DELIVERY OF BASIC INFRASTRUCTURE TO LOW INCOME SETTLEMENTS: ISSUES AND OPTIONS

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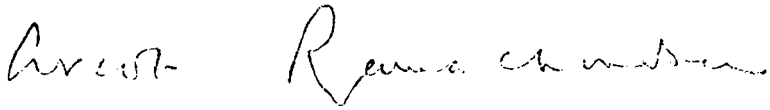
FOREWORD

The provision of basic infrastructure, that is, water supply, sanitation, drainage and solid-waste disposal, is essential for safeguarding health, protecting the environment and promoting the efficient operation of human settlements. These services also create opportunities for residents of low-income neighbourhoods to generate incomes and provide incentives to low-income households to improve their shelter and settlements. It is, however, widely recognized that the provision of these services to low-income communities is badly neglected. Nevertheless, recent years have seen an increased commitment on the part of national governments and international agencies to correcting the present situation. To focus attention on the need to improve shelter and services for the poor, the United Nations General Assembly proclaimed 1987 as the International Year of Shelter for the Homeless (IYSH). The IYSH programme, recognizing the role that basic infrastructure plays in overall settlement development, lays emphasis on the provision of basic services as an essential and integral component of the basic strategy to improve shelter conditions throughout the developing countries.

While the need to provide basic services is well recognized, there are a number of factors which have prevented action to change present conditions. Most of these factors relate to inappropriate technologies, weak institutional arrangements and inadequate financial-resource mobilization. This paper attempts to identify the main issues related to the provision of services to low-income communities, particularly the constraints to services delivery, and investigates options for overcoming constraints. The report has been prepared to assist decision-makers and senior professionals concerned with the delivery of services to low-income communities, by demonstrating the broad range of approaches that may be adopted in infrastructure activities during the IYSH.

The actions and reforms necessary to ameliorate the living conditions of the poor vary greatly, depending on the social, political and physical conditions of the concerned country. No prescription can, therefore, be recommended for universal application, and the present report is confined to identifying the most important issues related to the delivery of basic services to the poor and the most promising options for meeting these service requirements.



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INTRODUCTION

Inadequacy of infrastructure and basic services causes poor health conditions, reduction of employment opportunities and degraded settlement environment. Such conditions are not conducive to a reasonable quality of life and provide few incentives for residents to improve their housing and neighbourhoods. The need to integrate infrastructure provision with overall human settlements development is well recognized and is based on the knowledge that upgrading infrastructure has a beneficial effect on human settlements and livability and efficiency.

Governments of developing countries are becoming increasingly concerned with improving the living conditions of urban and rural poor communities, and the provision of infrastructure and basic services has been recognized as one of the most important means of achieving this objective. Water supply and sanitation together play a key role in promoting health and usually rank highest of all expressed needs in low-income settlements. These elements are often the only infrastructure provided in low-income settlement-improvement programmes. After water supply and sanitation, perhaps next in importance, from health and environmental-improvement viewpoints, would be drainage and solid-waste disposal. Low-income settlements are frequently situated on land subject to flooding, and drainage will, therefore, often have a high priority amongst residents. Solid-waste disposal, generally, does not rate highly with low-income households, because of lack of awareness of the health hazards associated with improper waste disposal, but it is, nevertheless, an essential element in promoting community health and the efficient operation of other infrastructure facilities.

The need to improve low-income settlements by upgrading infrastructure is now recognized in most developing countries, but the ability to implement programmes is still limited. Various factors have acted to limit the ability of developing-country governments to deliver infrastructure to low-income settlements. While there are regional and national differences in the extent and importance of these factors, a majority of them are common to most developing countries. Because provision of infrastructure to low-income settlements has, hitherto, been largely neglected, institutional weaknesses predominate.

This paper presents an overview of the current status of infrastructure in developing countries and attempts to identify the principal factors constraining its delivery to low-income communities. Various options which could overcome the present problems are available to national governments, and these are reviewed and discussed with the aim of promoting policies and strategies that could improve the quality of life in human settlements in the remaining years of this century. Although amenities, such as roads, electricity supply, transport services, communications facilities, security and social services, are all essential for promoting economic opportunities and social stability, this report has been confined to those basic infrastructure components which are essential for promoting minimal health and environmental standards - water supply, sanitation, drainage and solid-waste disposal.

