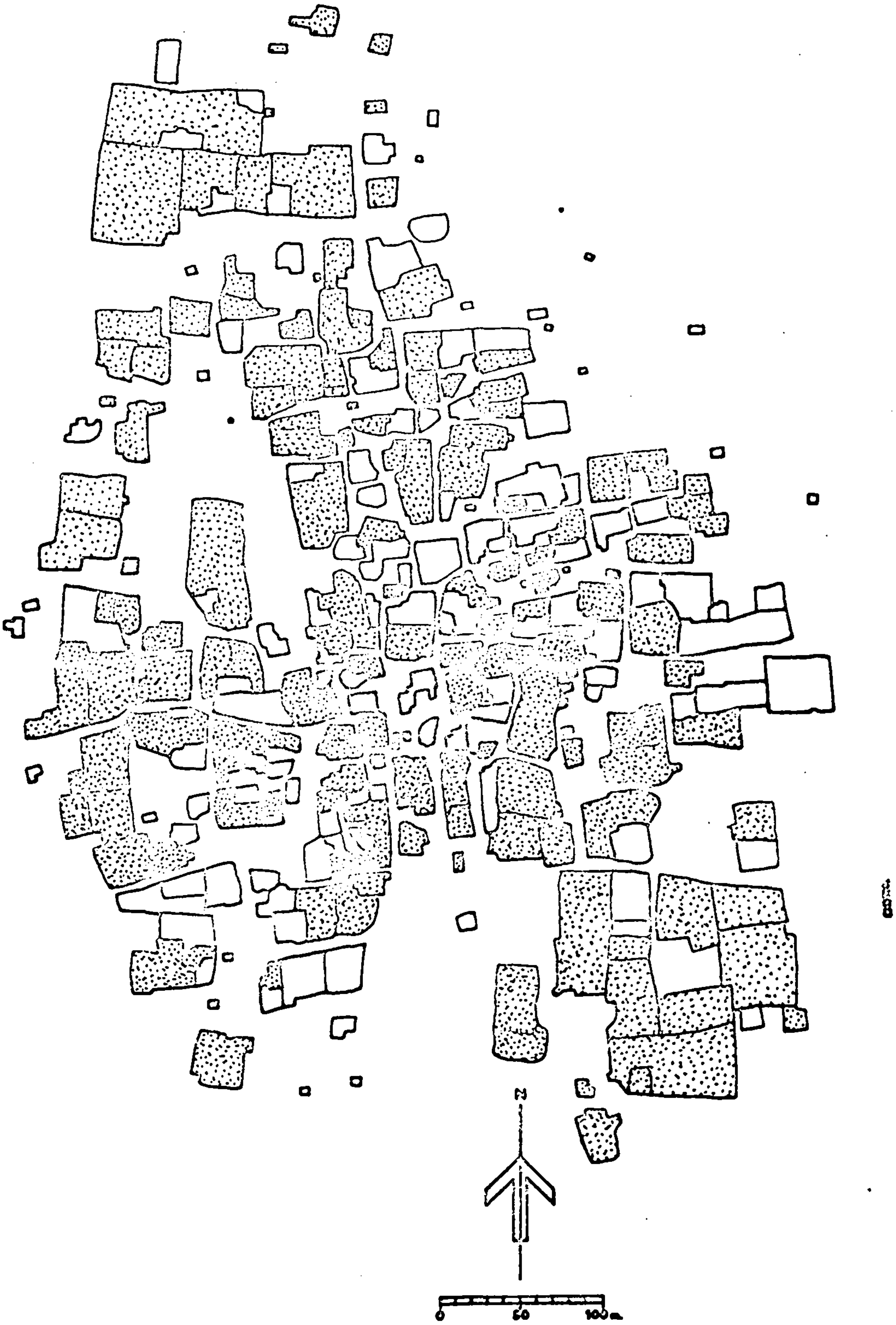


Figure 3 Plan of Gezira village (Udeid El Bashagra) tenant households shown dotted

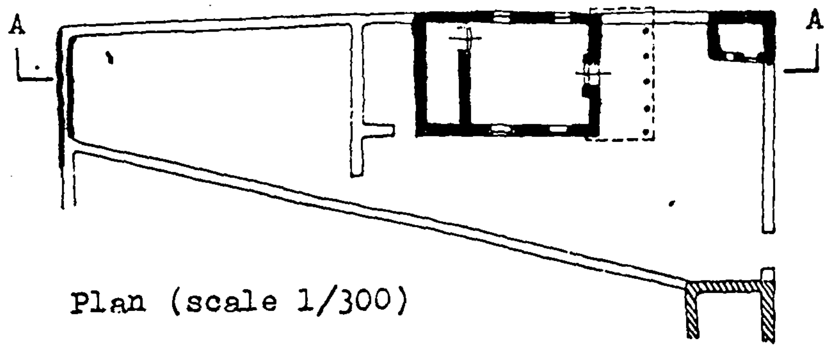
no tarmac roads except for the main road from Khartoum to Wad Medanî, the remaining roads are usually tracks following the pattern of canals and as the soil is predominantly of the black cotton type, they are impassable during the rainy season; even four wheel drive vehicles have considerable difficulty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

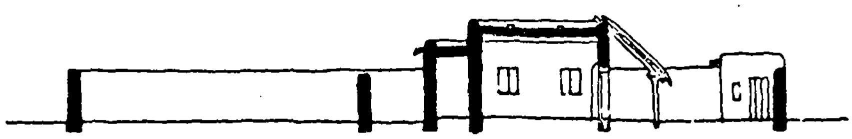
The square plan provides a room of approximately 4.60 meters square usually with one door and four windows. Rooms of this type became very popular in the 1940's and soon replaced all those of a circular plan. The walls are built of mud and timbers support thin branches which in turn carry a layer of 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.

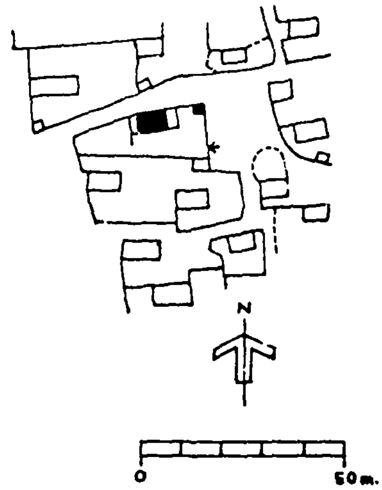
There are, of course, many variations in the combination of these elements. A study carried out by students of the University of Khartoum in 1963 on a group of villages known as Beshagra revealed seven basic types of room arrangement. The majority of rooms belonged to the first four types but a tendency 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

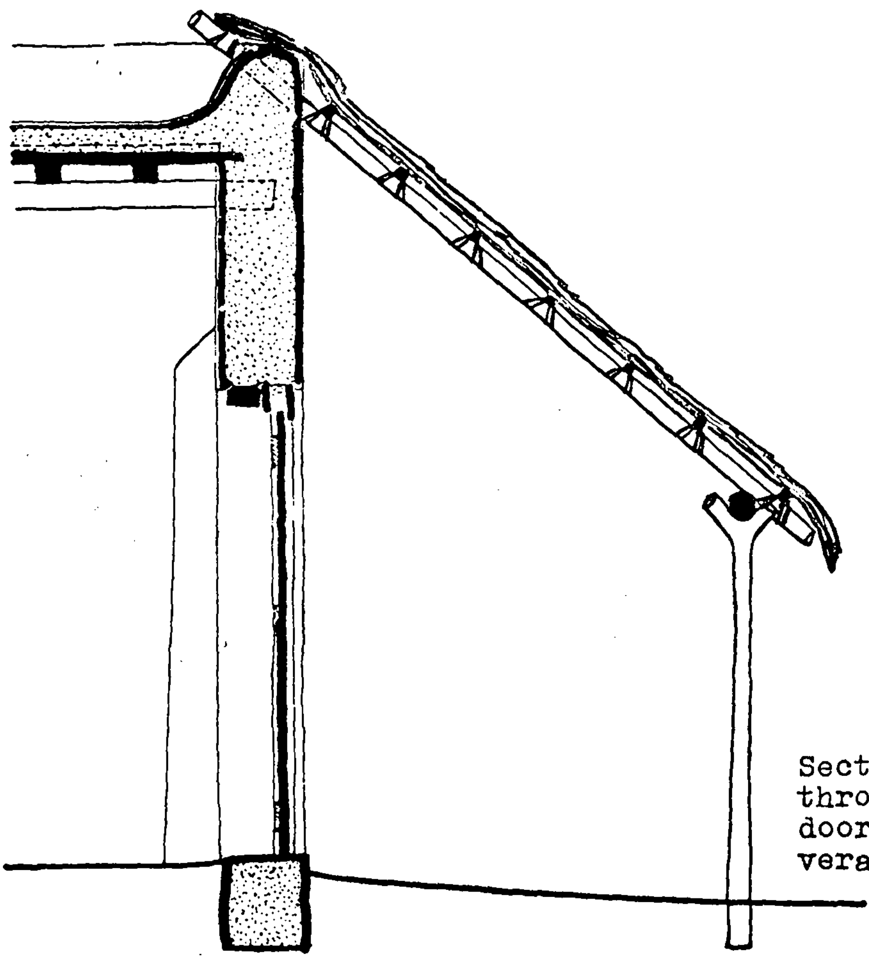


Plan (scale 1/300)



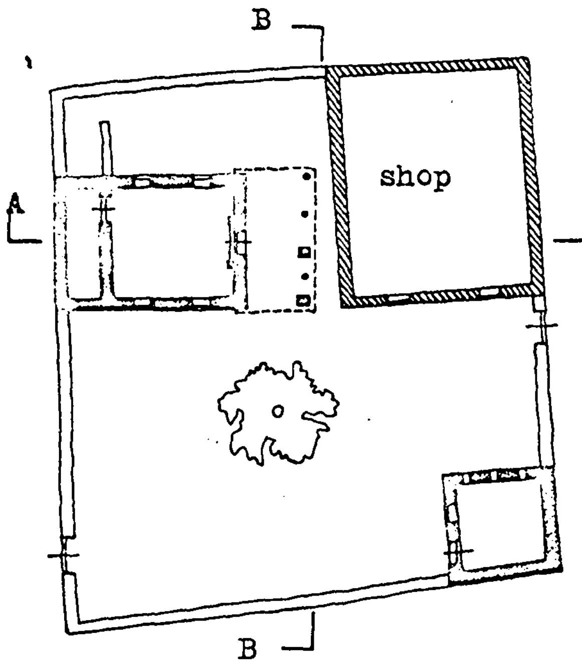
Section A-A



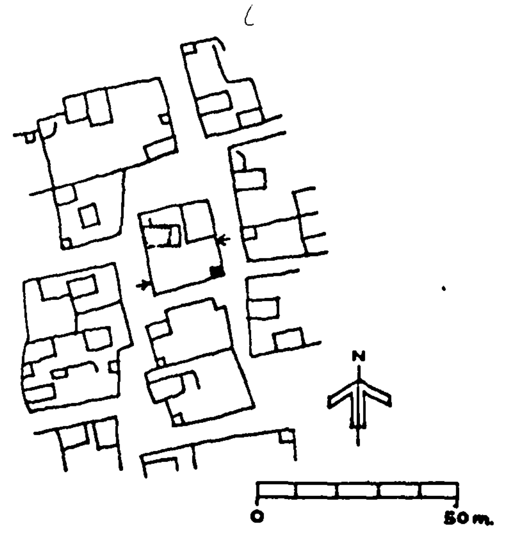


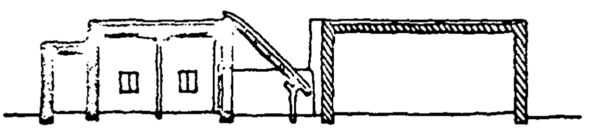
Sectional detail through the main doorway and kashasha verandah (1/30)

Figure 4 Typical dwelling of Jalous construction



Plan (scale 1/300)





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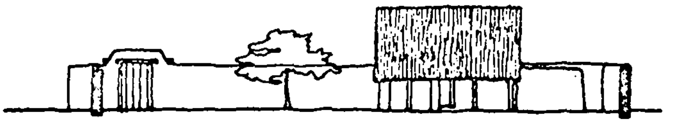
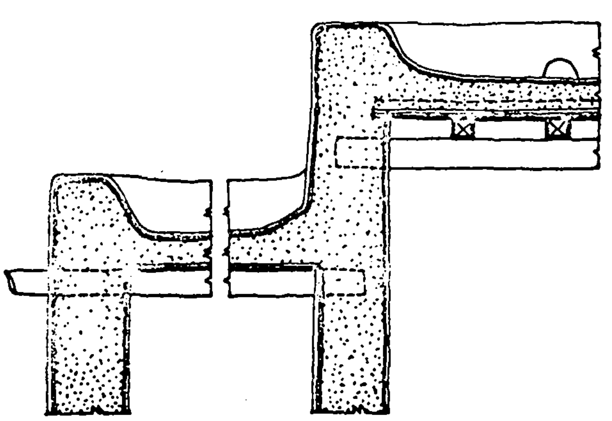


Section B-B



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.

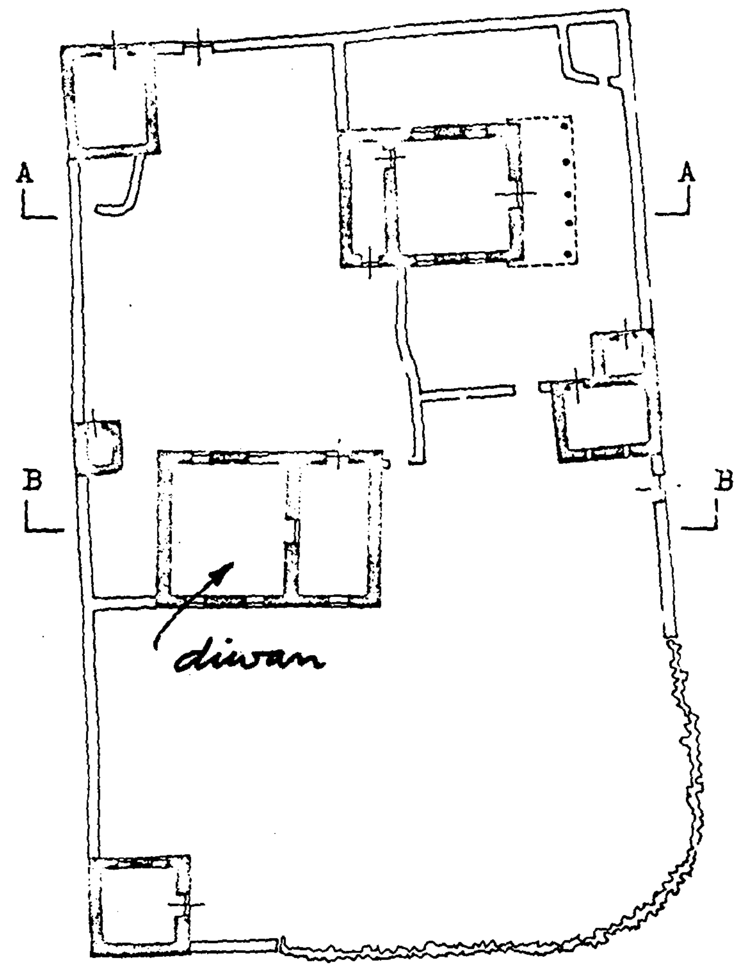
There are many difficulties involved in mud construction and the average life of jalous is about ten years although in exceptional cases such buildings can last up to 25 years. As these buildings usually have no foundations of any kind, they are vulnerable to ground movement in the black cotton soil 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 waterproof 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.

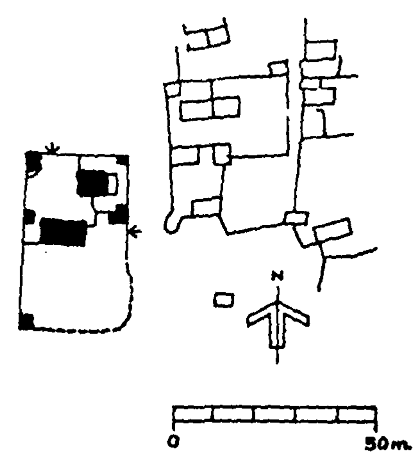
An alternative and more durable method of house construction has been developed but unfortunately it is rather more costly than jalous or mud brick. This method is known as Gishra and is a combination of mud bricks and burnt bricks. The burnt bricks are used as external facing and for the parapet walls 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.

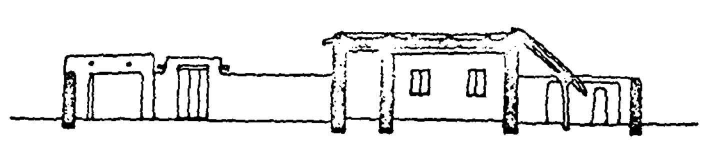
Buildings built mainly from Government sources, like schools and houses for officials and teachers, are built with solid burnt brick walls (one and a half bricks thick) laid in sand cement mortar with roofs of G.C.I. These are the most permanent buildings in the Gezira and are usually built by contractors 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

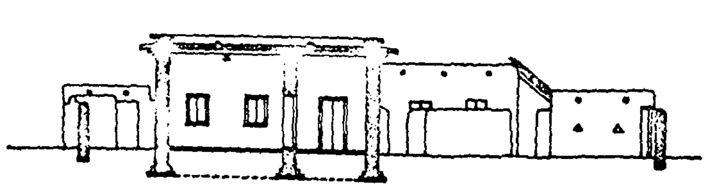


Plan (scale 1/300)



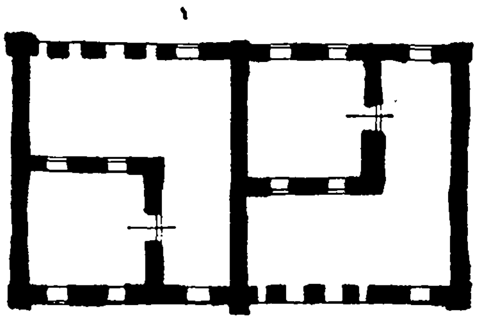


Section A-A (Jalous)

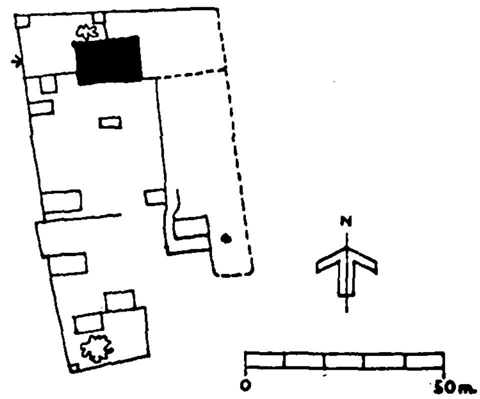


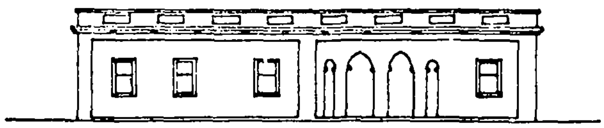
Section B-B (gishra)

Figure 6 Plan showing dwelling with diwan in gishra construction

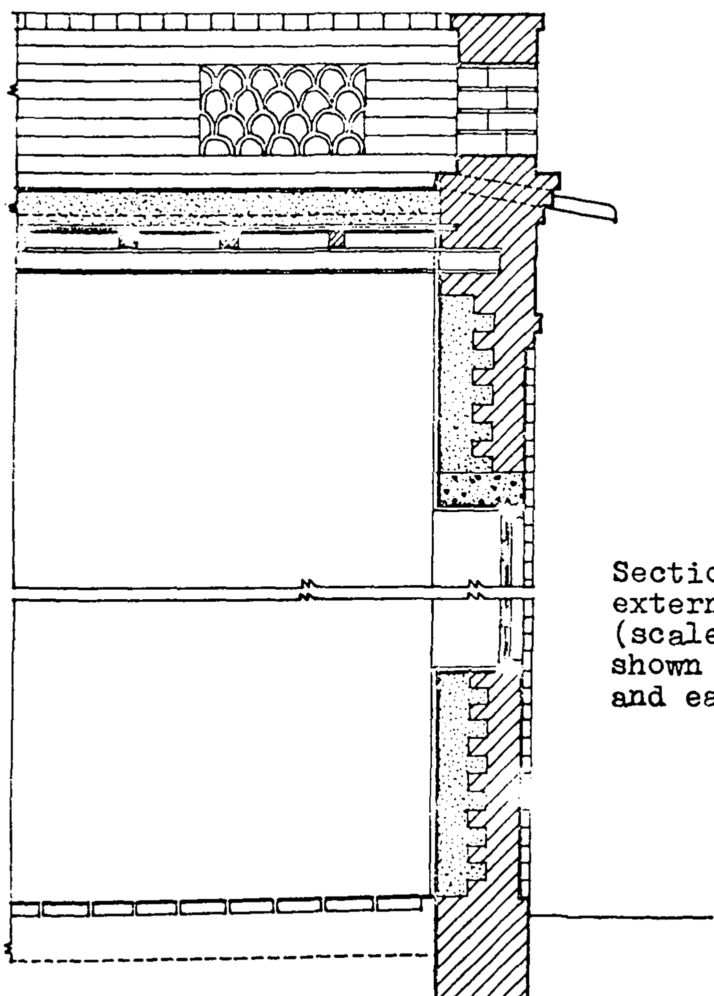


Plan (scale 1/300)





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.