I. SCOPE AND DIMENSIONS OF THE PROBLEM

A. Statistics on basic infrastructure

In 1983, the World Health Organization (WHO) estimated that, of the total population of 2,552 million in developing countries (excluding China), only 52 per cent had access to some form of water supply and 29 per cent had access to sanitation.1/ The availability of most services is higher in urban areas than in rural areas, and drinking water supply and sanitation are no exceptions. The water supply and sanitation sectors have, however, benefited from the launching, in 1980, of the United Nations International Drinking Water Supply and Sanitation Decade. Although, globally some encouraging progress has been registered since the start of the Decade, the increased number of persons served has only been sufficient to keep pace with population increases, and the overall numbers unserved have remained almost unchanged.2/

At present, three urban residents out of four have access to safe water services, supplied either by means of house connections or standpipes, and a little over a half have access to adequate sanitation. In rural areas, however, only two out of five households have access to water supplies, while only one out of every six has access to appropriate sanitation. These statistics give some idea of the magnitude of the problem in these sectors and are based on information provided by national governments and corresponding regional and global assessments. However unreliable these figures might be, no such data are available for other elements of infrastructure of concern in low-income communities, in particular, drainage and solid-waste management. Given the low priority usually attached to these elements, it may be safely inferred that coverage of these infrastructure elements is lower than the coverage in the water-supply and sanitation sectors.

The need for drainage varies vastly from area to area and region to region. It is, however, a high priority in most urban fringe and squatter areas, since these are usually located on land unsuitable for conventional development and, frequently, subject to flooding. Refuse-disposal services are usually only required for urban areas, and an estimated 25 to 50 per cent of all waste generated in large cities is collected by municipal authorities entrusted with its disposal. As is the case with water supply and sanitation, even this minimal level of solid-waste disposal service is not available to slums and squatter settlements which accommodate a majority of the urban poor.

1/ Progress in the attainment of the goals of the International Drinking Water Supply and Sanitation Decade - Report of the Secretary General, (A/40/108).

2/ World Health Organization, The International Drinking Water Supply and Sanitation Decade - World Health Statistics 1985, (Geneva, 1985).

As confirmed by the above statistics, the availability of most services is higher in urban areas than in rural areas, but, where urban deficiencies occur, these are invariably in low-income settlements. Service coverage in urban slums and squatter settlements is usually no better than that in rural areas. Hence, those unserved by essential services consist almost exclusively of residents of urban slums and squatter settlements and scattered rural communities. One reason for such neglect is the high visibility of projects for large urban areas and the ability of the middle-income urban consumer to pre-empt both government attention and funds. Factors contributing to the disparities are weak institutional structures and procedures, lack of a comprehensive policy for these sectors, lack of understanding of the benefits the sector provides (because they cannot be readily quantified), and lack of knowledge about the low-cost technologies appropriate for service levels affordable by the urban and rural poor.

B. Urban slums

Urban slums are usually located near the centres of large cities, but, recently, slums have also been noted on urban peripheries. Slum properties, being legitimate, are usually served by municipal utility networks. However, because of the age of many slums and the problems of overcrowding, services are deteriorating and out-of-date and cannot cope with the demands made on them. Water supply in those settlements sometimes takes the form of a single tap in each house but is often a public standpipe shared by hundreds of people. Sanitation, frequently consists of primitive household systems, such as the bucket conservancy system, and is usually only available on a communal basis. No refuse disposal service is usually provided in these areas and, consequently, refuse accumulates on the limited access-ways available for circulation within these communities or on unofficial dumping grounds, such as verges of watercourses. Where surface drains are provided, these serve as convenient disposal points. The result is a a hazard to health and a reduced efficiency of other infrastructure, such as accessways and drainage systems.

C. Urban squatter settlements

Between one third and a half of present urban populations in most developing countries live in squatter settlements. They are also the foci of new migration and will accommodate most of the naturally accruing population growth in urban centres. Squatter settlements have grown on sites usually unsuitable for conventional development and are often located on inaccessible areas, such as flood plains, swamps and steep hillsides. Services in these areas are often non-existent, and opportunities for connecting to municipal utility networks are poor.