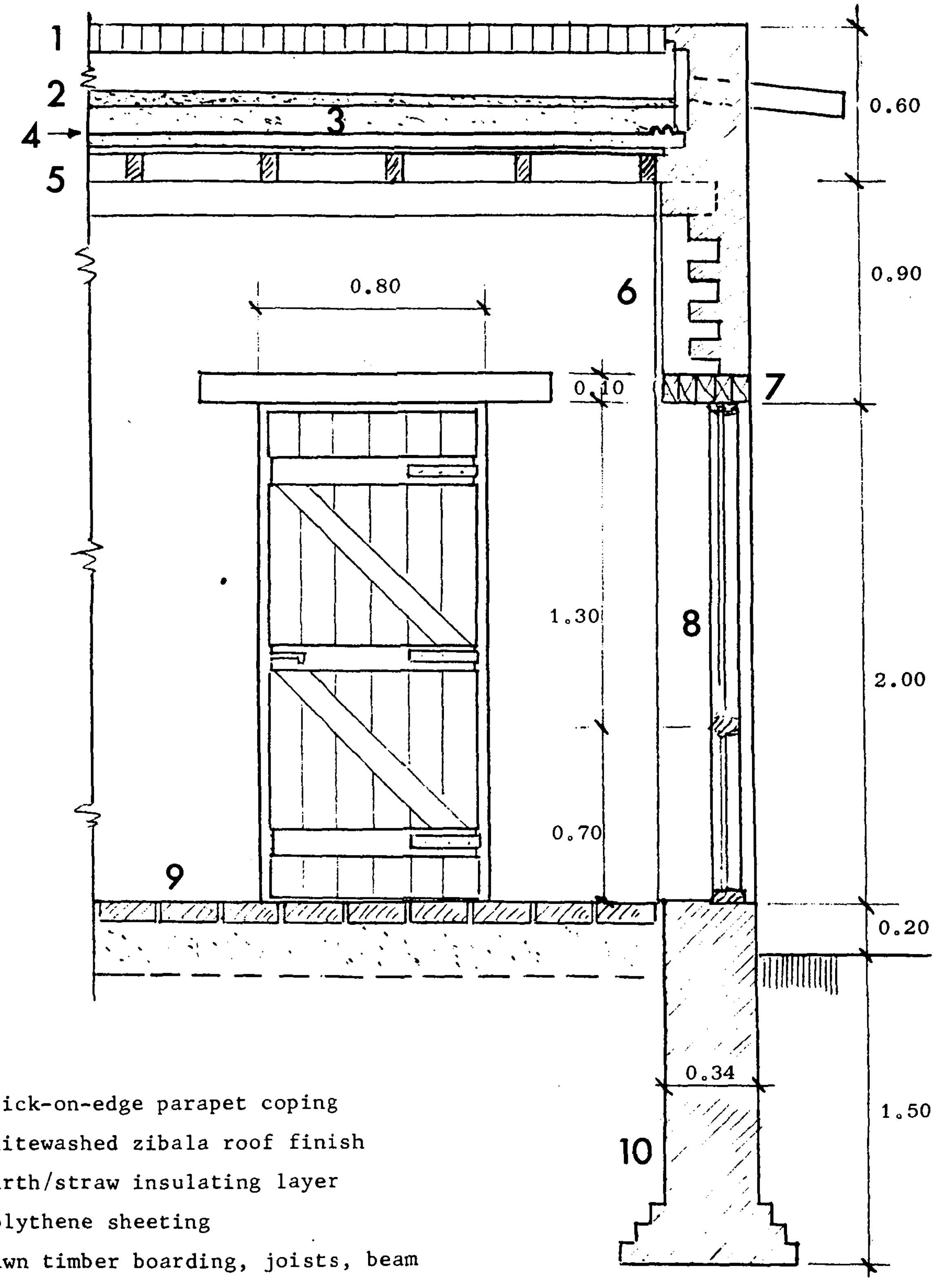
With relation to house construction methods, an experiment was financed by the Sudan Gezira Board in 1963/64 at a village called El Huda in the Manaqil extension of the Gezira scheme. El Huda was designated as a centre for public service for the surrounding district and as a result had grown in population 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.)

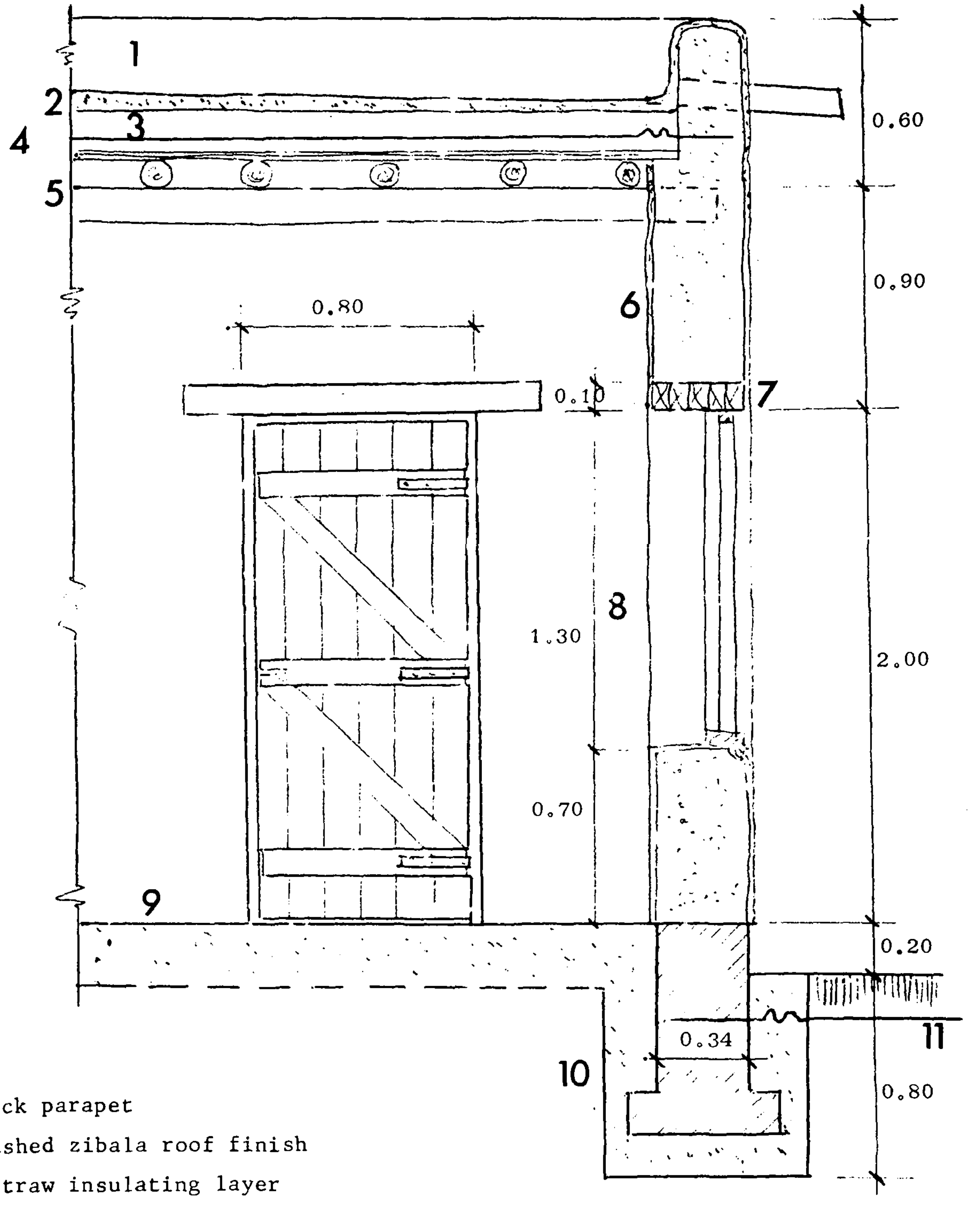
The trial houses were built to the same orientation with family verandah placed to obtain optimum through ventilation and shading by its roof and adjacent room from the south-westerly sun as it is used mainly during afternoons and evenings. The stores, latrines and washrooms were placed against the hosh 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

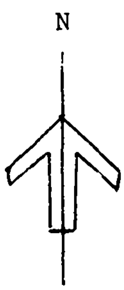
Figure 8 TYPE 'A' CONSTRUCTION
Typical Section Scale 1/25



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

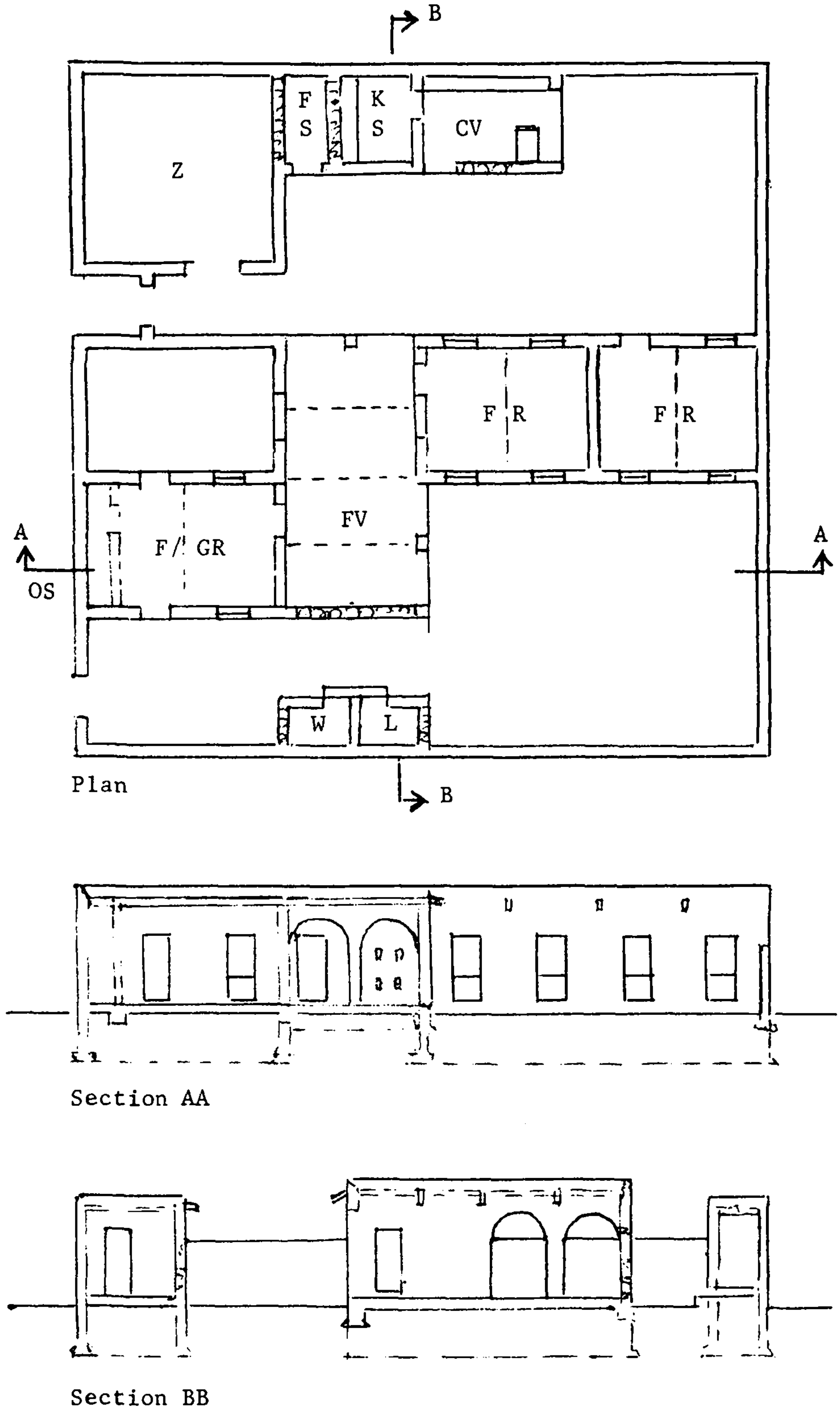


Figure 10 HOUSE PLAN WITH TYPE 'A' CONSTRUCTION
Scale 1/200
All stages shown completed

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.

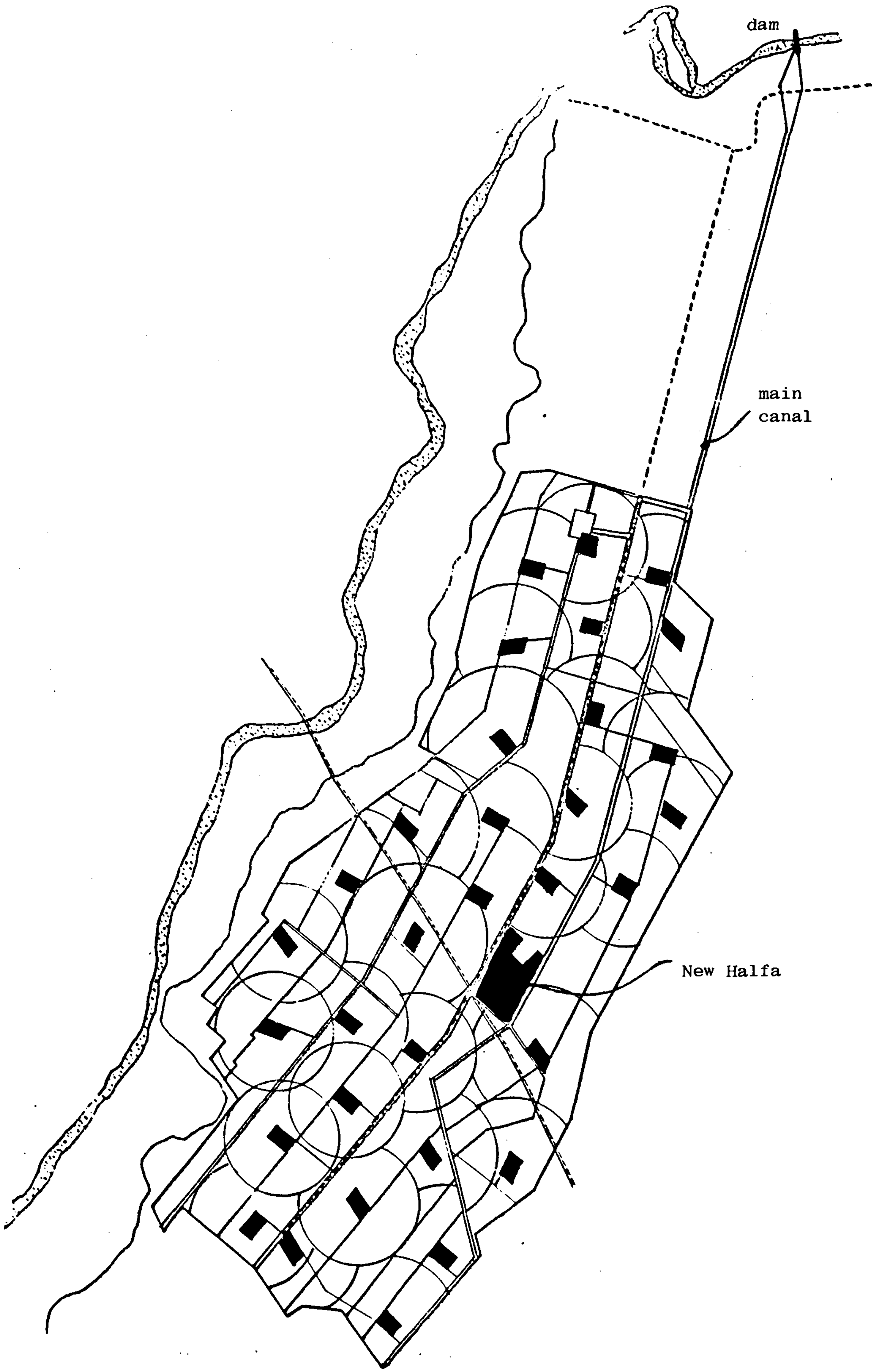


Figure 11 Layout of Khashm El Girba showing villages as built

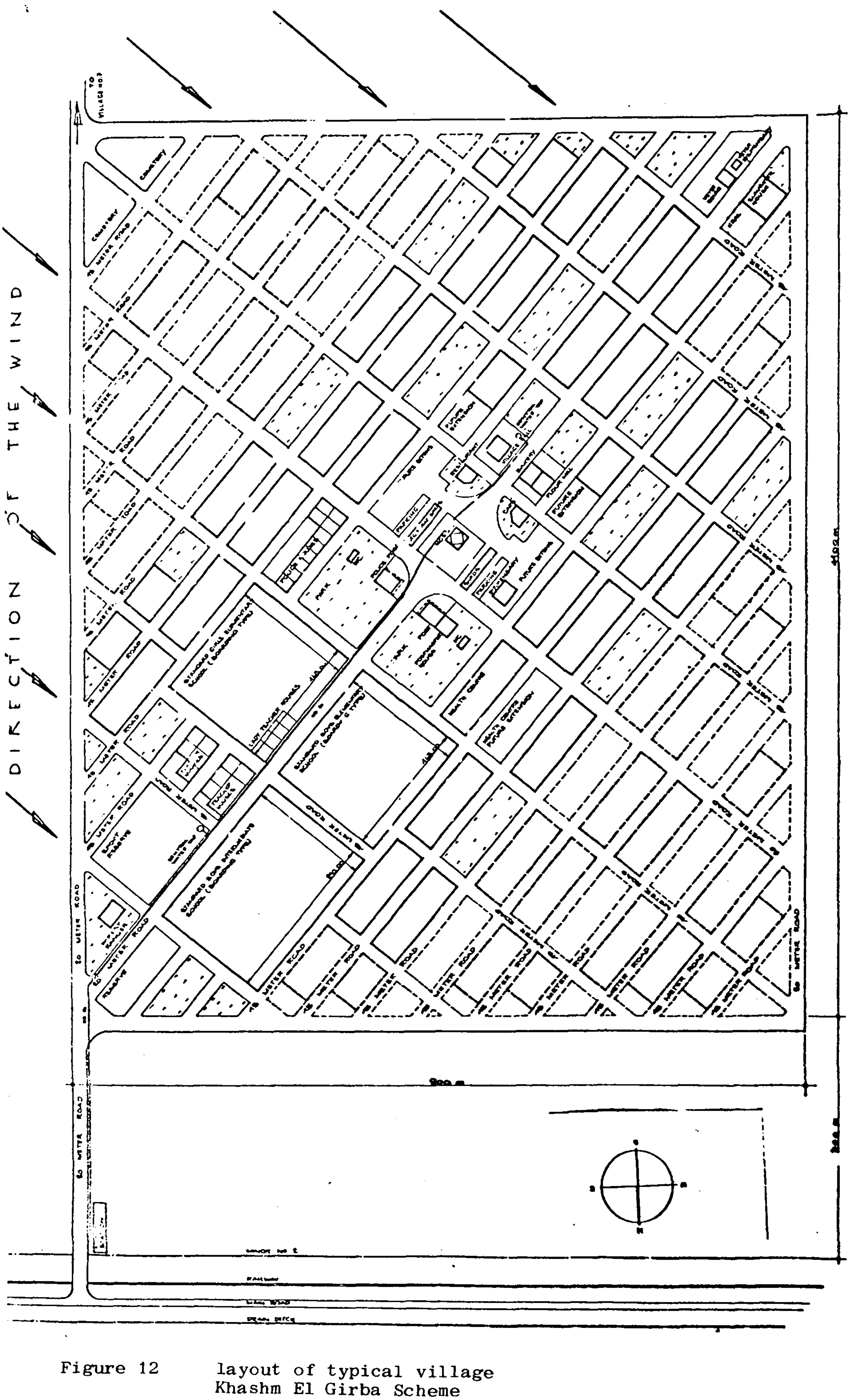


Figure 12 layout of typical village
Khashm El Girba Scheme

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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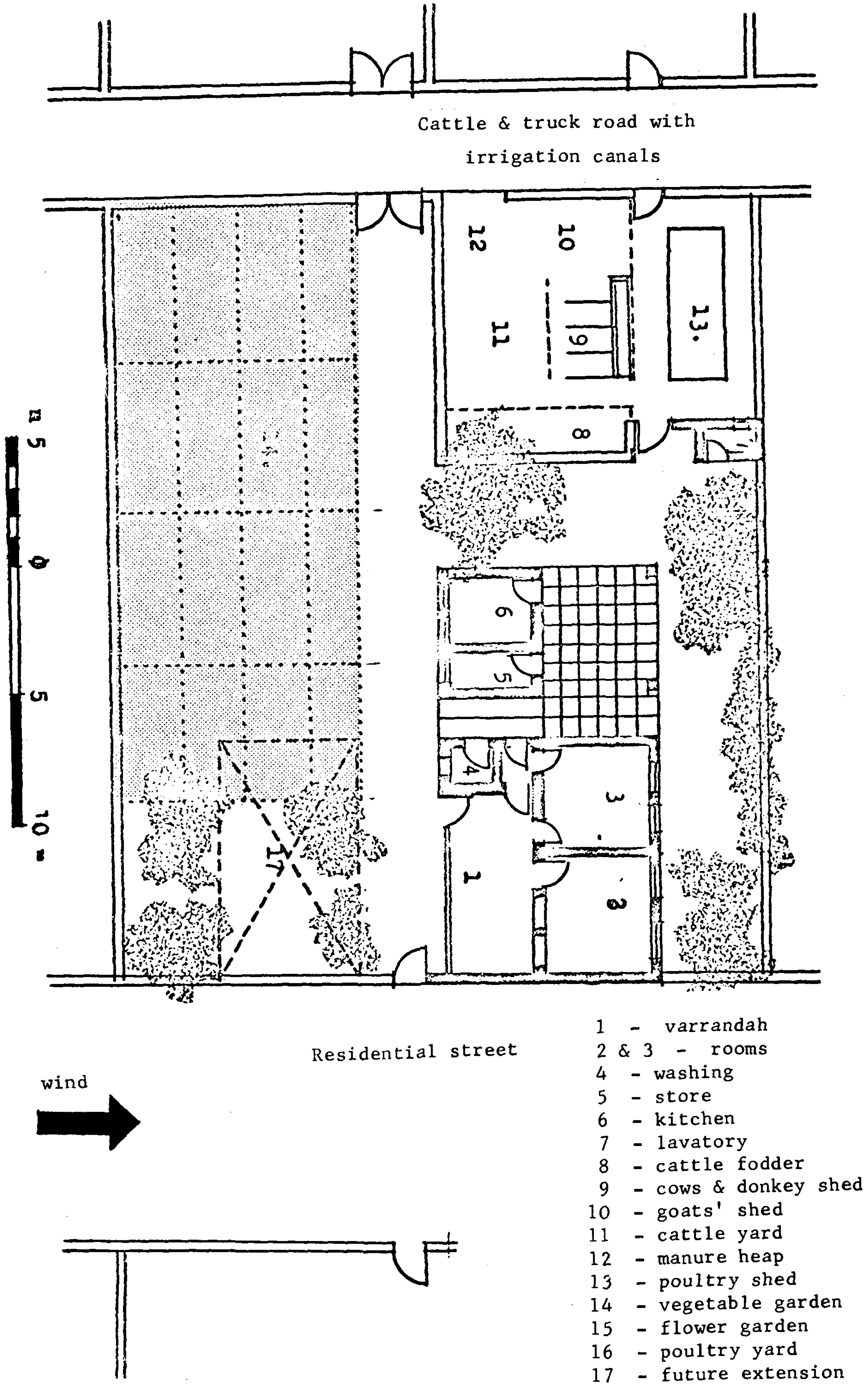


1 - varrandah
2 & 3 - rooms
4 - washing
5 - store
6 - kitchen
7 - lavatory
8 - cattle fodder
9 - cows & donkey shed
10 - goats' shed
11 - cattle yard
12 - manure heap
13 - poultry shed
14 - vegetable garden
15 - flower garden
16 - poultry yard
17 - future extension

Figure 13 Suggested Farmstead Layout (Kadic)

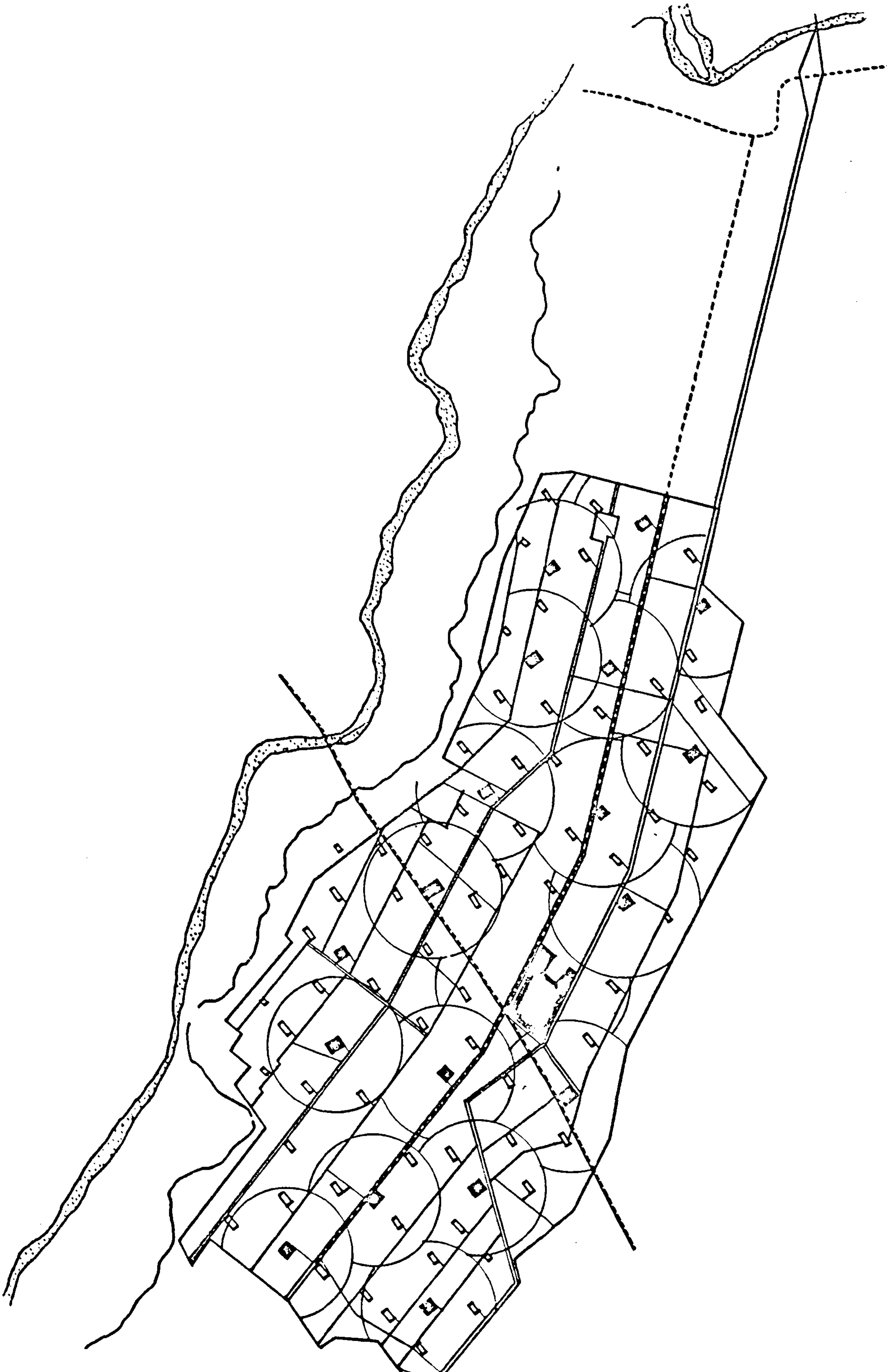
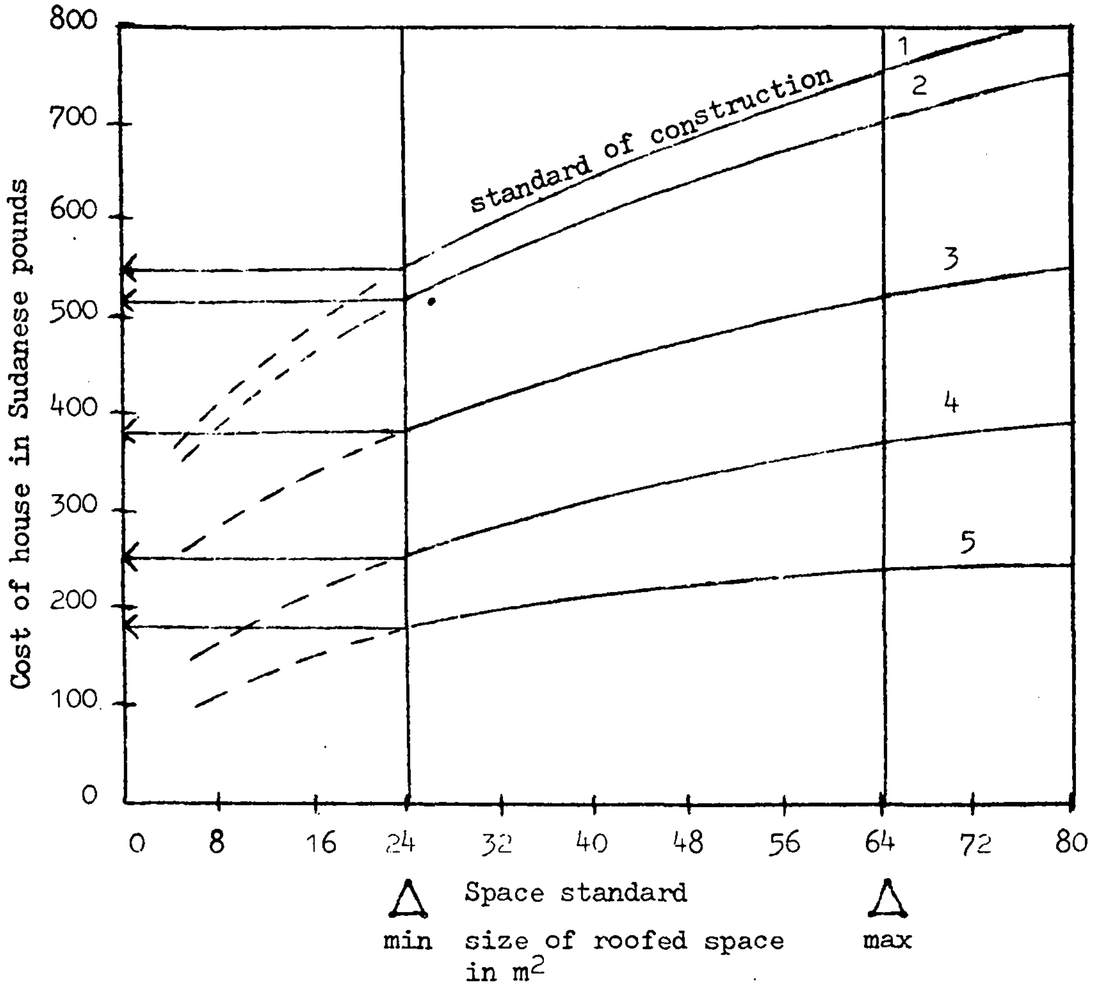


Figure 14 Khashm El Girba Scheme - suggested layout by Kadic



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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discussion

CHAIRMAN: R. G. ALLEN, BSc, PhD,
Director, Water Research Association

Professor M. W. DANBY said the subject was so daunting and wide that he did not know where to start, but decided that the best way to handle it was to look at a specific case. The irrigated area of the Sudan was a very suitable case for this Conference because the irrigated lands of the Sudan would not exist without artificial means of getting water there; previous to the irrigation system there was only a nomadic existence.

2. Professor DANBY showed maps of the area and the village area that was investigated by a combined inter-disciplinary team of architecture, sociology and economics from the University of Khartoum. Before irrigation there were two types of houses, a rectangular type and the circular type which was predominant. An aerial photograph of a village in the Gezira showed the very strong contrast between the geometric rigidity of the government-controlled part of the environment (the irrigation canals, the layout of the land and the civil servants' housing) and the rest of the community which was somewhat ramdom and for that reason rather superior to the rest of the environment. In all cities of the world as well as rural areas people left to build for themselves often made an overall job of the environment which was superior in some ways.

3. The irrigation scheme was intended to produce more cotton in order to produce more wealth in order to improve living standards generally. One of the important decisions in a scheme like this was to decide the optimum size of a tenancy. A rather large optimum size of tenancy was chosen in Gezira and therefore the tenant and his family were unable to do all the work required and there was a need for itinerant labour. This particular area of Sudan was strategically placed on the way from West and Central Africa to Mecca, so a large number of people from Nigeria and Chad and other parts of Africa settled there en route to or from Mecca.

4. A plan of one of the Gezira villages showed a variety of space; there were narrow paths which occasionally opened up for a variety of reasons - one family built a house larger than another and so on. Generally speaking motor vehicles could not get through and motor transport was not widely used; the usual method of transport for most people was by donkey. Usually vernacular or traditional architecture in most parts of the world met the climatic requirements. At El Huda some attempts were made to build pilot houses improving on the traditional methods of construction; simple rectangular houses had kashashas (shading devices) attached. The basic unit was a square room about 4½ metres square with the store room on one side and usually the shading device on the other side, and the houses were built up with this unit. In this part of the Sudan most people slept out of doors, and cooking took place out of doors. In Khashm El Girba the government built houses had rooms labelled on the plans as 'kitchens' which were never used as such. It was important in the design of a house in the Sudan to allow for animals by providing an enclosed area traditionally known as a zeriba.

5. Mud construction was not very good at standing up to driving rain and had foundation problems especially on black cotton soil. Zibala, the traditional Sudanese method of coating the outside of mud walls with a matured mixture of selected earth and donkey dung, produced a very beautiful texture, and was satisfactory from the thermal point of view. Unfortunately the price was rising sharply because experts from the United Nations told the people how they could improve their crops by using donkey dung. A slightly better type of construction - the gishra - involved the use of burnt bricks, sometimes in combination with mud bricks. Traditionally they used mud mortar which tended to be eroded and there was now an attempt to introduce mixtures of mortar using a small amount of cement.

6. A water tower and standpipe often indicated the centre of the village and it was important for planners of new villages to co-operate with water engineers, because the placing of a standpipe often dictated further development in the village.

7. Other points in the design of houses were the demand in a Muslim community for a separate entrance for male guests so that they would not come into contact with the ladies of the household, and the importance of the doorway.

8. Professor DANBY asked for suggestions regarding the use of soapy waste water in water-scarce areas. He had noticed that canna lilies grew well in pools of waste water in courtyards of houses, but had been informed by a botanist at the University of Khartoum that no plants would grow in such water!

9. The new town of New Halfa was sited strategically on the crossing of two roads and there were twenty-six satellite villages. The houses were relatively expensive, well over a thousand pounds each, because there was compensation money available from the Egyptian government. Professor Kadic from the University of Sarajevo in Yugoslavia was Visiting Professor in Khartoum for a few years and became very interested in the problem of houses in the rural environment. In a Paper he made a whole series of suggestions of how rural houses should be related to the vegetable garden, the poultry shed, the manure heap and so on and how the layout of roads should also be related to streets. Irrigation canals should be integrated; often it was assumed that irrigation was only for fields and not for people's gardens or to improve the centre of the town. Kadic was also rather critical of the idea of having one town and twenty-six equal-sized villages; it was more logical and easier to have a hierarchy of villages with three or four smaller villages gathered round a larger village which would include more expensive services like schools and clinics which could not be afforded if you had twenty-six equal villages. In the initial stages of Khashm El Girba the villages were even known by numbers and as they were of equal size they all looked identical.

10. Professor DANBY turned to some of the basic problems that anybody concerned with housing had to face, starting with squatters' housing. Many people had the idea that people should not be allowed to put up shacks; they must be cleared away and the government should build houses in neat rows so that it all looked clean and tidy. The possibility of being able to do this in most developing countries was completely out of the question and somehow ways had to be found to encourage squatters to improve the houses they built themselves, to help them get a satisfactory layout, to ensure that a water supply was put in the best place and that a market was developed in the right place.

11. Dr Bedri Elias when studying at the University of Edinburgh, had looked at economic aspects of housing in urban areas in the Central Sudan. He postulated a minimum and maximum size of roof space that you should have and the cost of the house enclosing that space in five different methods of building, and then worked out the percentage of families who could afford the minimum standard. Thus 92% could afford the mud house; with improved mud bricks the figure was 75%; red bricks and cement mortar (which is the gishra type of construction) 55%; hollow blocks 52%. As this was for urban areas, Professor DANBY thought it was utterly impossible to house large numbers of people in rural areas using modern methods of construction. So squatters building their own houses were doing themselves and the community a service, and all that government could do was to see how these people could help themselves in a better way.

12. In Port Sudan the Ministry of Housing tried to upgrade the squatter settlements and introduced water supplies. Initially authority reaction naturally was to clear the squatters away as the settlement was unauthorised development without planning permission. The squatters were living without water, low health standards and were bringing a burden to the ratepayers and so on. But just to clear them away when the Authorities were powerless to produce the required number of houses anywhere near was no answer and the only alternative was to look at their situation and try to help them in some way.

13. Finally Professor DANBY referred to his postgraduate course on Housing for Developing Countries at the University of Newcastle upon Tyne. One of the disappointments to date was that no Civil or Public Health or Water Engineer had joined the course to do a study of the relationship between housing and the engineering infrastructure.

14. Mr R. W. ADAMS said he was in Hong Kong in the 1960s when there was no rain and water was supplied for only one hour every three days. He had filled his bath, used the water for three days and then used the waste on tomato plants; it was the most marvellous crop he had ever seen, so it was quite certain that the use of waste water was possible.

15. His section of the Property Services Agency built accommodation for the armed services overseas. Although the opportunities for doing this are diminishing rapidly, work was still being carried out all over the world. He asked whether Professor Danby could suggest simple methods of cross-ventilation in buildings and to comment on the use of solar energy.

16. Professor DANBY said that a traditional way of obtaining through-ventilation was by use of a suitable cross-section such as that shown in fig 16(a). It was, of course, important

to ensure that the windows at 'A' could be shut and made rain-proof. A lay-out like that shown in the plan of fig 16(b) could also be used. In hot dry climates through ventilation was generally not desirable.

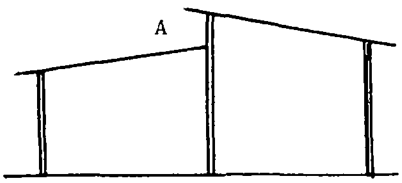

fig 16(a)

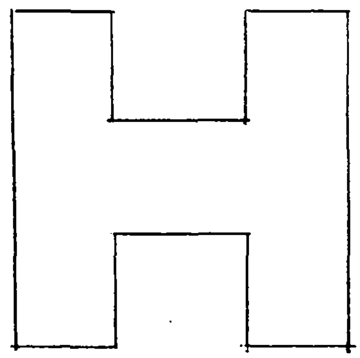

fig 16(b)

17. There had been fairly successful attempts to heat water by solar energy using simple apparatus, like putting a tank on the roof and painting it black. Experiments were carried out at Khartoum trying to turn machinery by solar energy, but this never became very workable. As an architect Professor DANBY spent much of his time trying to disperse solar energy and was never able to use it fruitfully!

18. The CHAIRMAN said that even the Water Engineer in Miami, Caesar Wertz, lived in a ranch-type house where all his water was heated with a black shallow tank on the verandah.

19. Professor DANBY suggested that there was no reward for the professionals who ought to be involved, the environmental engineers, in producing efficient solar energy equipment. Often consultants and aid agencies installed useless machinery in developing countries; this particularly applied to hospitals. The difficulty was to finance an adviser to say "you shouldn't be putting two horse-power air conditioners in every window". It was in everyone's interests to reduce energy consumption and it was absurd to go into a very hot country like the Sudan or Pakistan and design a modern house, and then build a dam or a thermal power station and make electricity and then put air conditioners in!

20. Dr G. J. MOHANRAO suggested that it might be possible to use the solar energy during the day time and convert it to some form of electrical energy which could be used for lighting at night.

21. The CHAIRMAN enquired whether lighting was a problem in the buildings Professor Danby had described because they required so much shade to keep them cool that it must be dark inside. Professor DANBY said that his office in Khartoum had shutters closed most of the day to prevent the sun shining straight onto his desk. He had checked the illumination with a light meter and found it was insufficient for a corridor according to the standards of the Institution of Electrical Engineers. In spite of this, he had found his office to provide a perfectly satisfactory working environment.

22. Mr W. S. MOFFAT referred to old houses in Dubai which had a tower on the roof which induced a breeze to the room below. Professor DANBY said it was still used in Iraq and in Pakistan. There was also an intermediate mechanical solution known as the desert cooler which was basically a large tin box containing a water pump and a fan and a spray of water passed over a filter made from shredded timber. Dr MOHANRAO said evaporative coolers were used in India, especially in the dryer parts. They used an exhaust fan and a reed material which was grown in India. Water was usually recirculated and the air temperature was reduced by as much as 20°F.

23. Mr PICKFORD said that in south Israel solar energy was used for water heating. On practically every house there was apparatus consisting of a tank and a sloping radiator.

24. Mr J. C. HOWARD said Oxfam had been involved in building some thousands of low cost houses but the poor needed a no-cost house! Soil-cement blocks had proved to be successful; Oxfam supplied the materials and simple block-making machines. On cotton soils it had been found that simple piles augered into the ground provided good foundations as the cotton soils moved under continuous foundations. Also whitening of the walls of buildings in high temperatures made a very marked difference in the living conditions inside the house.

25. Professor DANBY said that in his paper he mentioned that at Huda they experimented with landcrete blocks but for various reasons could not find the right mix and abandoned the use of landcrete. Everybody seemed to have a different idea of 'low cost' housing. The Gezira housing had virtually no cost. The Khashm El Girba housing of course was

relatively high cost. The intermediate, the Huda housing, was low cost by most means of comparison. He agreed with Mr Howard's comments on the foundations in black cotton soil, and continuous foundations were not satisfactory. Although it was not low-cost housing, some buildings for the University of Khartoum had virtually no foundations; the structure of the building was treated as a sort of three-dimensional box girder sitting on the ground waves so braced that the box would move but keep in one piece without the formation of cracks.

26. Mr A. H. EL BEIK had noticed that Professor Danby had shown two types of roofing - the conical and the flat. The conical one was traditional in this area and provided protection in the rainy season. The flat one had been introduced later and Mr EL BEIK wondered why the roofs had changed to the flat types.

27. This point had puzzled Professor DANBY, as the people themselves had adopted it. Omdurman and Nubia traditionally had flat-roofed houses with a parapet wall, but their climate was different from the Gezira.

28. Mr EL BEIK suggested that the people should be persuaded to use conical roofs and the CHAIRMAN suggested that the cones were made from reeds from the Nile. Professor DANBY thought it would be very difficult to re-introduce the conical roof because the people would think they were being asked to go backwards in time. They wanted a new type of house, which was an improvement over what they had. Professor DANBY wondered whether materials for the thatch were still available; this would be a problem that would have to be studied in relation to the agricultural practices of the area. The CHAIRMAN said that rubbish was piled on flat roofs and this reduced the thermal conductivity of the roof.

29. Mr E. BEIK said it was an engineer's responsibility to help people to live better. Development of any kind was very important, and it was also important to study the way people lived, the climatic conditions and so on and to try to develop what they were used to in such a way that he could make something very good without having the opposition of the people living there.

30. Mr M. E. D. WHITE referred to the problems of providing water services and sanitary facilities to squatter settlements and shanty towns, and asked whether Professor Danby felt it was right to provide some kind of water services such as stand pipes, or to completely ignore the area until such time as modern housing was provided.

31. Professor DANBY said that in broad terms he thought that unless in a particular situation there was a realistic likelihood of producing alternative housing in the next few years, there was no choice but to try to bring water and health to the people where they were. Obviously it would not be possible to persuade people to leave shanty towns if there was nowhere better for them to go.