A variety of naturally occurring water sources, such as springs, are used where available, and many communities are served with mobile tankers selling water. These communities usually pay more for their supply than communities legitimately connected to the municipal supply network. Standpipes connected to the municipal supply are used by squatters who have reasonable access to them, but very large settlements cannot be served by such inadequate, unreliable and improvized facilities.

Sanitation in squatter settlements is very primitive, where it exists at all. Open defecation and inappropriate systems, such as bucket latrines, are widely used. Communal sanitation blocks are

sometimes provided, but a majority of these are inadequately operated and maintained and are unsatisfactory.

Sullage, i.e., all domestic wastewaters originating from sources other than the WC, from squatter households is freely discharged on to the ground surface without concern for its ultimate fate. Consequently, naturally formed channels, containing sullage and latrine discharge mixed with solid-waste, are found throughout squatter settlements and give rise to unpleasant odours for most of the dry periods. The same channels act as drainage for rainfall during wet periods, when they receive a degree of dilution and flushing, but whole areas are frequently flooded, and diffused contamination is common. Inadequate means of disposing of sullage often leads to a deterioration of roads and footpaths and has been responsible for increased incidence of filariasis in certain urban centres of developing countries.

Few squatter settlements have any proper roads and pathways. This limits accessibility to dwellings, and few of the conventional refuse-collection vehicles can even enter these settlements. The limited capacity of low-income squatter communities to pay for refuse-disposal services and the fact that a majority of these communities do not pay municipal taxes have been used as the principal arguments against providing any form of refuse-collection service to them. Yet, it is in these communities that population densities and limited public awareness of the hazards of uncontrolled and indiscriminate disposal of refuse promote the spread of diseases and unhygienic neighbourhoods.

Squatter settlements are frequently located on inadequately drained flat areas or on steep slopes. Consequently, adequate drainage often becomes a priority in alleviating flooding of low-lying areas and in the prevention of erosion on steep slopes. The large demand for limited land in these areas, together with the lack of community awareness of the hazards of flooding, often results in the encroachment of housing units directly on to natural watercourses. Such encroachment, besides presenting a danger to the life and property of the encroacher, increases the threat of local flooding.

D. Rural settlements

The problem of supplying water and providing sanitation to rural populations in developing countries is exacerbated by the large number of communities lacking these services. Although most rural settlements have developed where water is available, many rural residents still have to travel long distances to a water source, usually of dubious quality. Even these sources of water often run dry during periods of dry weather and necessitate the abstraction of water further afield.

The water supply of rural communities is usually based on the use of standpipes, and untreated groundwater is generally the most satisfactory form of supply. Rural water-supply schemes have not always been designed to provide for basic needs at minimum cost, and the systems installed have proved too sophisticated for rural communities to manage or too costly to operate. In most developing regions, rural people traditionally use the fields for defecation, and sanitation is often considered unnecessary or unaffordable. However, the full benefits of safe water supply might not be achieved if there is no sanitary disposal of excreta. Few governments in developing countries have actively pursued a policy of improving rural

sanitation, and this fact is clearly demonstrated by the very poor rural sanitation coverage observed globally.

The need for refuse-disposal and drainage systems is usually minimal in most rural settlements. Rural households tend to handle materials of all kinds very frugally and reuse the bulk of food waste as animal fodder. They, hence, have few problems with refuse disposal. Community awareness is all that is often necessary to ensure safe and hygienic disposal of refuse in these settlements. Because of the dispersed nature of settlements and low densities of population, natural watercourses are usually respected and, hence, there are few, if any, problems of drainage. In some rural settlements, however, the lack of even rudimentary drainage channels for the collection of surface run-off and removal of household sullage sometimes gives rise to offensive waste streams. It is, however, rare for the lack of these facilities to lead to flooding.

E. Constraints to the delivery of basic infrastructure to low-income communities

Many factors have affected the delivery of infrastructure to low-income settlements in developing countries. Without a national human settlements policy or plan, agencies have approached the provision of infrastructure to low-income settlements on an *ad hoc* basis, in terms of the selection and implementation of projects. Efforts to improve and upgrade infrastructure in low-income settlements have been confined to a "project" approach as opposed to a "programme" approach and have tended to be one-off actions rather than first steps in a strategy for large-scale action.