32. Mr WHITE suggested that the more comfortable they were made in the settlements, the more difficult it would be to make them move in any event. Professor DANBY asked why they should be made to move if they were comfortable. Mr WHITE suggested that disease was prevalent in these areas, but Professor DANBY said this reinforced the argument that something had to be done in the shanty town. Squatter settlements differed considerably. For example, one on the outskirts of Dar es Salaam in Tanzania was a highly desirable neighbourhood; the dwellings were not too close together, the area was near the sea, the building methods used were sound and it was easy to grow produce in the gardens. In other parts of the world settlements were very different and it would be well to obtain the advice of the local Medical Officer of Health.

33. In reply to a further question from Mr WHITE, Mr VAN DAMME said he had seen some cities in South America where it would be completely impossible to provide a water supply. There was then a choice - to leave the people as they are or move them and give them water supply in a new area. The CHAIRMAN suggested that communal sanitation blocks could be provided, and Professor DANBY said this was being done at Port Sudan. At the same time some of the houses were demolished, alternative sites being provided for the owners.

34. Mr Simon WATT said students from the Architectural Association in London had carried out some studies of squatter settlements on the outskirts of some major cities in Chile. It was found that migrants moved into an area as squatters, and gradually built substantial houses during the following years, which made planning and construction of services very difficult. In one area open land was designated for development and the layout for the basic services was set out on the ground. Squatters from other parts of the city were then allowed to move in, and this suburb grew from eighty people to 80 000 in two weeks. Over the years reasonable houses would be built, but the basic services had been provided. Urban migration was producing massive problems for developing countries; in San Paulo, Brazil, over 40 000 people moved to the city each year, mostly because they had been obliged to move because of the system of land tenure.

35. Mr P. G. STANLEY referred to a paper by Professor Marais* in which the order of priorities for housing were given as access to work, water supply and sanitation, and lastly shelter. The provision of a house came last because the householder was motivated to build his own shelter, but not to lay on water supply and sanitation. Mr STANLEY thus indicated that government priorities ought to go to water supply and sanitation rather than to housing.

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*MARAIS G. V. R.: "Sanitation and low cost housing", in "Water quality: management and pollution control problems", Ed. S. H. Jenkins, Pergamon, 1973, pp 115 - 125.

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36. Mr L. BROWN agreed with Mr Stanley. In fact he wondered whether architects should have anything to do with housing in developing countries. Basically the greatest problem was one of land tenure, and this was particularly true of the shanty towns, where the squatters were living on land which did not belong to them.

37. Mr A. EL-HINGARI agreed. People who came to shanty towns did not intend to stay there permanently. They came to stay for a few months until they could move to another place, but never leave. It was not an engineering problem but a social one. Mr EL-HINGARI also thought that the style of housing should be kept traditional. This was not always done; for example in some oil fields in Libya houses were built with pitched roofs, because some like to feel at home with a roof suitable for snow.

38. Professor DANBY said there was a great difference between the situations in Libya and Sudan. It was essential that people should feel happy in their houses. There was often a great hurry to build, but in fact there was always time to produce some pilot schemes first, and these should provide a number of different options to find out what people really wanted.

39. The CHAIRMAN suggested that there was a need to concentrate on the inside of the house, and Mr A. H. M. SOMANI said it should be made square to fit the furniture.

40. Professor DANBY returned to some unanswered questions. It had been suggested that land tenure was a cause of squatter settlement, but such settlements occurred where there was no land tenure problem, for instance in the Sudan. People left rural areas quite willingly and frequently maintained a house in their village. Professor DANBY disagreed with Professor Marais' dictum: access to work, sanitation and water and shelter if it implied that order of priority. It was a great pity that these problems were put in an either/or situation - either sanitation and water or a house - there might be a possibility to do the best in both fields. The whole problem of providing shelter or what is loosely called "housing" was a highly complex problem and was totally inter-disciplinary. What had been lacking in the past was real machinery for getting architects, engineers and planners together at one time. Obviously access to work, sanitation and water were absolutely vital but even with a site and services scheme there was still a case for giving guidance to the people in the way they build their houses. It might not be a case of designing a house and producing a drawing in the traditional sense but it still required the advice and the presence of people who knew something about building construction.

41. Mr HOWARD thought the Marais thesis was very sound. Wherever he had seen squatters, the site had been chosen for proximity to work. Squatter areas in Delhi had been cleared with armed police and the settlers were put in locations that had been provided with water taps and modest sanitation, but the people had to spend a third of their day's pay on transport to work. Mr HOWARD disagreed with over-emphasis on tradition, especially with regard to thatch, because fleas live in the thatch and cause disease. A final point was the importance in housing design of sanitation and water supply, which some architects neglect.

42. Professor DANBY did not disagree with the concept of access to work, sanitation, water and shelter, but thought none was more important than the others. In his postgraduate course at Newcastle the students came from a variety of countries and were asked to bring a case history of a housing situation in their own country. They were given a check list which included sanitation and water, and the cost of these services. The case histories were compared and formed the basis of further studies. With agreement of their sponsors (usually governments or government organisations) they worked out a project which was actually built when they returned home.

43. When asked whether a manager was required rather than an architect in developing countries, Professor DANBY said the name did not matter - engineer, architect, activist, sociologist - but somebody had to train people and there were not many attempts at this. He had been involved in the Volta River resettlement scheme but the involvement was too late - advice was sought when the waters of the lake were creeping up. However, what worried him was that the decision-makers never seemed to be concerned about people and where they live

until the last possible minute; they were much more concerned with building a twenty million pound dam or flooding a great valley because it looked spectacular. But resettlement schemes resulting from large construction often cost more than the construction itself but this always came as a surprise to the people who organised at the beginning. The local people might do 95% of the work but there was need for guidance, to show where the water pipe was to go, where to build their house and what sort of materials should be used.

44. The CHAIRMAN suggested that team work was required, and Mr L. M. SOLWAY thought there was a case for architects not completing their work. For example, with very low cost housing the house could start with one very small room with space to expand in their own style. Professor DANBY said this was the traditional way of building a house in many African countries. In a book called "Shelter in Africa" edited by Paul Oliver a series of housing situations had been observed and analysed and there was a particularly interesting study of housing in Zaria in Nigeria which showed the history of a house over twenty years.

45. Mr SOLWAY suggested that governments should plan incomplete housing. Professor DANBY said that in the Volta resettlement houses provided for the settlers were not complete, and there was a lot of criticism about this at the time because there was concern as to whether the settlers would be able to extend the house in the materials and form in which the first part had been built. It had been laid down that the houses would be of a better standard than the houses from which the settlers came. In other words people were now beginning to think of a house as a continuous activity.

46. Mr SOLWAY thought it was surprising that when housing was a basic requirement governments should worry so much about appearance. Professor DANBY suggested the government concern was not so much for the visual point of view but the traditional bye-laws which required that within the town area inferior materials should not be used. Ideally the Volta resettlement house should have been pitched at exactly the right economic level in the first place so that extension could have continued without objections from authority but without the people feeling that they were having an inferior house in the first place. However it was difficult to gauge this and required a great deal of research beforehand.

47. Mr H. T. MANN described how the Forestry Department in Uganda, which was particularly interested in encouraging the use of wood, had a demonstration ground where they built a number of houses, some of which were circular with conical thatched roofs, and some were rectangular with corrugated iron roofs. The houses demonstrated the kind of improvements which could be operated by local people at low cost. They showed such things as methods of protecting wood from termite damage, the use of wood preservatives, good methods of making joints in roof beams, the use of cement as an earth stabiliser and the proper use of corrugated iron roofs. One reason for the rectangular corrugated iron roof replacing the conical thatched roof in this area was the use of the roof as a water catchment area.

48. Mr STANLEY asked whether Professor Danby thought it better to provide two thousand people with water and sanitation rather than a thousand with water, sanitation and shelter in a situation where funds were limited. Professor DANBY said a feasibility study would have to be undertaken. Water would be first priority.

49. The CHAIRMAN said there had to be a political decision in most of these circumstances. Professor DANBY told of an experimental housing scheme in Kenya built by the Housing Research Unit at the University of Nairobi which was intended for family living. The administration was in the hands of the local council and eighteen months later it was found that - there were thirty odd houses - every one of the houses was now let as a rooming house. Future design for Kenya might allow for houses to be used either for family occupation or for letting off.

50. Dr MOHANRAO said that in many places in India some people stay in slums because of the closeness to work. He asked for suggestions for improving sanitation for such people if the municipality was willing to provide some land. The CHAIRMAN suggested that simple timber construction, as built in South America, would be sufficient, but Mr HOWARD considered that sanitary blocks should be the grandest place on the site, and a pleasure to use.

51. Dr MOHANRAO said that even when public sanitation blocks were well constructed, many people did not use them properly. Mr STANLEY said that even in Britain it had been found necessary to have someone in attendance at all times and he thought this would have applied equally in developing countries.

52. Professor DANBY suggested that there was a need for research to develop a simple latrine that could be placed in individual houses. Communal blocks were socially undesirable and in many communities were unacceptable for various reasons - most of them very good reasons. It seemed incredible that nothing had been found already. What seemed to be lacking was the will and the funds to get off the ground on this. The CHAIRMAN said the simplest possible scheme was night soil collection. A modern version used polythene bags,

and there were projects on hand, particularly in Sweden, for the disposal of excreta without using water as the transport medium.

53. Mr John PICKFORD said that the most likely of the Swedish proposals was called the "Multum", and consisted of a glass-fibre bin under the latrine seat. Household refuse was added and the excreta/refuse mixture composted down to produce a material which was suitable as a fertiliser. It was free from pathogenic material, but the cost in Sweden was very high. In fact there could be no really low-cost sanitary system because of the vast quantity of material which had to be dealt with. To make it pathogenically safe it had to be kept for some considerable time by composting or other suitable method and therefore there could not be cheap methods of treatment. Night soil removal in buckets was the cheapest method in terms of capital expenditure, but was very expensive in terms of labour, and some means had still to be found to dispose of the material.

54. A promising communal system was the 'comfort stations' at Ibadan in Nigeria. The co-operation of the local people had been obtained by making them responsible for construction. Sanitary sites had been chosen for people asking for them. One type was for four hundred people and consisted of an aqua-privy latrine with ten holes, and a wash place with a tap. The Corporation, which was partly government and partly municipal, provided the material which cost about £1800 and the people themselves provided the labour. The stations were only built at the request of the local community and the people themselves had to provide for the cleaning afterwards.

55. Mr W. STEWART said that small activated sludge plants which required the space normally occupied by a septic tank, were available, but they were expensive and so were not suitable for use in developing countries.

56. Mr R. J. OWENS said that many of the things that had been mentioned came within the planner's field. Planning could be carried out at relatively low cost and this was an attraction in many developing countries. Water supply, water distribution and sewerage schemes were very expensive in relation to the gross national product in most countries. Planners should provide mixtures of high density and low density housing zones to make sure that water supply and drainage systems provided for the more expensive areas also benefitted the relatively poor areas. Planners should also ensure that land was made available for pipelines (both water supply and drainage), pumping stations and treatment works. The economics of some drainage schemes had to be justified to the World Bank, but schemes were often invalidated by the high cost of land. If planners, in zoning rapidly developing areas, could set aside areas of land for public health engineering works, it would certainly help to get them installed at apparently lower cost.

57. Mr J. M. G. VAN DAMME said that the World Health Organization in principle was opposed to public standpipes because of public health reasons, and asked whether they should be favoured from a social point of view, for example in market places. Professor DANBY thought this was basically an economic problem. If funds were available it would be ideal to have water in the house. A water standpipe was not necessary to generate a market place. A feeling of community in a space could be achieved by other means. It just so happened that a standpipe also generated a community feeling and it seemed logical to put it somewhere near the market.

58. The CHAIRMAN thanked all who had taken part in the discussion, which had been especially stimulating. On behalf of everyone he thanked Professor Danby, and Mr PICKFORD thanked Dr Allen for the wonderful way in which he had led the discussion.

G J MOHANRAO

Waste-water and refuse treatment and disposal in India

INTRODUCTION

A. General

India is predominantly an agricultural country and has a high rural population. The water carriage system of excreta disposal which is almost universal in the western countries is restricted in usuage to the larger towns and cities in India. Even in these cities and towns, not all the population is served by sewers. The population on the fringes of the town generally use either house-hold septic tanks or the dry conservancy system. In most of the Indian towns, the sewerage system is either non-existent or not at all adequate for the population. In the villages even latrines, wet or dry, are scarce.

B. Population Served by Sewers

India's present population is 547 millions (1971 Census) out of which approximately 109 million people are known to live in the urban areas constituting about 20 per cent only of the total population. The urban population is classified as that population which lives in towns having population above 5000 and cities having population above 100 000. Out of the 2921 towns and cities, only 186 are sewered at least partially. This works out to 6.4% of the total number of towns. In terms of population, about 33 million (30 per cent of the urban population) is served with sewers which amounts to 6 per cent of the total population.[1]

C. Types of Wastes in Different Sections

The problem of domestic wastes in India can roughly be classified in the following manner:

Cities: Sewage and town refuse (some night soil and sullage)

Towns: Sullage, night soil and town refuse (some sewage)

Villages: Sullage, night soil and refuse

While sullage (domestic wastes excluding faecal matter) and night soil are a minor portion in the cities, sewage is a minor portion in most of the towns. The problems of the urban and rural sectors in India are shown below.[2]

Urban Section

Sewered population	33 million
Volume of sewage	785 MGD
Unsewered population	76 million
Volume of sullage	960 MGD
Volume of sewage + sullage	1745 MGD

Rural Section

Unsewered population	438 million
Population served with piped water supply at 10 gpcd	22 million
Sullage volume at 80% of water supply	176 MGD
Population not served with piped water supply at 5.5 gpd	416 million
Sullage volume at 80% water supply	1830 MGD
Total sullage from rural sector	2000 MGD

MGD = Million (Imperial) Gallons per day

D. Potential Growth of Sewerage

According to an extensive survey carried out by the WHO to study the status of community water supply and wastewater collection and treatment in several developing countries, the system of sanitary collection and disposal of household wastes is either non-existent or grossly inadequate throughout Asia, Africa, and Latin America.[2] This was in contrast to considerable success in expanding community water supplied in the same areas (Table 1). It should be emphasised that water supply and waste collection and disposal should go hand in hand to avoid repetition of past mistakes.

E. Refuse

Refuse is generated in cities as well as in villages. The amount of refuse or solid waste generated per capita in India is nearly 4 times that of the dry weight of sewage solids. However, the amount of money and effort spent on solving the problems relating to refuse disposal is comparatively small.

Most of the cities and towns use somewhat primitive methods of refuse disposal which involve unhygienic and unsatisfactory manual handling of waste in loading, unloading and land-filling or composting operations. A majority of the smaller towns in

India dispose of refuse in pits for conversion into compost.

Table 1. Relative Importance Given to Water Supply and Sewage Collection and Treatment in the Urban Sector of Developing Countries

	Urban Population		Total Population		
	Millions	% of Total Population	% of Population served with water supply	% of Population served by sewerage	Sewage treatment
India*	80	13	12	5	
Japan	98	68	69	11	There is little or no treatment facilities in these countries except in 1 or 2 urban towns
Lebanon	2.4	32	85	few	
Phillippines	35	17	30	6	
Thailand	26	15	3	nil	
Ethiopia	22	8	8	nil	
U.A.R.	30	40	40	few	

* Uttar Pradesh State only

A regular scheme for composting town refuse has been in operation since 1954. About 2400 urban centres are under such scheme. The annual urban compost production is of the order of 4.4 million tonnes.[1] Whereas the per capita production of town refuse in the western countries varies from 0.4 to 2.4 kg/day, it varies from 0.1 to 0.5 kg/day in India.

F. Night Soil

As mentioned earlier, about 94 per cent of the Indian population is not served by sewerage system. A minor population is served with septic tanks. A majority of the urban population uses the dry latrine which is served by the dry conservancy system. Most of the village population has neither latrines nor sewerage. The urban population which uses the dry conservancy system generates night soil which is disposed of by trenching or composting under anaerobic conditions.

G. Pollutional Aspects

With the spread of protected water supply to the majority of the communities in the western countries and the rivers flowing perennially, the major objectives of sewage treatment are not to allow the dissolved oxygen in the stream to go below a certain limit in order to protect the fish and to prevent foul conditions from being generated in the streams. On the other hand, in countries like India where the protected water supply is still very limited, the waste treatment (especially domestic waste treatment) assumes a much greater importance. As a majority of the citizens depend upon shallow wells or surface waters for drinking purposes, the contamination of these water sources will reflect on the health of the nation. One of the most important items of water pollution in this country is the biological pollution which starts from the human excreta.[2]

It has been reported by the National Institute of Communicable Diseases, Delhi, that nearly 30% of the deaths (due to infectious diseases) and 50-60% of the morbidity in the country have been due to water borne diseases. In view of the above, it should be recognised that the elimination of pathogens is one of the most important objectives in the treatment of sewage in the developing countries.[2] The incidence of typhoid, cholera, dysentery, infectious hepatitis, poliomyelitis and diseases due to various helminthic parasites is very common in India. Certain areas which use shallow well waters are known to be endemic to cholera. It is obvious that this type of pollution is happening because of recycling of infection from the infected human through sewage or night soil and drinking water.

The seasonal nature of rain fall in countries like India is another factor to be kept in mind in the treatment and disposal of sewage. The fact that most of the rainfall occurs during 3 or 4 months of the monsoon season renders a majority of the rivers dry for 4-6 months of the year. During the dry season, the sewage or its effluents will essentially form the rivers from which the relatively uneducated people drink water (directly or from nearby wells) adding to the pollution recycle.

SEWAGE TREATMENT AND DISPOSAL

A. Status of Sewage Treatment and Disposal

It has been mentioned earlier that only 6.4% of the towns and cities are sewered serving 6% of the total population of India. Even in those few cities which are sewered, a majority of the sewage is being discharged into the sea, rivers or on land with very little treatment. With the exception of a couple, most of the large cities discharge their sewage into the sea, rivers or on to land with practically no treatment. A major portion of the sewage is used on land for irrigation of various crops including vegetables. The present practice of sewage disposal in the 20 largest cities in India are given in Table 2.

B. Types of Existing Sewage Treatment Plants

A variety of treatment plants exist in India today. Some of the older plants are of the mechanical aeration (Simplex type with a draft tube) activated sludge plants. Trickling filters mostly of the high rate type using 4-6 ft and one or two 12 ft deep (with forced air circulation) are quite common. Among the trickling filters various flow sheets and designs are used. In the very small units, compressed air activated sludge systems of the Fowler Type have been in usage. More recently, activated sludge plants with mechanical and forced bubble aeration, Inka grid low pressure aeration system are being used. The oxidation pond has come into existence about 10-15 years ago and is being increasingly used. A few oxidation ditches (Pasveer type) for small populations are coming up. A few aerated lagoons have come up but are finding greater use in treating industrial wastes than domestic wastes.

C. Problems Associated with Existing Plants

A survey made by CPHERI, Nagpur has revealed that about 75 per cent of the surveyed sewage treatment plants of the conventional type (trickling filters and activated sludge plants) have not been

Table 2. Status of Sewage Disposal in Some of the Major Cities of India

	City	Approximate Population (1971 Census) Millions	Present Practice of Sewage Disposal
1.	Greater Calcutta	7.8	Only a part of the city is sewered and primary treatment provided. Part used for farming. Balance to River in untreated condition
2.	Greater Bombay	6.0	Only 10% of city sewage is treated partly with secondary treatment. Balance goes untreated to the sea, and an odour problem exists in some areas.
3.	Delhi	4.1	Two modern plants with primary and secondary treatment.
4.	Madras	3.2	Part of sewage used for irrigation and part goes direct to the sea.
5.	Kanpur	1.3	No sewage treatment plant. Part for irrigation.
6.	Hyderabad	1.8	Screens, grit and balancing tank followed by irrigation.
7.	Bangalore	1.6	Primary sewage treatment plants under construction
8.	Ahmedabad	1.7	Two modern sewage treatment plants. Also irrigation.
9.	Poona	1.1)	
10.	Nagpur	0.93)	
11.	Lucknow	0.81)	
12.	Agra	0.63)	No treatment. Pumped for farming.
13.	Varanasi	0.61)	
14.	Madurai	0.71)	
15.	Allahabad	0.51)	
16.	Amritsar	0.46)	
17.	Indore	0.56)	
18.	Jaipur	0.64)	Secondary treatment plants. Effluents used for farming.
19.	Sholapur	0.40)	
20.	Patna	0.49)	

working to their designed efficiences. They were either not working at all or performing poorly. The reasons for such poor performance are: i) the plants were not designed properly, ii) they were lying idle because of mechanical breakdown or lack of maintenance, iii) not working properly because of the lack of skilled operators. A good number of the conventional sewage treatment plants in this country are based on the designs commonly used in temperate climates. In view of the warmer temperatures that are closer to the optimum of microbial activity, it should be obvious that there is a great need for changing the design criteria. It is also necessary to provide units which are simple to fabricate and easy to operate. An important aspect is to keep the mechanical content to as little as possible because of the non-availability of skilled technicians to operate and maintain these units.

Although training facilities for skilled technicians are increasing, it is still found that the waste treatment plants are in short supply of the properly trained people for reasons beyond the control of waste treatment engineers.

D. Waste Treatment Methods Suitable to India

From the discussion in the previous item, it must be obvious that if sewage treatment plants have to work efficiently and reduce water pollution in developing countries like India, they should be of a simple design with very little mechanisation and automation. Among the various treatment methods available, stabilisation ponds, oxidation ditches and aerated lagoons appear to be the most appropriate methods for the developing countries.

An economic analysis of the cost of various sewage treatment processes in India has revealed (Table 3) that the waste stabilisation pond is undoubtedly the cheapest method for all population ranges.[4] As long as the cost of the land does not exceed Rs. 55 000 (Rs. 18 per £1.00), the waste stabilisation pond system will be the cheapest even up to a population of 250 000, provided land is available. The oxidation ditch system (extended aeration activated sludge) is always cheaper to construct. However, when running costs are taken into account, the conventional systems are cheaper than the oxidation ditch for population above 150 000. A scrutiny of a list of 72 plants constructed in India over the last few years revealed that 86% of them are below 4 MGD capacity, corresponding to a population of 135 000 or less.[5] Considering the various factors including intangible benefits such as ease and efficiency of operation, freedom from breakdowns, it should be obvious that the low cost waste treatment methods should be the methods of choice under the above circumstances.

Table 3. Per Capita Cost Estimates for Various Sewage Treatment Processes in India[4]

Process	For Constrution of plant (including land cost at Rs 10 000/acre)	Capita cost plus capitalised running costs	Total annual expenditure to defray all running costs including repayment of loan
	Rs.	Rs.	Rs.
1. Waste stabilisation pond	8.80 to 15.70	10.60 to 27.20	0.93 to 2.30
2. Aerated lagoon	12.00 to 19.00	32.20 to 55.80	2.80 to 4.86
3. Oxidation ditch	14.00 to 21.00	43.75 to 79.60	3.80 to 6.06
4. Conventional treatment	16.00 to 65.00	40.88 to 152.00	3.55 to 13.22

LOW COST WASTE TREATMENT

A. Stabilisation Ponds

1. General

Although waste stabilisation has been occuring in ponds for a long time, ponds designed on an engineering basis have come up only recently and are in operation for the last 15 years. The stabilisation ponds can be utilised for partial, complete or tertiary treatment. The stabilisation ponds may also be used to treat wastes in conjunction with other treatment methods. The principle of waste stabilisation in these ponds is the oxidation of the organic matter through the bacteria and the supply of oxygen through the algae. The process is known to be symbiotic, as there are two major groups of organisms helping each other. The bacteria oxidise the organic matter and release carbon dioxide, water and minerals. The algae utilise carbon dioxide, water and minerals and release oxygen using sunlight as a source of energy.

2. Types of Ponds

Stabilisation ponds are primarily of 3 types: i) oxidation ponds that are completely aerobic, ii) facultative ponds that are aerobic in the higher layers and anaerobic in the deeper layers, and iii) anaerobic ponds which are mostly anaerobic. Only the first two categories are discussed in this paper.

Although in the past, the ponds were designed primarily as aerobic ponds, it is now apparent that it would be of much greater advantage to design them as facultative ponds especially in the warmer regions of the world. It has been found that there is no danger of having the lower layers of the pond anaerobic provided at least 1 foot depth of the water layer below the surface is aerobic.[6] This will prevent any potential odour nuisance. In the facultative ponds, a part of the BOD is stabilised by means of anaerobic decomposition, releasing volatile acids and alcohols. These are oxidised aerobically in the upper layers as they diffuse upwards. The suspended organic solids settling in the bottom layer of the pond undergo stabilisation through conversion to methane which escapes the pond in the form of gas. It can be seen that the oxidation of the organic matter and fermentation into methane would reduce the BOD load on the aerobic organisms.

3. Performance of Ponds

There are more than 50 stabilisation pond installations in India, a majority of which are of the facultative type. These were found to give 75-90 per cent reduction when the loads were reasonable. The ponds vary in their size from 0.029-63 acres and the depth varies from 2 ft to 5 ft with a depth of 4 ft predominating.[7] The influent BOD ranged from 160-418 mg/l.

At 200 lb BOD/acre day loading, oxygen penetration was up to the pond bottom during day time. At night, it was only up to 1.5 ft from the surface. At a loading of 600 lb BOD/acre day, the pond was completely anaerobic at night but had an aerobic layer in the day time (Fig. 1). Even under such conditions of operation, the pond did not cause odour nuisance.[8]

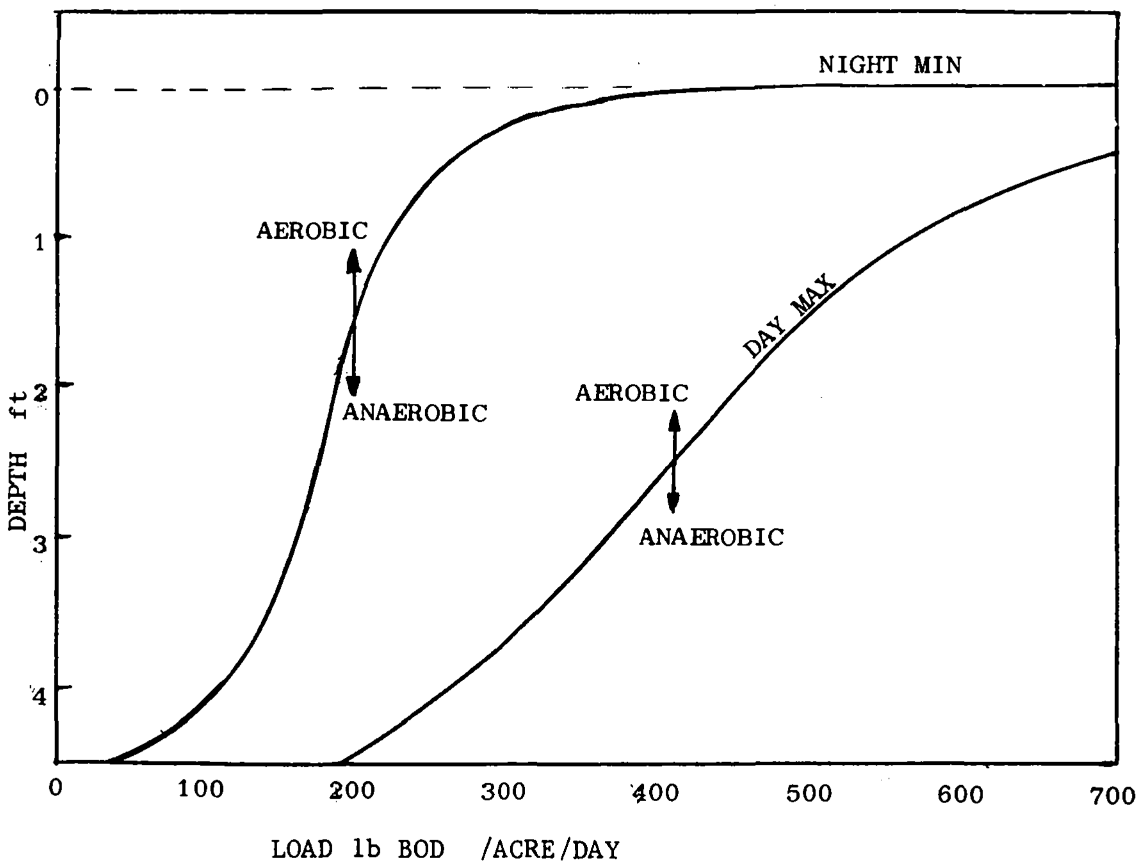

FIG. 1 - AEROBIC AND ANAEROBIC ZONES IN STABILIZATION POND

4. Approaches for Design

Two basic approaches have been used for designing the stabilisation ponds. One proposed by Oswald[9] and recommended by some investigators in India equates BOD load to the oxygenation capacity of algae which is a function of the available solar radiation. The other approach given by Herman and Gloyna,[10] emphasises the influence of temperature on pond volume. Recently Marias has forwarded a model based on Phelphs' approach to describe the behaviour of facultative ponds taking into account both aerobic and anaerobic reactions. However, its utility as a basis for designing ponds is questioned by Siddiqi because of difficulties in evolution of various kinetic constants used and generalising this from the limited experience.[6] Although the approaches proposed by Oswald as well as by Herman and Gloyna are sound, they should not be applied directly for designing ponds in India for the following reasons: i) the ponds which receive raw sewage invariably develop an anaerobic zone at the bottom and hence the BOD stabilisation through anaerobic reaction must be taken into account for sufficient and intensive utilisation of land area, and ii) temperature influences efficiency in the case of stabilisation of the organic matter in the anaerobic zone only when pond temperatures fall below 15°C. For most of the locations in India, the temperature of the pond does not fall below 15°C for any extended period of time. For a majority of location in India, the volume concept would be more useful. Hence it is possible to design ponds in Central and South India at a depth of 5 to 6 ft. This would automatically reduce the area required for the pond which is one of the important factors in the design.

Under Indian conditions, the BOD due to settleable fraction in the domestic sewage may be considered as 50 per cent in view of the low hydraulic loading on ponds. The surface area of the pond required can be calculated on the BOD of settled sewage on the basis of the figures given by Arceivala et al[7] (fig. 2), and not on raw sewage. A depth of 5-6 ft can be used. The detention time thus obtained should be equal to or more than 6.5 days which is the time required for 90 per cent reduction of BOD assuming the overall reduction rate constant of 0.15/day. In areas where the temperature of ponds is likely to be below 15°C for long periods of time (above 30° latitude in India), the stabilisation of BOD through anaerobic activity may be neglected.[6]

4. BOD Reduction Efficiency

Ponds that are well designed and operating well can be expected to give 75-80 per cent BOD reduction. McGarry and others[11] and Siddiqi and Handa[12] have given empirical relationship between the efficiency and surface loading. Both these relationships show a suitable response to the pond in the loading range of 300-500 lb/acre day, which should be the design value for most of the Indian sub-continent, according to the procedure outlined above. If the influent sewage BOD is taken to be 250 mg/l, an effluent with a BOD of 50-60 mg/l may be expected. Under summer conditions, the performance of the pond and the quality of the effluents would be still better.

5. Removal of Pathogenic and Indicator Organisms

As mentioned earlier, in a country like India, the removal of pathogens during sewage treatment is of primary importance. Stabilisation ponds when properly designed and operated have proved to be better than the conventional methods from the point of view

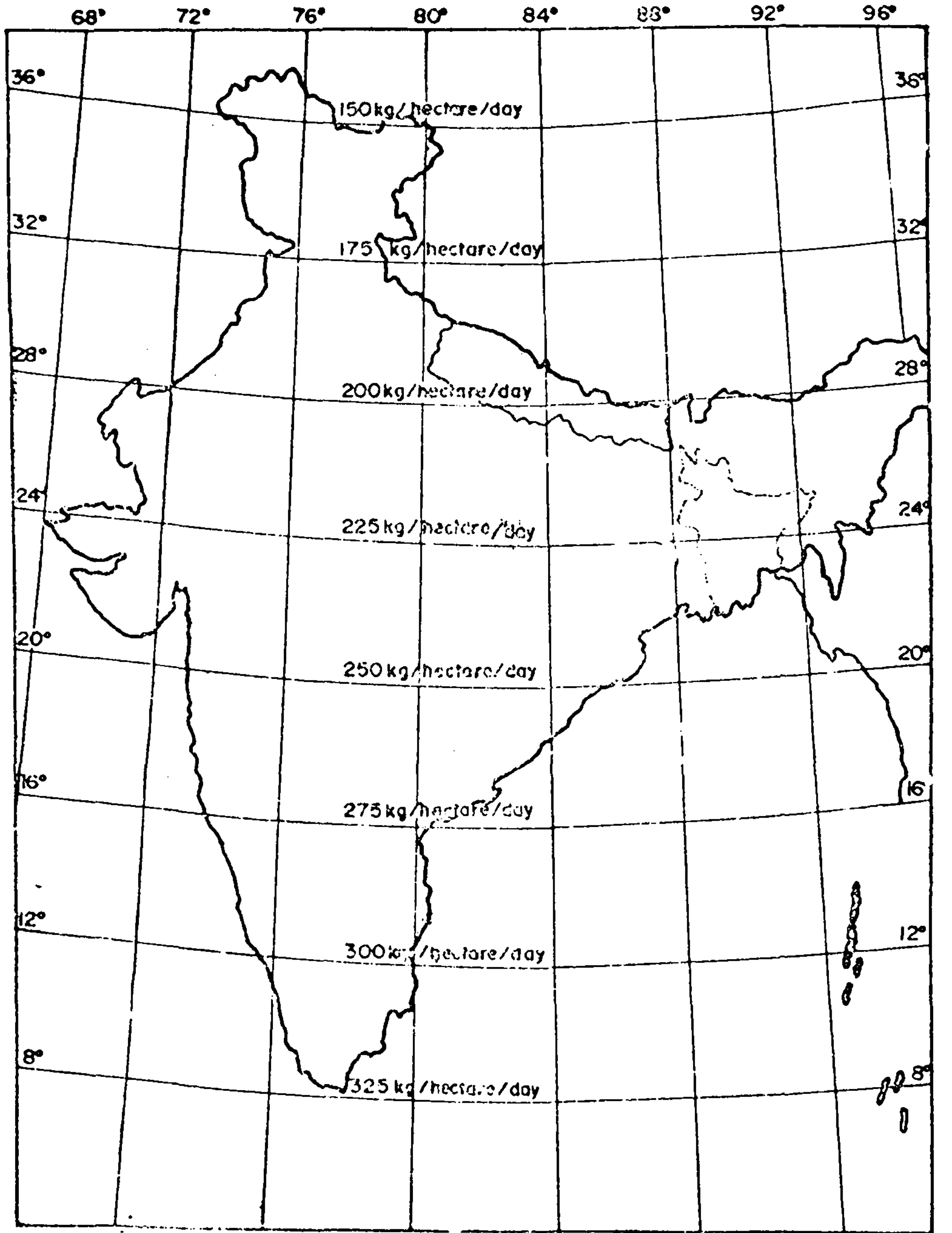

Fig. 2 The approximate BOD loading in Kg/hectare day that can be given at different latitudes (to convert to lbs/acre day divide by 1.12)

of removal of pathogenic and indicator organisms. Due to extremely favourable conditions for sedimentation, treatment by ponds provides almost 100 per cent removal of helminths and amoeba. Anaerobic conditions in the lower layers of the facultative ponds also contribute to their destruction. In a 3-cell stabilisation pond system having a total detention time of 6 days, 90-99 per cent of all forms of helminths were removed in the first cell. Only a few larvae of Ancylostoma were found in the final effluent.[13] It was reported by Joshi et al. that a total of 99.99 per cent reduction was obtained in indicator organisms (Coliforms, *E. coli* and *S. faecalis*), in a 3-cell pond system of one acre each. The increase in pH due to photosynthesic activity of algae was found to be the main cause of such reductions. Salmonella organisms which are commonly observed in raw sewage in India were found to be eliminated in the stabilisation ponds at Nagpur. Over a period of 6 months, it was observed that one litre samples (taken once a week) were always negative. During the period of study the influent contained 4-450 organisms/100 ml.

6. Maintenance

Grit and digested sludge accumulate in the ponds. Experience in India has shown that the accumulation rate is about 2-3 cft/cap year. Most of the accumulation takes place in the primary cell which may be cleaned once in 5 or 6 years.

It is advisable to divide the total pond area into 2 or 3 ponds in view of the space required for sludge accumulation. The first pond may be kept deeper than the second and the third. Multiple cell ponds have proved better primarily because of less short-circuiting. The shore lines should be kept free from vegetation as otherwise there is a possibility of mosquito-genesis. The tanks should be safeguarded against erosion. Any scum accumulated on the shore lines should either be removed or broken.

B. Oxidation Ditch

1. General: The oxidation ditch is operated mainly on the extended aeration principle. It is, in short, a modification of the activated sludge process which does not have the primary sedimentation and digestion units. The aeration is done by means of mechanical rotors which splash the sewage into air and allow oxygen to dissolve into the medium. The name oxidation ditch comes after the earthen models that were originally installed in Holland, the cross-section of which looked like an irrigation ditch.

Stabilisation ponds and aerated lagoons, although very simple to construct and operate, require substantial amounts of land area. Where land is expensive, those systems would be relatively expensive. Under such circumstances, the oxidation ditch which employs sludge recirculation is used. In this system, the raw sewage is directly pumped to the ditch and the BOD loading on the microbial mass is so regulated as to produce a well stabilised sludge (does not require further treatment), and can be dried directly on sand beds. Due to low organic loading, excess sludge production is kept to minimum. Looking at it from another point of view, excess sludge solids are oxidised by endogenous respiration. The process may also be thought as an aerobic sludge digestion coupled with activated sludge system.

2. Design: Oxidation ditch system is designed at a low BOD loading with reference to the amount of mixed liquor suspended solids maintained in the system. Whereas conventional activated sludge process uses MLSS in the range of 2000-2500 mg/l, oxidation ditch systems are designed with 3000-5000 mg/l MLSS. The organic gravimetric loading used in these systems varies from 0.05-0.1 lb BOD/lb of MLVSS in the temperate zones. However, in the tropics like India, the loading can be considerably higher, i.e., up to 0.5 lb BOD/lb MLVSS.[6] The higher temperature in these regions helps oxidation and stabilisation of organic matter at a higher rate.

Working on a 20 000 gal capacity pilot plant at the CPHERI campus, treating 5000-40 000 gal waste/day it was found that specific resistance of the sludge (a measure of sludge filtrability, sludge stabilisation or mineralisation) increased sharply as the loading was increased from 0.5-1.0. Excess sludge production also increases acutely above a loading of 0.5.

3. Fabrication and Installation: The fabrication of the oxidation ditch is relatively a simple operation and can be accomplished at many local workshops in the developing countries. The installation of the ditch is also quite simple. The mechanical parts that are required are an electric motor, a reduction gear, a rotor and a sludge pump. The system includes a settling tank to separate the clear liquid from the sludge and to return the latter. In India there are several installations of the oxidation ditch system in small townships which are too large for servicing by septic tanks. The system occupies a small fraction of the land that is needed by the stabilisation pond.

C. Aerated Lagoons

1. General: Aerated lagoons have come into prominence in the last 10 years in the western countries especially in the U.S.A. In India, the CPHERI had started recommending aerated lagoons for the treatment of sewage and several industrial wastewaters. The aerated lagoon is preferred to stabilisation pond for the reasons that it requires less land and gives greater reliability of performance.[6] Oxygen is supplied through surface aeration by the mechanical rotor or compressed aeration. The lagoon is usually constructed 8-12' deep. The waste enters at one end and leaves at the other. Two types of aerated lagoons are described in literature: 1) completely aerobic lagoons requiring power input of 0.1 H.P./1000 gal of basin volume, and 2) facultative lagoons requiring 0.01-0.02 H.P./1000 gal of basin volume. Due to the lower requirement of power in the facultative lagoons and consequently low mixing velocities, suspended solids settle to the bottom and undergo anaerobic decomposition. For most wastes only facultative lagoons are possibly used in view of economy of operation. The power requirement is calculated on the basis of oxygen requirement of the system. Very little data is available on aerated lagoon performance in this country. Data from the pilot plants of CPHERI are utilised for this discussion. The aerated lagoons are normally designed to discharge a mixed liquor. The CPHERI has tried a modification in providing a settling compartment before the outlet in order to retain and recycle the sludge solids. The latter work on the basis of extended aeration principle whereas the former would be somewhat close to the high rate activated sludge systems. In both the cases, it must be recognised that the solids are not completely mixed. Some amount of BOD removal takes place under anaerobic conditions in the bottom layers where sludge is settled.

2. BOD Removal Efficiency: In the common aerated lagoons, there is no separation of the biological solids from the liquid waste. Therefore, the effluent from the lagoon will contain suspended solids essentially as much as in the upper layers of the lagoon. The effluent BOD will be that exerted by the clear effluent and the biological solids. The rate of respiration of the biological solids decreases with increasing detention period. In the modified aerated lagoon using settling compartments, the effluent would exert primarily soluble BOD. In the aerated lagoon working on the basis of extended aeration, the following 3 advantages were envisaged:

1) the effluent will be free from suspended solids;

2) an increase in the efficiency of the system will be obtained because of increase in biological solids concentration in the lagoon; and

3) by creating an anaerobic zone for stabilisation of the BOD and biological solids, the oxygen and power requirements of the lagoon are decreased.[6]

The operation data on the pilot aerated lagoon at the Institute is shown in Table 4.

Table 4. Operational Data from the Pilot Aerated Lagoon

1.	Detention time	1.8 days
2.	Influent BOD_5	205 mg/l
3.	Effluent BOD_5	21 mg/l
4.	Aerobic depth	2-3 ft (0.6-0.9m)
5.	BOD_5 load	1223 lb/acre-day (1370 kg/ha d)
6.	Gas produced	11090 cft/acre-day (776 m^3/ha d)

Area = 1370 sft ($127\ m^2$)　　Water depth = 8 ft (2.4m)

Table 4 shows the average of three months operational data. Gas was collected by means of a floating cover. On an average the gas had 62 per cent methane gas. It is seen from the data that the lagoon was producing effluent comparable to that from any conventional aerobic system. Assuming that 10-12 cft of gas is produced for each pound of BOD stabilised, almost all stabilization was through anaerobic reactions. The lagoon was provided with an aerator which was supplying about 1000 lbs of O_2/acre-day. This resulted in creation of a top aerobic layer of 2-3 ft depth and nuisance associated with anaerobic reactions was avoided. It is therefore indicated that with slight modifications in operation and design of aerated lagoons not only a better quality effluent may be obtained but the power requirement may also be reduced. In such a lagoon, with total retention of solids, there will be a gradual deposition of digested sludge. The rate of deposition may be expected to be the same as that in a facultative stabilisation pond. Cleaning may be required once in five or six years. Aerated lagoons should therefore be constructed as multi-celled units, the various cells operating in parallel, to facilitate sludge removal.

REFUSE COLLECTION AND DISPOSAL

A. Character

The character of refuse in India is considerably different from that obtained in the western countries. In the major cities like Calcutta and Bombay, the refuse, as deposited in the street bins, contains green cocunut shells, torn paper, rags, metals, garbage, broken glass, earthenware, china-ware, ashes and soil. In these two cities green cocunut shells form 10-11 per cent of the total refuse.[15]

The character of the refuse at the disposal site is considerably different from that at the point of collection. This is primarily because of the fact that paper, rags, metals, unbroken glassware and sometimes even broken glass are salvaged. The per capita quantity varies from city to city. In the larger cities like Calcutta and Bombay, the contribution is about 0.5 kg/head day. In the smaller cities, it is around 0.3 kg/hd[16]. There could be a few industrial townships where high income population lives which dispose of a larger quantity of waste. The above figures are at the points of collection. At the disposal site these figures will be slightly lower.