Even where sector development plans exist, they rarely address the special needs of low-income communities. As a result, very few infrastructure interventions in poor areas have managed to extend their coverage or "scale up" to broadly based programmes. Target communities have rarely been involved in the planning or implementation of projects and, after completion, they have had no interest in the continuing success of what they perceive as a governmental responsibility. Planning of infrastructure systems by outside agencies, not familiar with local needs, customs and aspirations, has led to the use of technologies and systems which have, on occasions, proved unacceptable to the users.

Quite often, institutional arrangements are so complex, with many different agencies having responsibility for different elements of infrastructure, that the administrative problems of co-ordination and delivery have not been overcome. Qualified manpower is in short supply in most developing countries, and agencies responsible for infrastructure services have been handicapped by inadequate staffing as well as limited budgets. The quality of staff in many agencies has not allowed imaginative approaches to be taken, and all too frequently costly developed-country technology has been applied indiscriminately. Technical training has followed conventional practices and approaches and has had little or no relevance to the needs of the majority of the poor. Heavy reliance on external funding for infrastructure projects, with few or no effective local mechanisms for recovering infrastructure capital and operating costs, has limited the prospects of reinvestment in the concerned sectors and so has constrained the expansion of services to the poor.

Design criteria and standards used in the provision of infrastructure for low-income settlements have not been appropriate,

and this has limited the number of people that could be served using the budget available. Legislative instruments such as codes, regulations and standards, suggest the use of unnecessarily high standards and contain recommendations to adopt inexpedient technologies. These instruments have, as a result, prevented the use of cheap and relevant technologies.

Many sector agencies fail to budget for system maintenance, with the result that systems fail and fall into disuse. The quality of service suffers as a consequence, and the need to replace service facilities is precipitated prematurely. Intended benefits are often substantially reduced by poor operation and maintenance.

From the foregoing, it is evident that, in common with most programmes in developing countries, the problems in infrastructure delivery are those of financing, personnel and institutional structures. These problems may be summarized in the following broad categories, although there is naturally overlap between some of the elements:

Technological:

Lack of awareness of appropriate low-cost relevant technologies;

Inadequate operation and maintenance of systems;

Institutional:

Lack of specific sector policies which form part of a national human settlements policy defined to include the needs of low-income communities;

Existence of several governmental agencies with overlapping and competing responsibilities;

Lack of trained manpower;

Financial:

Inadequate resource mobilization and utilization;

Inadequate cost recovery;

In view of the increasing attention given to the plight of the poor segments of society in developing countries, both in rural and urban areas, it is essential that developing-country governments become aware of the problems facing the various service sectors and the options available for overcoming them.

II. TECHNOLOGICAL ASPECTS

A. Use of appropriate technology

The reduction of per capita (unit) costs for construction of basic infrastructure facilities is clearly an effective means of increasing the real value of resources available for expanding drinking-water-supply, sanitation, refuse-disposal and drainage services, provided, of course, that the systems remain consistent with acceptable performance and safety standards. Costs may be reduced in many ways; of these, the adoption of inexpensive and resource-conserving technologies and the use of locally produced materials and components hold the greatest promise. Governments are becoming increasingly aware of the importance of using least-cost technologies as a principal strategy in attempting to increase service coverage. However, much remains to be done before this objective can be translated into effective action to the benefit of low-income communities.

There is available a wide range of appropriate low-cost technologies which lend themselves to use under differing physical, social and economic conditions of the communities they are intended to serve. A technology that provides a socially and environmentally acceptable level of service and the full anticipated benefits, at the least economic cost, may be considered appropriate. Not all these technologies are readily known to senior professionals and decision-makers, although many publications have been produced recently which give prominence to these technologies.

While knowledge about appropriate low-cost technologies for infrastructure is increasing and governments are becoming aware of the use of these technologies as a basic strategy in increasing service coverage, much still remains to be done in order to incorporate and promote their use in general practice. Legislative instruments, such as public health acts, regulations, service codes and standards, utilized in many developing countries present serious shortcomings. A majority of these instruments are based on high imported standards and contain recommendations to adopt inappropriate technologies. Very few of these instruments have been revised since their inception and, hence, they rarely address the economic and social realities in which they are applied.