A survey conducted on the character of refuse all over Calcutta indicated an average moisture of 41 per cent and an organic content of 35.2 per cent, the latter being on dry basis. Carbon was found to be 19.6 per cent of the total solids and carbon to nitrogen ratio was 37.4. It should be obvious that Indian refuse contains a much higher inorganic content than that of the western nations resulting in smaller values of calorific values on dry solids basis (1500 Kcals/kg at Calcutta as against 2728 the 1963 average of 4 cities in the U.S.A.).

B. Collection

Refuse is generally dumped in either metallic or concrete, square or round street bins. It is generally collected through open trucks and carried to the disposal site. Some of the progressive municipalities have been using closed trucks but have no compression of the refuse. Compression of the Indian refuse perhaps is also not as important as the refuse in the western countries, as the former does not contain large quantities of loose paper or paper cartons. The density of Calcutta refuse is 470 kg/m^3 at source and 540 kg/m^3 at the disposal site. It is not uncommon to see that during the transport of the refuse from the collection to the disposal site, the refuse is lost from the trucks because of wind action, a phenomenon that is ugly and that can be unhygienic.

C. Treatment Methods

1. Composting: Two well known processes of town refuse treatment to make compost have originated in India. In spite of this fact, the methods practised presently in India are far from satisfactory. With a view to conserve as much of the plant nutrients as possible, the Bangalore process and the Indore process have been developed for composting of refuse.

a) Indore Process: The Indore process developed during the period 1920-1930 uses easily decomposible organic material such as night soil, animal manure, sewage sludge and garbage which are are laid in alternate layers with relatively stable material like straw, leaves, town refuse and stable wastes. The material is kept in piles or windrows on the ground to a height of about 5 ft or put in shallow pits (2-3 ft) raised up to a height of 5 ft and in an area as large as practicable. The composting material is turned twice for aeration by manual labour during the period of decomposition which is generally about 3-4 months. The liquid draining from the piles or windrows is sprinkled to moisten the decomposing mass or added to other drier piles of windrows. The moisture content is maintained roughly at about 13-14 per cent. The method has been further improved by adding digested sludge as seed material, thus reducing the period of decomposition. It is supposed that the material is aerobic for a few days after the initial piling and after each turning, and anaerobic for the rest of the time. This method of composting is useful where labour and land are cheap. The process is partially mechanised where high quantity of waste is to be handled. The material is directly put in shallow trenches and turned as many times as needed by means of mechanical gadgets to keep the process aerobic for most of the time. Increased number of turnings reduce the total time taken for composting. Under aerobic conditions the piles reach a temperature of 60-75°C which would help eliminate helminthic parasites and their eggs. The process however, has the following disadvantages:

i) high labour and land requirements;

ii) the material is not protected from extreme weather conditions and hence is suitable only in milder climates or requires shelter;

iii) it may create odour problems.[17]

b) Bangalore Process: The Bangalore process was developed by Acharya in 1939. In this process the town refuse, night soil and cattle waste are used for the preparation of compost. The night soil and other wastes are put in alternate layers in the pits (3-4 ft deep). The breadth and length of the trenches depend on the availability of land and the quantity of material to be composted. After each filling the pit is covered with 6-9" thick layer of refuse. The material is left in the pit in this condition with no turning for 3 months. During this period the material settles down and additional refuse and night soil are placed on the top and covered finally with earth to prevent loss of moisture and fly breeding.[18]

This system of composting provides aerobic conditions and high temperature rise in the pits only for a few days. Although the material decomposes under anaerobic conditions for the remaining period, high temperature is retained for about 15 days due to insulation. As the decomposition under these conditions is slower it requires about 4-6 months to achieve the same degree of compostability. The advantage of this method is the fact that it does not require any labour for turning the refuse in the interim period. However, this method suffers from the disadvantage of requiring longer time for composting and hence more space as compared to the Indore method. The reduction in pathogens is lower and the odour and fly problem is higher.

2. Incineration: Incineration of town refuse is practically non-existent in India. It is generally found in hospitals and occasionally in private institutions and some industrial townships.

D. Disposal

The most common method of disposal of refuse in India is uncontrolled tipping in low lying areas. Here again a few of the progressive municipalities are trying to control the tipping. Where composting is practised, the refuse is put in pits in a controlled manner and transferred to the crop areas after composting.

NIGHT SOIL

A. Character

The night soil handled in India primarily consists of human faeces. The average night soil contains 10-12 per cent total solids, 72-83 per cent of which is volatile. It contains 3-5 per cent nitrogen

(N), 2.5-4 per cent phosphorous (P_2O_5) and potassium (K_2O) 0.7-1.9 per cent, all on dry basis. The average per capita contribution of night soil excluding urine is estimated to be 0.18 lb/d (80 g/day) on dry basis and 1.8-2.2 lb/d (0.8-1.0 kg/day) on wet basis.[19,20]

B. Collection

It has been mentioned in the earlier pages that a major percentage of urban population is served by dry conservency system in which the human excreta is manually collected in the form of night soil. By and large, this night soil excludes human urine as the collection chambers are provided in such a manner that they are kept relatively dry. The night soil is manually collected from individual houses in buckets and carried to night soil carts in the different municipal wards. The night soil carts are hauled by bullocks to the disposal site. In the larger towns trailers are used for the transport of night soil and hauled by tractors to the disposal sites.[19]

C. Treatment Methods

The most common method of treatment and disposal is by way of trenching. The other popular method is to compost with town refuse by the Bangalore process. Trenching has the major disadvantage of requiring large areas and of contaminating shallow wells. Unless done extremely carefully, trenching also has a tendency to create fly nuisance especially in the warmer weather.

Anaerobic digestion of night soil has been proposed as an alternative to trenching in the towns where night soil is collected. Experiments at CPHERI have indicated that digester capacities of 1 cft/capita at Madras and 1.8 cft/capita at Delhi are required. The variation in the capacity required is due to difference in winter temperatures. It has been found that 7-9 cft of digester gas can be obtained per lb of dry solids of night soil charged. It was also found that the digesters could be loaded to as high a figure as 0.1 lb total solids/cft day at a place like Nagpur. However, a loading of 0.05-0.08 would be preferable to avoid any strain on the operation of the digester. Higher loadings result in digester failure. Total solids in the digester influent will have to be restricted to a maximum of 8 per cent. It is preferable to use a 5 per cent slurry which obviously requires some water for dilution.

It has been observed that digested night soil is completely free from bad odours and that it could be dewatered and dried quite easily. However, it was found that the eggs of helminthic parasites such as that of hook worms were not completely eliminated during the digestion. Hence it may be worthwhile to consider aerobic composting of refuse using digested night soil as a supplement for the nitrogen and phosphorous content. Incidentally, this will also help in reducing or eliminating the cysts of the parasites of Ancylostoma and Ascaris. Alternatively, heat treatment of night soil either before or after digestion will be needed to totally eliminate the parasites.

D. Disposal

As mentioned earlier, the most common method of disposal of night soil is by trenching with or without refuse. By and large, the trenched night soil is used as a plant manure after allowing it to decompose for 6-9 months.

SUMMARY AND CONCLUSIONS

1. The type of sanitary services existing in India in the cities, towns and rural areas are described.

2. The water pollution loads from solid and liquid domestic wastes in India are presented.

3. Sullage and night soil should be considered as domestic wastes in addition to sewage and town refuse.

4. Pollution due to pathogenic organisms emanating from human excreta is one of the most important aspects to be considered in waste treatment.

5. It has been observed that conventional waste treatment plants with considerable mechanical content do not function properly in developing countries due to inadequacy of properly trained personnel. Hence waste treatment plants with simpler design will have to be developed.

6. Oxidation ponds, aerated lagoons and oxidation ditches would be most appropriate and low in cost for a majority of the towns and a few cities. The design criteria for these processes suited to the Indian conditions have been described.

7. The character, collection and treatment methods of refuse and night soil presently being used are described with suggestions for improvement.

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discussion

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Dr G. J. MOHANRAO said his paper tried to give the conditions in tropical countries which would be of assistance to consulting engineers and contractors going overseas for work. The difference between the tropics and the temperate climates from the waste treatment point of view was so great that it was worthwhile to consider tropical conditions. As India was large the conditions there applied to several other tropical countries in Asia, Africa and Latin America.

2. India was predominantly an agricultural country and had a very high rural population; the last census indicated that the rural population was about 80% of the total. The cities and towns together had a population of about thirty-three million. There was great dissimilarity between the western countries and India in the method of disposal of excreta; whereas WCs and sewers were common in Britain they were uncommon in India. In most Indian towns the sewerage system was either non-existent or inadequate for the population. Out of the 3000 towns and cities only about 186 were partially sewered, no city was completely sewered, and 94% of the Indian population had no access to sewers.

3. Sullage (domestic waste water excluding faecal matter) was generally passed to surface drains in the smaller towns and occasionally in cities without an underground drainage system. Invariably the sullage channels became filled with refuse and occasionally contained some faecal matter. In the villages there were only earth drains for sullage, and night soil was not collected. The villagers mostly used the open fields; very often they refused to use even bucket latrines. In developing countries all over the world the rate of growth of sewerage was much slower than that of water supply, and this tendency was common in India.

4. The quantity of refuse in western countries varied between one and five pounds per person a day, whereas in India it was only about 0.2 to 1.1 pounds per day. In India night soil consisted mostly of faecal matter; dry latrines were built in such a way that urine went another way and only dry faecal matter was collected in the troughs, and hence less putrefaction took place between deposition and collection.

5. With the spread of protected water supply to the majority of the communities in the western countries and the rivers flowing perennially, the major objective of sewage treatment was to prevent dissolved oxygen in the stream dropping below a certain limit in order to protect fish and to prevent foul conditions from being generated. On the other hand in countries like India where the protected water supply was very limited the exclusion of pathogens was of primary importance, and waste treatment assumed a much greater importance. As the majority of the citizens depended upon shallow wells or surface waters for drinking purposes, the contamination of these water sources reflected on the health of the people. It had been reported by the National Institute of Communicable Diseases in India that nearly 30% of the deaths due to infectious diseases and 50 - 60% of the morbidity in the country were due to water-borne diseases. These resulted in very high costs to the society for treating the people in hospitals and for medication. Common water-borne diseases in India were typhoid, cholera, dysentry, infectious hepatitis (also known as jaundice), poliomyelitis and diseases due to various helminthic parasites such as hook worm, tape worm and round worm. Certain areas which used shallow well waters were known to be endemic to cholera.

6. An additional feature in the tropics, which was to the disadvantage of public health engineers, was the seasonal rainfall. Although India had a large amount of rainfall, most of it fell in three or four months in the monsoon

which varied from May to October depending upon the location. In these four months it poured and after that there was hardly any rain, and after January most of the rivers started to dry out; from March to May most of the rivers were dry. This was a great disadvantage, since there was no dilution during certain months.

7. In the few Indian cities which were sewered the majority of the sewage was discharged into the sea, rivers, lakes or on land with very little treatment. A major portion of the sewage was used on land for irrigation of various crops including vegetables. Because rainfall was seasonal irrigation water was required after October and it was easy to use sewage as an alternative for water. Sometimes people purposely broke sewers and tapped the sewage for irrigation. Research at the Indian Institute of Science from 1937 to 1947 showed that vegetables should not be irrigated with raw sewage, but agriculturists on the periphery of towns used this perennial source of water to grow vegetables which were later sold in the city. Fortunately in India most people boiled vegetables before eating.

8. In India there was a whole range of sewage treatment plants from the simplest septic tank to the most complex treatment plant which included reclamation of water for industrial purposes from domestic sewage. There were a few simple aeration activated sludge plants; percolating filters of the four to six feet depth were most common, high-rate filters being used more often than low-rate filters. There were one or two 12 feet deep filters with forced air circulation, and recently activated sludge plants with Inka grid type low pressure aeration were being used. The oxidation pond was being increasingly used. A few oxidation ditches of the Pasveer type and some aerated lagoons had recently been installed, especially for industrial waste.

9. The problems associated with existing plants had been investigated by CPHERI who had made a survey of about seventy existing sewage treatment plants and found that 75% of these plants were not working at their design loadings or design efficiency. The reasons were threefold. Some plants were not designed properly; some designs were copied from textbooks from Western countries and were overdesigned, which did not always bring in greater efficiency. Some works were unusable becuase of mechanical breakdown or lack of maintenance - probably the largest category. Some were not working properly because of lack of skilled operators. Because of the absence of skilled operators and the inability to maintain sophisticated mechanical equipment and automation, the waste treatment method most suitable for India was the stabilisation pond. Table 3 showed that unless land cost over £3000 an acre, waste stabilisation ponds were by far the cheapest method. Another CPHERI survey showed that 86% of Indian plants had a capacity of less than 4 mgd, serving a population below 135 000.

10. Waste stabilisation ponds were mostly used in India for treatment of raw sewage. Raw waste entered two to three feet above the floor of the oxidation pond, and sludge was deposited at the bottom. There were two zones in the pond. In the aerobic zone carbon dioxide and water were converted into algal mass using sunlight as energy. Then sewage organisms, primarily bacteria, converted complex organic substances into carbon dioxide and water. Algae required carbon dioxide and the bacteria required oxygen, so mutually helped each other - the process was called 'symbiosis'. In the anaerobic zone the complex organic matter was oxidised to volatile acids as in anaerobic digestion, and the volatile acids were converted by methane-fermenters into carbon dioxide and methane. Methane being insoluble bubbled out to the surface. Once in four or five years the pond had to be emptied to remove the excess sludge, as otherwise it would reduce the volume of the pond. This sludge had good manurial value and was purchased by the farmers around.

11. There were three types of ponds: first, oxidation ponds which were completely aerobic; secondly, facultative ponds, and thirdly, anaerobic ponds. Aerobic and facultative ponds generally gave between 75% and 90% BOD removal. Data from about fifty stabilisation ponds in India, showed that they varied from 0.029 acres to 63 acres and the depth varied from two to five feet with a four feet depth predominating. The influent BOD ranged from 160 to 480 mg/l - the highest figure coming from larger towns with limited water supply. The loading of the ponds varied from about 100 to about 750 lb BOD/acre day. Some of the ponds were pilot plants but the one at Ahmedabad was the 63 acre pond which had worked for a long time for the city. Later a political decision was made to abandon the Ahmedabad pond and replace it with conventional treatment, in order to sell the land which had originally been outside the town but was then inside. Figure 1 showed that as the loading on the pond increased beyond 250 lb BOD/acre day the anaerobic zone got closer to the surface even during the daytime. Observations in India showed that a pond could be loaded to 500 or 600 lb BOD/acre day without causing an odour nuisance, because during the day there was an aerobic layer above the anaerobic zone. The volatile acids and hydrogen sulphide formed in the anaerobic zone would permeate into the aerobic zone and were oxidised there. The advantage of keeping up these two layers was obvious - the ponds could be heavily loaded and therefore required less land than with completely aerobic tanks.

12. Figure 2 was based on the traditional approach for stabilization pond design, equating the BOD removed to the oxygen generated by the algae, which was in proportion to the area and the solar radiation. Moving northwards there was less solar radiation, and as the temperature dropped the bacterial activity would slow down. The figures on the map referred to sea level and corrections had to be applied for high altitudes. Because the basis of the map was only for aerobic reactions, an adjustment could be made to allow for stabilization taking place in the anaerobic zone - the figures could be applied to the BOD of settled sewage rather than raw sewage. The aerobic treatment only handled the settled sewage, and anaerobic treatment handled the settled sludge. However, where the temperatures were below 15°C anaerobic digestion reduced rather sharply, and therefore the loading should be based on the BOD of the raw sewage.

13. A depth of four feet was used by the Americans, as the development of ponds was started in the northern states with low solar radiation. But in India the solar radiation could penetrate to five or six feet, with a reduction in the land area required.

14. One of the most important benefits of stabilization ponds was the removal of pathogenic organisms. A three cell pond in series behaved much better than a single cell pond because there was less short circuiting. Generally the retention time in India was between six and ten days; at six days the indicator organisms reduction was over 99.99%. Due to extremely favourable conditions for sedimentation, treatment by ponds provided almost one hundred per cent removal of helminths and amoeba, and anaerobic conditions in the lower layers of the facultative ponds also contributed to their destruction. The removal of Salmonellae, as reported in the paper, was especially important. CPHERI had compared the elimination of coliforms in different treatment plants in India and found that stabilization ponds removed the maximum percentage. The reason for this was the high pH reached in the pond in the afternoons - as much as 9.5 and 10.

15. Maintenance was generally very easy. Some sort of a lining should be provided at the water interface to reduce the chance of mosquito breeding. Any scum should be either removed or pushed under the surface.

16. Dr MOHANRAO next dealt with the oxidation ditch. An experimental oxidation ditch constructed on the CPHERI campus had masonry vertical walls for ease of operation, as there was highly porous soil on the campus. The 3-ft diameter rotor, reduction gear and electric motor were assembled at the Institute workshop. The oxidation ditch was operated on the extended aeration principle, with a settling tank at the side; sludge was lifted by a screw pump and returned to the liquor. The oxidation ditch system worked at a high mixed liquor suspended solids (MLSS), 3000 - 4000 mg/l being maintained at Nagpur. With these extra solids it could take shock loads better. The organic loading on the micro-organisms was low and hence the excess sludge production was low; the sludge was already in a stabilised condition and could be disposed of directly without anaerobic digestion. In India loadings as high as 0.5 lb BOD/lb MLSS were possible, and 0.2 - 0.4 lb BOD/lb MLSS were not unusual.

17. CPHERI introduced aerated lagoons into India. The paddles were simple rectangular steel blades - a very simple mechanical system that could be made in India without difficulty. Aerated lagoons were traditionally of two types: in one enough power was provided to give complete mixing; in the other type, less power was used to mix the top layers, and there was settlement of sludge in the bottom layers. Complete mixing systems used 100 horsepower per million gallon lagoon volume, whereas with incomplete mixing only 10 to 20 horsepower was used for the same volume.

18. With the original system the effluent had the same suspended solids concentration as in the top layers of the lagoon. With incomplete mixing suspended solids built up from 50 to 500 milligrams per litre. So whatever suspended solids were developed would pass through because no settling chamber was involved. A settling baffle (as shown in fig. 3) had been fitted at Nagpur so that suspended solids would settle and slide back into the tank. The MLSS concentration was raised to 1500 - 2000 mg/l. This required slightly more power but anaerobic reactions at the bottom converted the settled sludge into methan and carbon dioxide, and the effluent had relatively little suspended solids, 20 to 50 mg/l. Table 4 gave data for the experimental aerated lagoon at Nagpur. As ten to twelve cubic feet of gas was produced per lb of BOD it was clear that the anaerobic reactions were going on smoothly and that a good amount of BOD reduction took place under anaerobic conditions.

19. Fig. 4 showed the variation of specific resistance of sludge against BOD loading for an oxidation ditch. As the loading on the ditch increased the excess sludge to be disposed of increased and the specific resistance was higher, so sludge treatment facilities would have to be introduced.

20. Dr MOHANRAO outlined the remarks in his paper about refuse collection and disposal. Composting of refuse had been carried out in India for a long time. In the Bangalore

process the material was often allowed to ferment by itself for up to a whole year. The Indore process had the advantage of temperatures of 65°C - 70°C, which tended to eliminate pathogens. The Bangalore process had the advantage that no labour was involved once the trench had been filled, and was the most common method.

21. Composting by mechanical means was almost unknown in India. There were a few incinerators, but the calorific value of the refuse was low and the moisture content was high, so it was necessary to add fuel. The most common method of disposal of refuse in India was uncontrolled tipping - dumping in low lying areas. Composted material was utilised as manure for agriculture after the proper period.

22. Night soil collection was very common in all the towns of India. CPHERI had made various attempts to reduce the obnoxiousness of collection, and had designed one or two types of wheelbarrows using buckets with lids. Certain precautions were being taken to reduce the fly and odour nuisance. The most common treatment method was disposal by trenching, but attempts had been made at Nagpur to digest the material, with some success. Because digested night soil was not completely free from cysts of round worms and hook worms, Dr MOHANRAO considered that the most satisfactory treatment would be digestion followed by composting using the Indore process.

23. Mr A. W. DESHPANDE congratulated Dr Mohanrao for his excellent paper. He had designed some of the oxidation ponds which Dr Mohanrao had mentioned. He asked what length-to-breadth ratio had been chosen; and he asked for further details of inlet arrangements to the ponds.

24. Dr MOHANRAO said the preferred breadth to length ratio was between 1:2 and 1:3, although it could be up to 1:4. If three cells were to be provided, there might be advantage in making two primary cells in parallel and the third in series with both. This would have the advantage that the system could remain in use when one of the primary cells was closed (once in four or five years) for the removal of accumulated sludge.

25. The inlet arrangement had two objects: to reduce short-circuiting and to provide maximum distribution space for the sludge. The inlet at one third of the length from an end was used in the United States to distribute the sludge. On the other hand, multiple inlets gave better chance of distribution of the liquid and reduced short-circuiting. Another type was a masonry channel extending along the whole of one end, giving a sort of a plug flow system and had the advantage of reducing short-circuiting as well.

26. The CHAIRMAN remarked that Dr Mohanrao had tilted at western sophisticated sewage treatment plants such as filtration and activated sludge. However sewage treatment had been empirical until a very short time ago. Dr Mohanrao had put forward three possibilities for India: stabilization ponds, oxidation ditches and aerated lagoons. This was very much related to economics - what should be used immediately and how things would develop.

27. Mr K. V. ELLIS had noted in the paper that increase in pH in the stabilization ponds helped to kill off the pathogenic organisms; did this also have adverse effect upon the necessary micro-organisms for purification? There had been a high intensity of gas production in the aeration lagoons. Obviously as well as the methane, a great deal of carbon dioxide was given off; did this have any effect on pH in the system? It would be expected that algal growth would result in a rise of pH during the day; was this countered by the production of carbon dioxide in the anaerobic zone? Regarding night soil digestion, Mr ELLIS asked whether the experimental digestors were stirred and at what temperature were they operated.

28. Dr MOHANRAO said that pathogens had a more limited range of optimum conditions for their survival than saprophytes. The higher pH of 9.5 was not found inimical to the normal bacteria growing in the stabilization ponds to the same extent and this was reflected in the performance.

29. The aerated lagoon at Nagpur was green at the start, but as sewage was added and aeration started it turned brown like activated sludge, and algae had not been found where there was proper aeration. Dr MOHANRAO had often wondered why algae did not grow in activated sludge units, oxidation ditches and aerated lagoons, and was still looking for an answer. Carbon dioxide production did not radically change the pH in the aerated lagoons.

30. CPHERI had investigated night soil digestion in two ways. One digester had a dome to collect the gas with a fond hope of utilising the gas for kitchen or other purposes. Unfortunately the apparatus was expensive and troublesome to maintain, especially in a village or a small town in India. Incidentally most of the digester gas even in the larger cities in India was burnt in a waste gas burner. At one sewage plant a dual-fuel engine was installed to generate electricity, it being intended that oil would only be used when gas was not adequate, but now after ten years that was working entirely on oil. It was therefore doubtful as to whether it was worth the expense of providing a dome, gas pipes, water traps, flame traps and whatnot. The second type of digester had no dome; it worked well except that it formed a scum layer which could generate domestic flies. To avoid the fly nuisance it was necessary to stir with

bamboo two or three times a day. As soon as the scum was broken down the fly generation stopped and incidentally the organic matter returned to the medium for better digestion.

31. Mr A. M. BRUCE added his congratulations to Dr Mohanrao on a very excellent paper, full of useful data which would be used by engineers and research workers for a long time to come.

32. Various people concerned with stabilization ponds had commented that they tended to produce effluents that looked like pea soup with high concentrations of algae, and it was mentioned in the paper that the BOD concentrations were 50 - 60 mg/l which could render them unsuitable for discharge to some rivers. Possibly all this BOD was attributable to dead algae rather than organic matter from the sewage. Mr BRUCE asked the degree to which control measures were necessary for stabilization ponds. Was it just a matter of designing the right loading and letting the pond get on with it, or was it necessary to adopt any sort of control measures? Could the system get out of balance if, for instance, sludge digested too vigorously at the bottom and sludge particles rose up to the surface? To what extent was mosquito-control a problem? Finally, Mr BRUCE wondered whether facultative operation was the most efficient system since anaerobic and aerobic processes were incompatible.

33. Dr MOHANRAO said that BODs of 50 - 60 mg/l had to be accepted in the winter when the temperatures and solar radiation were relatively lower. But he had walked around the 63-acre oxidation ponds in Ahmedabad in the summer when water pollution was most critical and the effluent was not like pea-green soup - it was crystal clear with algae floating around like emeralds. BOD of 50 - 60 mg/l might not be acceptable in western countries but in India where 300 - 450 mg/l BOD was discharged to rivers and where sewage was irrigated on vegetables this was a great improvement. The standard could be improved by adding another cell, which would increase the cost but would bring the BOD down to below the 20 mg/l limit.

34. Good design would go a long way towards efficiency but maintenance should not be neglected. Control of weeds was the first priority. Stabilization ponds could go out of balance if sludge was not removed for too long a time. Rising sludge rafts might pass to the second cell if there was one, or pass out with the effluent and deteriorate the quality. Very occasionally in the CPHERI experimental plant which was grossly overloaded a crustacean called Moina dubia took over, grazing on the algae, and the oxidation pond no longer looked green but greyish. When ponds were designed for the ultimate population of the city and only one fifth of the population was connected to the sewers and the sewage was admitted into all the five or six ponds each pond had only a foot depth of water some ponds were even drying out. In such circumstances the flow should be used to fill one pond after another. Some new ponds lost water by percolation but became clogged after some time. It was preferable not to allow the seepage if there were shallow wells around, but if there was no danger of groundwater being polluted the ponds could be allowed to seal themselves. Mosquito-genesis was one of the greatest worries especially from the medical side, and oxidation ponds in India were restricted for about five years because of the apprehensions of the medical people. CPHERI had conducted several studies with mosquito nets etc to collect mosquitoes and had found that if banks were adequately lined and kept free from weeds there was no mosquito genesis. Mosquito larvaes could be controlled by gambusia fish, which could survive on very low dissolved oxygen.

35. For some time Dr MOHANRAO had felt that an anaerobic lagoon should precede the oxidation pond but from the experience at Nagpur and other places it was found that the grey appearance of the anaerobic lagoon could be avoided by using the facultative pond, in which the lower layers were anaerobic and the top layers were green. Even when an anaerobic lagoon preceded oxidation ponds there was not ideal efficiency. At a distillery, an anaerobic lagoon was followed by a series of eight oxidation ponds, but the first two or three were grey.

36. Mr M. A. ACHESON asked if there was a great fluctuation of pH in stabilization ponds, and whether any research into the collection of algae and the preparation of protein concentrates from it had been done at Nagpur. There had been some work on this in Thailand and Japan, using the excess algae for protein concentrates which could be used for animal feed. Dr Mohanrao had mentioned gambusia as a possible predator on mosquito larvae; had CPHERI done any work on fish culture as an additional form of protein?

37. Dr MOHANRAO said that pH variation in stabilization ponds followed a sinusoidal curve, with peaks in the afternoon at pH 9.5, and troughs at night between pH 7 and 6.5. With six day retention sewage passing through a pond would meet six peaks and this apparently eliminated the Salmonella and some of the other more delicate bacteria.

38. Many people, especially the Americans, had spent a great deal of money in harvesting algae from oxidation ponds, but there was still no satisfactory method. The collection and harvesting of these microscopic algae was very troublesome, but Dr MOHANRAO suggested that the oxidation pond effluent should be allowed to

flow over grass plots, where algae would be trapped. When the grass was cut and fed to cattle they would receive the algal protein. Fish culture was used at a steel town called Bhilai where the sewage was relatively weak. In two large ponds in parallel edible fish weighing 4 - 6 lb were harvested.

39. In reply to a question by Mr T. J. LEONARD, Dr MOHANRAO said that sludge accumulation was 1 - 2 cubic feet per head per year. It was found in India, where labour was cheap, that the value of the sludge exceeded the cost of lifting.

40. Mr H. T. MANN had seen pond systems dealing with an influent strength up to 1500 mg/l BOD. He asked for advice on initiating oxidation ponds, which often gave rise to difficulties in subsequent operation if they were not started properly.

41. Dr MOHANRAO said that sewage in India usually had a BOD strength of up to 500 mg/l, although sullage in slum areas had a BOD of 1500 mg/l showing that it was a slurry of night soil.

42. In India the best way to initiate a pond was to dig it before the monsoon and allow it to fill during the monsoon by rainwater; then sewage could be admitted when the pond was full of water. If this could not be done the pond should be filled by stages of about 6 inches each day. There might be poor efficiency in the beginning, but it would reach full efficiency in two or three weeks. Mr MANN suggested that a channel should be constructed down the middle with an earth bank on either side, so that there was a smaller area of pond to be initiated. Dr MOHANRAO thought this might add too much to the cost of construction.

43. Mr M. E. D. WHITE asked if Dr Mohanrao had any experience of urban communities with stabilization ponds serving only part of the community and night soil collection for the remainder, where the night soil was treated in stabilization ponds. He also wondered whether in the initial stages of the sewerage of the town stabilization ponds could be constructed with a view to gradually uprating their capacity by providing floating aerators.

44. Dr MOHANRAO said that night soil had been treated in stabilization ponds in South Africa. Night soil had 10 - 15% solids - 100 000 - 150 000 mg/l compared to 1000 - 2000 mg/l solids in sewage. It was necessary to provide dilution water from a river or well, or to use sullage. The water requirement could be reduced by using some of the effluent for re-circulation, but this was limited by the build up of inorganics and ammonia.

45. Floating aerators could be used to uprate stabilization ponds but it would be necessary to deepen the ponds. Generally oxidation ponds had a depth of not more than 5 feet but with floating aerators at least 8 feet depth was required.

46. Mr A. D. BARRETT had noticed on one of Dr Mohanrao's slides that the pond banks were unprotected, and asked whether there had been erosion from wave action or heavy rain. Dr MOHANRAO said that the pond in question was at a place where alluvial clay was predominant and there was little problem of erosion. With lighter soils the banks could be lined with random rubble although a less expensive method was to use puddled clay. Bricks, with or without mortar joints could also be used. On the top and the reverse banks turfing was useful.

47. Mr J. C. HOWARD observed that in the paper it was stated that the elimination of pathogens was one of the most important objectives of sewage treatment. He asked what work on the control of pathogens was undertaken at Nagpur, and in particular had CPHERI studied the best conditions to eliminate the cholera vibrio in sewage.

48. Dr MOHANRAO said there was a Microbiology Division at CPHERI. Little work had been done on cholera, but there had been extensive studies of typhoid and helminths. Mr MANN said that mention had been made of the use of grass plots as a method of isolating algal protein. One of the particular advantages of grass plots was the high rate at which pathogens were removed by grass plots. With rates of application of 0.85 cubic metres per square metre per day Coliform removals of up to 90% were obtained.

49. Mr M. F. G. ARCHER had been surprised at the amount of sewage used for irrigation in India. In some towns in Libya treatment plants were being installed to tertiary treatment standards with chlorination of effluent intended for irrigation of crops. What was the incidence of disease propogation in the irrigation areas of India because of the use of crude sewage? Dr MOHANRAO did not approve of crude sewage irrigation. CPHERI had made a survey of the farm workers who utilized sewage for irrigation, and found that there were subject to a much higher rate of enteric disease and some lung diseases than workers on farms using unpolluted water. If less than 10% of the area used for sewage farms were allocated to oxidation ponds, there could be a relatively pathogen-free effluent which could well be used on the remainder of the farm. Chlorination had been found to be very difficult in India, and Dr MOHANRAO would avoid all chemicals, as most chemicals were expensive in developing countries.

50. The CHAIRMAN asked whether at this stage Dr Mohanrao was satisfied with a BOD of 50 - 60 mg/l for irrigation. Dr MOHANRAO said he

regarded elimination of pathogens as more important than reducing the BOD to 20 mg/l.

51. Mr P. G. STANLEY referred to the absence of the nuisance from odours because of the positive oxygen content in facultative ponds during the day and wondered whether overloaded ponds in which the oxygen was entirely deficient at night presented an odour nuisance at night. Dr MOHANRAO said that provided there was one foot of aerobic layer during the day, there would be enough buffer to provide oxygen at the surface layers and to prevent odour nuisance, during the night.

52. Mr R. J. OWENS asked how far metrification had progressed in India. In Table 3 of the paper the price of land was quoted at £550 per acre which seemed quite expensive. Was this fairly typical of the more rural land in India? In the same Table in section 4 there was a large range of costs for conventional schemes, which must be due to various factors, although only size had been mentioned. Had the economic life of all plants been taken as the same in this Table? Mr OWENS asked Dr Mohanrao to comment on the removal of pathogens in conventional plants. Finally in connection with digester capacity, Dr Mohanrao's figures gave a 30 day retention, which was fairly conventional in Britain. Apparently pathogens were removed but parasites were not. Was this due to the operating temperatures in the digesters being about body temperature?

53. Dr MOHANRAO said that India was slowly changing to the metric system. Land cost 10 000 rupees (about £500) an acre on the fringes of the cities, but was less in rural areas. A higher figure was given in Table 3 so that the disadvantages to the conventional treatment would be minimum. The cost per capita of the treatment plant varied in the way shown in figure 3 , and details had been given in CPHERI Technical Digest No 10*.

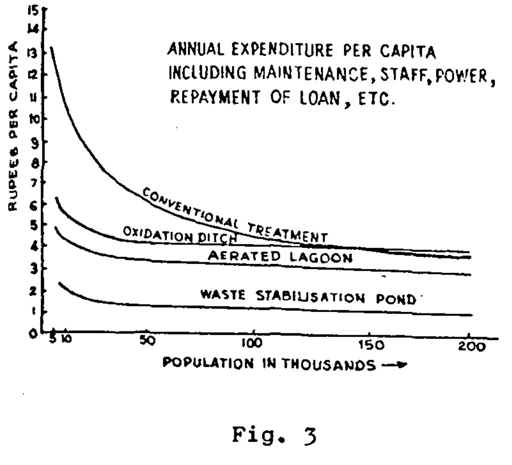

Fig. 3

*Copies of the complete series of CPHERI Technical Digests and other CPHERI publications are held by the Editor at Loughborough.

54. Digesting night soil was more difficult than digesting sewage sludge. The night soil was rich in nitrogen and this created a problem when the loadings on the digester were increased. There was a build up of ammonia, which was toxic to anaerobic digestion above certain limits especially when the pH was high. With 30 days' retention some of the pathogens were killed but egg-laying pathogens like the Ascaris and Ancylostoma were hard to eliminate, unless exposed to temperatures above 55°C. Thermophylic digestion of night soil would give better removal of pathogens but it was difficult to maintain the temperature at 55°C. Other methods of eliminating pathogens were to post-heat digested night-soil or to use digested night soil for composting.

55. Mr P. K. JAIN wondered whether mechanical composting plants were suitable for Indian conditions. He suggested that an inexpensive disinfectant such as lime could be used for raw sewage intended for irrigation, and that bacteria and viruses might be removed by passing irrigation water through slow sand filters.

56. Dr MOHANRAO said three or four cities in India were actively considering the economics of mechanical composting, but Indian refuse had a low nitrogen and phosphorous content, and most of the mechanical compost plants were expensive. Regarding the use of chemicals, chlorine would not attack pathogens in preference to organic matter so the demand for chlorine by raw sewage was too high. Lime would have to be dovetailed to agricultural requirements; if the pH was too high on an already alkaline soil it might not be good. Generally India had more alkaline soils than acidic soils. It was harder to eliminate viruses than bacteria. So to be sure of eliminating viruses by chlorine the effluent must be very pure. Dr MOHANRAO agreed with the use of slow sand filters in adjunct to sewage treatment to eliminate some of the pathogens.

57. The CHAIRMAN thanked Dr Mohanrao for presenting a most valuable and comprehensive paper and for the splendid and comprehensive manner in which he had answered the various questions that had been put to him.

J. W. LOVATT
& P. I. HELMORE

The organization of overseas work

INTRODUCTION

The previous papers presented to this Conference have dealt with the specific problems associated with water supply, sewerage, sewage treatment and the built environment in hot climates and the developing countries. The purpose of this paper is to consider some of the problems which arise when the works come to be implemented.

The problems will be better appreciated if we look first at the general situation in the developing countries. It is a matter for great concern because statistics show that two-thirds of the world population now live in these regions which include South and East Asia, Africa and Latin America and 85% of all childbirths that occur in the world today take place in these sectors. It has been estimated that the population of the developing countries is increasing by one million people each week and the fact that, generally, they are located in regions of climatic extremes adds considerable to the problems. Poverty, hunger and illiteracy abound and the bleak mathematics of population growth leave no doubt about the threat to humanity in the developing countries. Technological and scientific advances in communication media have brought a new awareness to the people in these countries that poverty is not their natural and unavoidable inheritance. There is growing concern about the ever widening gap in living standards of the richer and poorer nations and the tensions which this situation generates.

Vast expenditure is required to resolve this situation and it will be the engineer's task to ensure that available finance is expended to give the greatest good. It is an increasing feature of the engineer's role, however, that final success will depend on his ability to convey to all concerned a clear sense of the direction of development activity and to take a positive interest in the reactions. It is no longer sufficient for the engineer operating in the developing countries just to exercise his technical competence and skill. Progress will be measured by his ability to understand and interpret the physical, political and cultural environment in which he is operating and this will almost certainly involve matters which transcend the normal scope of his profession. He must, therefore, acquire a much firmer grasp of the social, economic and ecological consequences of his operations and the past mistakes of the more industrialised nations, when everything was sacrificed to economic gain, will then be avoided.

It is against this background that the engineer operating overseas today has to conceive his solutions to a particular problem. The procedures for the implementation of the works are involved and complex and they do not follow any fixed pattern. Much will depend on the location of the country, its climate and geological formation, the form of government, the economy and, most important of all, the availability of finance. Nothing is possible without it but it is not necessarily a problem in all the developing countries. The oil rich nations of North Africa and the Middle East, for example, have money available for their development projects. They can establish the priorities, instigate any projects they please and commission experts to implement them.

The majority of the developing countries, however, are not so fortunate and, generally, they must rely on financial assistance from the more developed and richer nations either in the form of direct aid or by loans channelled through the international monetary agencies. Much has been achieved by this international co-operation but it has been calculated that the financial aid is, at present, still only one-third of what is required.

The procedures for the loan of international finance can be lengthy and complicated. Invariably they involve a feasibility study with no assurance that, on completion, the works will be implemented. The engineer will be involved in assessing and demonstrating the viability of his proposals and it is no simple matter always to measure the improvements to the well being and health of people in monetary terms. There is no doubt that the engineer operating overseas in such circumstances carries great responsibility in assessing and deciding with the economists, accountants and the politicians what is appropriate in any particular place. Local conditions vary considerably but there are basic factors common to all the developing countries which must be taken into account in implementing any project overseas, whatever the discipline may be. The most important of them are listed below and they fall conveniently into three groups, viz. design, construction and operation.

(a) <u>Design</u>

i. Site investigations
ii. Design Considerations
iii. Availability of Materials

(b) Construction

i. Climate
ii. Availability of Labour
iii. Contractor's previous experience
iv. Local customs and religion
v. Communciations
vi. Contract Documents
vii. Supervision of Works

(c) Operation

i. Training

SITE INVESTIGATIONS

Before commencing any designs the engineer would be wise to carry out detailed site investigations for local conditions will greatly influence his designs. Apart from the usual engineering investigations into ground and subsoil conditions, the availability of materials and labour will play an important part in the design and implementation of the works. The engineer must use local materials to the largest possible extent and he may be confronted with materials he is not familiar with and which may have a quality standard lower than he would consider acceptable in his home country. The investigations will almost certainly reveal a shortage of skill and experience in the labour to be employed and it may not even exist at all in any quantity. It will inevitably be less productive and greater numbers will need to be employed to produce an output equivalent to that in the more developed countries.

DESIGN CONSIDERATIONS

It behoves the design engineer operating in the developing countries to keep his designs as simple as possible and to avoid complicated construction features and sophisticated equipment. This is particularly important in countries where there is a shortage of skilled labour both for construction and subsequent operation and maintenance. His designs should, therefore, be simple and robust, maybe even a little out of date if this makes them easier to understand, to construct and to operate. In his enthusiasm always to improve on what has been done before the engineer is in some danger of imposing on a people something for which they may be quite unready and which will fail through inexperience and lack of operating skill. Progress is a fine thing but it has no mandate to change things overnight. It can still be achieved, however, providing the engineer takes into account the local conditions, accepts them and then, with a little ingenuity, exploits them to create something from the minimum of human and physical resources which will give some material benefit to the local people.

The engineer must understand that the works and equipment will possibly be misused, not intentionally, but through ignorance and inexperience of its operational features and lack of proper maintenance. Not only must they be simple to construct, therefore, but they must be simple to maintain. This applies particularly to mechanical and electrical equipment which can become unusually temperamental when installed a long way from home in climatic conditions not fully appreciated when it was designed and manufactured.

Design specifications for such equipment must be comprehensive and detailed both as to its protection during transport to a particular country and the conditions under which it will have to operate when it arrives.

AVAILABILITY OF MATERIALS

The engineer would be wise to consider the availability of materials for construction. It is not unusual to find a complete dearth of any constructional materials such as timber and cement and even local aggregates can be unsuitable. By their very nature developing countries have limited industrial facilities for the manufacture of steel, pipes and mechanical equipment.

The engineer will need to take these factors into account at the design stage in order to exploit such local resources as are available to the full. The importation of materials will add considerably to the cost and he will need to examine the resources of neighbouring countries to minimise transportation charges. If materials are arriving from several countries a carefully co-ordinated delivery programme is essential.

It must be remembered that manufacturing techniques and standards vary between one country and another and the engineer must investigate these in detail and, where necessary, adapt his specifications to conform with what is reasonably possible and practicable in the particular circumstances. He must also learn to improvise for despite the most detailed forward planning materials do not always arrive on time.

The exploitation of local resources is not always so simple as it may first appear. Despite pre-contract promises that they can be exploited the arrival on site of the construction teams is often the preliminary to endless negotiations and bargaining as to the prices to be paid and these can rocket overnight. The acquisition of land and opening up of quarries for aggregates can, for example, be a tortuous business particularly where alternative sources are limited or even non-existent. Simplified testing techniques may have to be established for quick checks on the quality of local materials.

CLIMATE

Allowance must be made for extremes of temperature which in a single country can vary from near freezing to the lower fifties centigrade. Very often construction work can be interrupted by sand storms and periods of torrential rain. Blown sand can play havoc with mechanical plant during site storage; transportation and erection and maintenance costs are high where these conditions occur. Heavy rain, lasting sometimes for several days, can seriously interfere with progress of work by washing away access roads and destroying excavations completely. High temperatures necessitate special arrangements for curing of concrete. Sometimes they necessitate staggering of working hours and the introduction of shift working to avoid the hours of temperature peaks. This imposes onerous working conditions on site supervisory staff. Considerable lethargy can occur amongst all concerned and constructional programmes are soon upset.

The health hazards are obvious particularly when a Contractor is operating in a country other than his own and his labour is unused to violent climatic extremes, the local food and standards of hygiene. Medical facilities can be very limited in some places.

AVAILABILITY OF LABOUR

The construction of a major project in a developing country involves the recruitment of a large labour force for local resources are often extremely limited both in numbers and skill.

It is usually a Government requirement in such countries that local labour be employed to the full, and indeed, that it be given priority, even though it may be completely inexperienced. Inevitably, the contractor will have to import skilled labour, supervisors, managers etc. and possibly several hundred unskilled labourers as well. The processing of visas, work permits etc. is a mammoth task in some developing countries, particularly where there is an inexperienced administration.

Language difficulties can arise and a labour force of mixed nationalities presents endless problems. Often they are quite incompatible as a result of local habits and customs. The contractor might well be faced with the necessity of establishing large labour camps with suitable housing, messing and entertainment facilities. If these are in remote areas the feeding of a large labour force and the disposal of its wastes present considerable problems in organisation and management.

It is, perhaps, not always appreciated that a contractor may be operating in another country because there is insufficient work in his own. He may be subsidised by his Government which may be seeking foreign exchange and his labour force may have been directed to work overseas, possibly unwillingly. This is not always conducive to happy relations and maximum effort in the execution of the work. Labour is not easily and quickly replaced when there are complicated procedures to be complied with regarding visas and work permits.

CONTRACTORS PREVIOUS EXPERIENCE

Construction of a major project in a developing country will usually attract tenders from a variety of international contractors. They will have their own methods and standards of workmanship peculiar to their own country but these might well prove inadequate elsewhere, particularly if the Contractor is now to operate in a discipline of which he has no previous experience.

Specifications for materials and workmanship must be detailed and clear as to what is required of the contractor. Tenders will need to be carefully compared to ensure that the requirements have been fully met and there are no ambiguities. When the successful tenderer is known a visit to his country is helpful to inspect works undertaken by him, to discuss and resolve possible difficulties in interpretation of the contract documents and to interview site supervisory staff. Language is an obvious problem which can cause endless communication difficulties on site.

LOCAL CUSTOMS

It is extremely important that all concerned with the execution of a project in a country other than their own acquaint themselves with the customs and habits of the local people. Apart from being discourteous, any attempt to override or ignore century old traditions and religious practices is to court disaster.

Some countries appear to have a constant stream of public holidays and feast days some of which may on occasion be declared overnight and without prior warning. They can last one or several days completely dislocating work schedules and leading to claims for delays.

Interference with the rights of way of local people and their animals can be troublesome while accidents and injuries to either may cause endless wrangling in the Courts.

Considerable patience, tact and understanding must be exercised in all relations with the local inhabitants.

COMMUNICATIONS

It may seem strange in this modern age to have to refer to communications but there are still many countries where they, or rather the lack of them, can be extremely frustrating. The postal and telegraph services are often inefficient and transport non-existent. When it would be desirable or comforting to seek advice or guidance of one's superiors it is often quite impossible without interminable delays. Supervisory staff have, therefore, to be much more self-reliant and capable of making on-the-spot decisions involving considerable sums of money.

Aircraft, carrying some vital spare part, arrive late. Bulk materials travelling by sea are delayed by the weather, strikes in some port thousands of miles away prevent them being loaded and when they arrive the dock facilities may prove inadequate for unloading. Onward transmission to the site over poor roads, or no roads at all, can be a hazardous business resulting in damage or breakages to materials urgently awaited at their destination.

CONTRACT DOCUMENTS

The preparation of documents for international tenders is an onerous task as they will be interpreted differently by Contractors of varying nationalities. Very often the employing authority has its own contract conditions which are, at times, penal in their effect on the Contractor and restrict the authority of the engineer. It is not always appreciated by the employer that the engineer also has a duty to the Contractor to ensure that he gets just and fair payment for the work executed particularly that which could not have been reasonably foreseen.

Any reference to standard specifications or codes of practice should be explicit and made with care. What is easily complied with in a highly developed country may be quite impossible in another where development is just commencing.

Local manufacturing arrangements can often be instituted to produce on site something which would otherwise have to be transported hundreds of miles and specifications should provide for this to be done if money can be saved thereby.

The Conditions of Contract should include particular clauses to cover any special local requirements or customs which may affect the progress of the work, particularly those which restrict the Contractor's commonly accepted activities.

SUPERVISION OF WORKS

Operating in a country overseas the engineer may well find himself involved in much more detailed supervision than would normally be the case. This applies particularly when the Contractor is from another country, too, and constructing works, of which he has no previous experience with poor quality labour.

It is fairly common for the engineer's site staff to find themselves performing menial tasks and instructing workmen themselves as to how a particular operation is to be carried out. The lower the skill of the labour the greater is the degree of supervision necessary and more site engineers are usually necessary on overseas work if standards are to be maintained.

A responsible contractor and his workmen will usually welcome instruction in executing works of which they have no previous experience and the engineer will have the satisfaction of having established proper standards of workmanship from the beginning. This co-operation can result in a finished project having a quality higher than is sometimes achieved in the more developed countries.

TRAINING

Whatever the discipline the completed works cannot operate satisfactorily without skilled operators particularly if the project includes any quantity of mechanical and electrical equipment. It is unlikely that suitable operators will be available locally and the engineer usually becomes involved in setting up some training programme locally or for selected personnel to be trained on similar installations in another country.

This task is not so simple as it may first appear for, not only is it common to find a lack of basic education, but it is difficult, in some countries, for workers to apply themselves to routine tasks for any length of time if this has not been their way of life. Training of personnel in another country does not always carry a guarantee that they will return to their own and accept the post for which they have been trained. As industrial activity develops counter-attractions appear in other spheres and it is understandable that trained personnel will exploit this situation to their material benefit.

The Author's experience is that under expatriate direction and Government control, training programmes are best carried out locally. They can, however, be time-consuming and frustrating and they require great patience and understanding of the local temperament and customs. The engineer must be in no hurry to depart from his completed works until he is quite satisfied that they are understood and will be operated and maintained properly.

It will be necessary to impress on the controlling Authority or Government Department the need to maintain adequate stocks of stores and spares. There is a strange reluctance in some countries to do this and very often a complete lack of understanding that new equipment needs any maintenance at all.

CONCLUSION

The main conclusion to be drawn from most of the various points set out earlier in the Paper is that successful participation in overseas work demands a very flexible approach in the design and organisation methods to be adopted.

As Engineers who have been trained and who have probably received most of our working experience in developed countries, we may have become mentally adjusted to established working methods and standards that have been evolved there. We must, however, recognise that such methods and standards may not be sensibly applied to all circumstances. This is not an argument for accepting "second best" but rather for acceptance of what is adequate for the particular requirements and can be readily achieved. Some real, although limited, achievements by simple methods are infinitely better than probable failure due to over sophistication.

In this respect our teaching institutions and all of us who take part in the training of students of Environmental Health Engineering from overseas countries have some part to play. When these students complete their training and return to their own country they often take up important positions with some influence on Environmental Health Engineering in their country. It is then important that they should understand that the working methods and standards that they have experienced in the developed countries may not be applicable or may take a long while to achieve in their own country and that they should have some understanding of what is necessary and can be achieved in their local circumstances in the immediate future.

Some flexibility should also be applied to the scope of work which the engineer recommends for a project. In considering the scope of a project and its objectives allowance must be made for the future but when this is done in respect of a developing country we are dealing with a period in which great fundamental social and economic changes must be expected. The nature and extent of these changes will not be predictable and neither is the speed by which they will occur but they are likely to have a significant effect on future public health requirements. In defining the scope of a project the engineer will consider the problems and the works necessary to provide solutions. In the case of developing countries it may be possible to start such considerations without the constraints of existing or previous systems. This should provide the engineer with the opportunity to influence the problems at source so that he can avoid difficulties which would probably be outside his control in a more developed society.

It is important that the engineer grasps this opportunity for he has a vital part to play in dealing with the problems overseas. If he is to make any real impact on the situation, however, he must adapt his thinking to the rapidly changing conditions. The economist will almost certainly insist that he does so, because the environment in the developing countries is changing at such a staggering rate that anything built there now might well be obsolete within a normal life span. The economist will argue that in this present financial climate we cannot afford to build for eternity. Labour and money are too expensive and with discount rates at such high levels, we can no longer afford to provide for generations as yet unborn.

It is difficult for the engineer to accept completely this philosophy for he is not accustomed to designing for obsolescence in his own lifetime. It must, however, influence his approach to the design and construction of works in the developing countries in view of the particular conditions which now exist there. It is a situation of tremendous challenge and opportunity for the engineer with an interest in Environmental Health Engineering which has been the theme of this Conference.

With tact, patience and a proper understanding of the problems, however, he could gain considerable satisfaction in overcoming them. At the same time he will have made a valuable contribution to the health and welfare of the people in the developing countries. He will certainly return to his own country a more able and wiser engineer and more understanding of his fellow men.

discussion

CHAIRMAN: J. H. J. WATSON, FICE, FIMHE, MIWE,
Immediate Past-President, Institution of Public Health Engineers

The CHAIRMAN said that Mr Lovatt had been ordered by his doctor to rest for a couple of weeks and therefore Peter Helmore would deal with the whole paper.

2. Mr P. I. HELMORE said that the paper dealt with the organization of works in overseas countries in three categories: design, construction and operation. The paper outlined some of the problems facing the engineer in the execution of work in developing countries. Much of the discussion on previous papers had been concerned with low cost works and lack of finance in these countries, but this paper was oriented more to larger projects looked at from the consultants' view. Nevertheless some of the conclusions drawn in the paper were very much in line with some of the comments that had been made on the other papers.

3. Because of the widely varying circumstances in these countries the problems did not follow a fixed pattern and much depended on the location and climate, economy, and sources of finance and particular discipline in which the work was done. The authors had commented on the physical problems of developing countries and also upon the need for engineers to free themselves from the political and engineering constraints of the developed countries. There was an opportunity for the engineer to become more involved in the basic policies in development with all that this implied, and engineers should grasp this opportunity with both hands because their status in the developed countries had tended to become eroded in recent times. On the technical side there was a need to adopt simple but robust methods and not to impose upon a people sophisticated systems or techniques for which they were unprepared and which were unnecessarily expensive in the particular circumstances.

4. Mr HELMORE showed slides of work in Libya which illustrated the problems of developing countries that had been referred to in the paper. His firm had been concerned with the design and construction of public health projects in Libya both before and since the discovery and exploitation of the large oil resources there. Libya could still be regarded as a developing country even though its financial resources were relatively limitless. This affluence had meant that necessary projects had not been delayed or stifled due to lack of financial support, and it had been possible to gain a wide variety of experience in a relatively short period. Even though financial resources were readily available most of the other problems referred to had arisen.

5. The first slides showed the physical characteristics of the country, and views of some of the towns. Around the towns, there was a drift of population and shanty type accommodation which was gradually replaced by modern housing schemes. Libya had no rivers and there was no surface water except in the winter, when there tended to be too much. There were good sources of underground water, adequate for the population's needs at their present level, although they were being supplemented by desalination schemes in certain places. However, there was insufficient water for irrigation. Libya was a country of great contrasts. Summer temperatures in the desert areas and even on the coast could be well up in the 40's but there was a severe contrast in the hills in the winter and even the occasional snow.

6. Libya had a very good road system, but transport in under-developed countries could be a great problem. Some roads in Libya suffered from washout problems in the winter at Wadi crossings, and from being buried under the sand whenever there was sufficient sand movement. Transport of imported materials might prove difficult, and there was need to ensure that equipment was adequately packed and loaded and unloaded carefully. Local

materials, such as media for biological filters, should be used whenever possible. Libya was somewhat unfortunate in terms of construction materials; there was a certain amount of good stone which was adequate for aggregates but these were often at considerable distances from working sites. There was no good natural sand for building purposes, and crushed stone often had to be used for fine aggregate. An extreme case was when sand was shipped from England to Libya for use in rapid gravity sand filters.

7. One of the problems of construction had been the narrow streets in which sewers had to be laid. Traders and the population attempted to carry out their normal way of life and were more tolerant than people in industrial countries. Safety during construction was difficult, as barriers tended to be removed.

8. The Benghazi and Tripoli sewage treatment plants were constructed to take all the foul sewage from the cities and treat it to a standard where it could be reused for irrigation on farm projects around the treatment plants. The effluent standard which conditioned the type of treatment required that the water be suitable for irrigation and should also be non-harmful to anyone who took it, as nomads would, for drinking purposes. In a desert area it was somewhat hazardous to produce water that looked clean and expect the local people to know that it was bacteriologically polluted. At Sebha in the south of Libya effluent was pumped through a main across a market garden area and the local farmers had hydrant points from which they could take off effluent to grow their crops.

9. Mr HELMORE had used Libya as an example for illustration purposes of the way in which the problems described in the paper had been dealt with. The overall message was that engineers should use their influence to bring about more practical achievement in construction of projects and less on elaborate paper exercises, and that design and construction techniques could be readily achieved in the localities. There was much more benefit from achieving something simply than providing something sophisticated which failed.

10. Mr R. J. OWENS congratulated the authors on the interesting paper and particularly the slides. The paper could almost be used as a manual for those who intended working overseas, if they were not frightened by its contents. The theme of the paper was that schemes depended on the technical skill of the engineer plus political, social, economic and ecological consequences of his actions and particularly on finance which was something that normally was in short supply. The engineer was often required to assess the benefits in monetary terms and one of the biggest problems was to obtain data showing the cost of disease and the associated cost of domestic and industrial inefficiency. These attempts were often wrong because most schemes could not be assessed purely on a financial basis. More use should be made of statistical evidence to justify schemes.

11. In developing countries when an original investigation was carried out, there were often few developed natural resources but as the scheme proceeded many people took an interest in supplying basic materials. 'Availability of materials', therefore applied not only in the design stage but also in the construction stage. Often factories were built to produce pipes, for example, and embargos were placed by the government who often helped to finance the factory.

12. Mr OWENS emphasized the importance of simple things like labelling of imported packages, so that it was clear whether the contents required housing indoors or could be left out of doors.

13. It was becoming more common for consulting engineers to assist in training of overseas personnel, and this was a great benefit to developing countries.

14. Referring to standards, Mr OWENS told how he had been involved in providing surface water drainage channels in Kano, north Nigeria. The channels were trapezoidal and the banks were retained by concrete blocks cemented together with a slight inclination from the vertical. It could not be proved that the walls would stand up, but nevertheless existing walls were standing up. A decision had to be made whether to design to British Standards which would produce a much flatter slope to the side of the channel or build to the existing standard accepting that perhaps 5% of the wall might fall down. Economically it was better to design generally to the local standards and allow for portions of the wall to fall down than to design to more sophisticated standards and provide a much more expensive scheme.

15. Mr M. F. G. ARCHER stressed the importance of design being suited to the particular local circumstances to facilitate construction and to facilitate operation and maintenance. Matters which warranted attention included easy access to points of inspection and maintenance and to valves, etc. Spares were consumed at an enormous rate in these countries for various reasons, and designers should make sure that ample spares were allowed for in the contract documents - preferably one set of spares for two years operation and another set for five years operation. Tools were also important, and some machinery required special tools, the absence of which could cause con-

siderable headaches. Instructions on operation and maintenance were essential obviously and should be provided in the local language or languages as well as English. It was essential to give thought at the design stage to the possibility that no maintenance at all would be done. When designing pumping stations it was good practice in some areas to provide in addition to each duty pump, one standby and one to be in pieces. Precast work, particularly precast manhole chambers and culverts made for ease of construction. Sewers should be as shallow as possible, particularly bearing in mind that skilled labour was in very short supply, and there was often a different interpretation of what constituted "skilled" labour.

16. Professor M. DANBY was concerned about the training of local professionals. Often ex-patriate consultants brought their own staff to a developing country, put up a sewage works or schools programme or whatever it was, and failed to employ the local professional who would benefit from the professional experience.

17. Mr HELMORE said that when professionals from developing countries came to industrial countries, their training should indoctrinate them with the idea that they should not look for ideal textbook solutions of a sophisticated type when they were constructing or designing plants for their own country, and that they should realise that robust simple methods might be best. Regarding training in the overseas country itself, much depended on whether the design was being carried out in that country or whether information was collected in the country and the design carried out in the consultant's home office. Local graduates should be used, especially at the collection of information stage because that was a valuable part of their training. It was fairly common practice to use graduates from overseas countries in consultants' British offices, but perhaps more design work should be done in the overseas country taking in local graduates on a training basis. There was also value to holding meetings in developing countries at which discussion could take place about engineering problems.

18. Mr A. H. EL-BEIK said it was important that consultants should be careful to prepare realistic estimates of the cost of projects and be willing to advise the government (or other client) regarding suitable contractors. Sometimes estimates were too low and the Tender Board was in a difficult position. If a contractor put in a price which was also too low and was accepted he might not be able to do the job or when he began he would lose money and reduce the standard or speed of construction, and instead of three years a project might take five years or even taken away from the contractor.

19. The CHAIRMAN said it was difficult enough in Britain to be able to choose other than the lowest tender so it must be very much more difficult for the consultant when dealing with international tenders. Mr EL-BEIK added that the consultant's estimate ought to allow for price increases up to the time of the submission of tenders, as there might well be a delay of up to a year.

20. Mr HELMORE confirmed the Chairman's comment that it was difficult in industrial countries as well as undeveloped countries to select other than the lowest tender. The consulting engineer might put in what he thought was a fair engineering price, but the price submitted by an international contractor might not be entirely related to engineering costs. Much depended on the international money market, and on currency problems, and national and international politics. Many contracts were carried out for a low price because a particular foreign country wanted to work in the developing country. Engineers could perhaps do more in terms of making better estimates, and should try to dissuade the Tender Board from taking on a contract at what was obviously the wrong price.

21. Dr MOHANRAO suggested that when engineers from developing countries worked with consultants or equipment manufacturers in industrial countries there should not be too much emphasis on computers and other sophisticated equipment which might not be available in their own country. Foremen technicians and other non-professionals should also be trained in industrial countries, so that plant would run smoothly when installed.

22. Mr A. H. M. SOMANI had been at the receiving end of a training programme. After years' training in Britain he returned to Tanzania and worked for the Tanzania Government for three years. He found that most of the interesting work was done by consultants, so he joined a firm in Dar es Salaam. He then found that most of the work was done in London, so he moved to London. More work could be done locally where more than one local graduate could be trained. The CHAIRMAN thought that perhaps too much design work was done in Britain instead of setting up local offices.

23. Mr HELMORE responded to Dr Mohanrao's point about the training of foremen and senior operatives, and thought it was better to let these people obtain their training alongside personnel imported into their country, so that they would actually operate the plant. Once people were taken from their own social environment for training in say England or America they were subjected to other pressures and it was more practical for them to be trained in their own circumstances. Dr MOHANRAO agreed with

this, provided the trainers sent out from industrial countries were old-fashioned people with resourcefulness who could actually train the foremen.

24. Mr M. LE MASURIER said that direct labour contracts in overseas countries could be a way of helping the local department to do the work and also of getting round the problem of not being able to find suitable contractors. Mr HELMORE agreed that this could be a good way of getting a scheme done at a relatively low cost to the receiving country, and was also a good way of training people in skills. The CHAIRMAN thought that direct labour required more ex-patriates to run a job initially. Mr HELMORE said that most overseas projects involved more supervisory staff than normal because the local labour was not used to the skills demanded, and because supervisory staff were doing a training job while they were supervising.

25. Mr C. BASHAM represented a manufacturer who was continually giving technical talks and site demonstrations with their piping systems in the U.K. However, they had received only one such request for a similar demonstration abroad. They would be pleased on their visits overseas to stay an additional day or two to give such demonstrations to contractors and others. The CHAIRMAN thought it was a legitimate criticism that British firms were not sending sufficient respresentatives out to give service.

26. Mr P. G. STANLEY enquired whether the effluent from the Benghazi works was free from pathogenic organisms. Mr HELMORE said that most of the sewage treatment projects which his firm had built in Libya, including Benghazi and Tripoli, were conventional biological filtration schemes followed by tertiary treatment through rapid gravity sand filters and then followed by chlorination with adequate contact time from whence the effluent passed to reservoirs from which irrigation pumps operated. Chlorination was therefore applied to an effluent with a very low organic content and the results so far had indicated that it was fairly harmless.

27. Mr W. STEWART spoke of difficulty trying to get British engineers out to Tripoli. The client complained because they were to be paid much more than they paid local engineers. Neither Mr HELMORE nor the CHAIRMAN could see any simple solution to this.

28. Mr P. K. JAIN said maintenance must be considered at the design stage, when consideration should be given to the efficiency resulting from easily-maintained plant. The CHAIRMAN thought that throughout the two days of the Conference it had been clear that engineers should consider not only what was simple but what was appropriate to the particular area in question so that the people themselves could use or develop schemes rather than importing newer techniques.

29. Another speaker said that there had been particular emphasis during the Conference on lack of local skill in both design and maintenance. He wondered whether consultants failed by not including a clause about the use of local labour in contract documents. He had been involved with a contract in Malawi which was split into two parts: one part used African labour and the other part used mainly European labour. Much to his surprise the African labour was far better than the European labour which came from mainly Portugal and Italy. The Africans were very helpful and had received their training from contractors because that particular clause had been written into the contract. The training of a good maintenance man should start with the installation. However, often the more interesting installation was done Europeans whereas some of the people who were already employed would do it adequately.

30. Mr A. EL-HINGARI said that choosing a system or method for any project depended on the site, because in the same country there might be good workers in the cities but no skilled people in the rural areas.

31. The CHAIRMAN thanked Mr Helmore for his most interesting talk, and Mr PICKFORD thanked all who had taken part in the Conference.

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DEPARTMENT OF CIVIL ENGINEERING

JAP/RMS

5th June 1974

Dear Hans,

Here, at last, is your complementary copy of the Proceedings of our Conference last September, which the University Printing Unit produced in less than the expected time. I hope you find it a useful record of the two days' discussion.

If you keep a note of next year's dates at the back of your current diary you might like to enter "21st-23rd September: 2nd Loughborough Conference: Hot climates and developing countries". Accommodation has already been booked and I hope we will have as interesting papers as last year.

Further copies of the Proceedings may be obtained, price £3.00 each, which includes UK or surface overseas postage; overseas airmail is another 75p. To save clerical work, I regret that we can only send the Proceedings on pre-payment; we have stopped our previous invoicing system.

With kind regards.

Yours sincerely,

John Pickford
Senior Lecturer