Efforts to adhere to these regulatory procedures and standards cause construction to become too costly or simply inappropriate to given cultural contexts, and, in their attempts to reduce costs, service agencies and housing authorities have come into conflict with public health authorities whose role it is to enforce the legislation as it now stands. This inconsistency between standards and needs has restrained progress in the delivery of infrastructure services in developing countries. The low-income communities in developing countries bear the brunt of the resulting deficiencies, because the demand to use exaggerated standards often results in excluding this social group from benefiting from infrastructural investments made with limited national resources.

Arguments stressing the inability of low-income communities to pay for these unnecessarily high standards are often used as reasons for not serving these communities. As a result, urgently needed improvements to rural and urban slum and squatter settlement areas cannot be undertaken because the neighbourhoods do not conform to the

legal standards. Few or no controls are, consequently, applied in these communities which are often left to their own devices in meeting their basic service needs.

Thus, there is an imperative need, in most developing countries, to produce up-to-date codes, regulations and standards for infrastructural services that are suited to the requirements of low-income communities. Some of the relevant technologies offering hope for reducing costs are discussed below.

B. Water supply

Providing a water supply to a community involves tapping the most suitable source of water, ensuring that the water is fit for domestic consumption and supplying it in adequate quantities. Quality standards for water supply are principally concerned with ensuring that the water does not contain any matter, either chemical or biological, which could affect its safety or acceptability. Water quality standards for hardness, iron, manganese and the like, which have little bearing on health may be relaxed in the interest of economy. Besides ensuring that the water is both chemically and biologically safe for consumption, it is often necessary to establish whether it is acceptable to the community. Failing to do this has, in some cases, resulted in the community's returning to its traditional sources for drinking water.

The per capita quantity of water consumed daily varies with physical and socio-cultural conditions and, consequently, varies widely between and within regions. The level of service provided has also been found to have a marked influence on water usage. Where water has to be carried over long distances, consumption may be as low as 10 litres per capita daily (lcd). The quantity consumed may be five or more times this, when a supply in the house or courtyard is provided.

All water sources (including ground-surface water and rainwater) should be assessed, so that the most suitable and acceptable source can be selected. Different sources of water require different degrees of treatment which has a marked bearing on the cost of installation. Source protection and improvement are permanent methods of ensuring water quality.

The interception of rainwater from roofs and other impervious surfaces is common in many parts of the world. In Thailand, for example, a programme for the construction of bamboo-reinforced rainwater storage tanks has been a principal strategy in increasing rural water supplies and has shown considerable success. Rainwater interception, as a principal source, is not necessarily confined to areas where rainfall is plentiful but can also be applied in semi-arid countries, such as Algeria, Jordan and Tunisia. Technology for harvesting rainwater directly is well established, but programmes which use this source have not been applied to their full potential, and there is scope for increasing such programmes.

Springs form a useful source for supplying water in limited quantities and are easily protected from contamination. They constitute one of the most widely used sources of supply to rural settlements in developing countries. Surface water is exposed to the atmosphere and is, easily contaminated; therefore, it is not as good as water from other sources. In fact, in many areas, wells have been drilled (especially deep wells) to replace surface-water sources - a

practice that is recommended but not always possible. Large-diameter hand-dug open wells are usually provided where no drilling equipment is available to produce deep, small-diameter wells which are easy to protect from contamination. Artificial aquifer recharge is not widely practised in developing countries but it does have potential and should be considered.

A variety of handpumps have recently been developed, using locally manufactured components and standardized designs to facilitate local maintenance. In countries such as Bangladesh, India, Kenya, Malawi and the United Republic of Tanzania, handpumps have formed the backbone of the thrust to supply rural communities with adequate supplies of safe water. In Sri Lanka, locally manufactured PVC handpumps are promoted as an income-generating activity at the village level, with the objective of facilitating pump operation and maintenance. Handbooks illustrating the installation, maintenance and repair of the pumps have been produced and distributed in villages in Indonesia, Malaysia, Philippines and Thailand.

Where large quantities of water are required, surface sources are often utilized. Most water used to supply domestic and industrial needs in developing countries comes from surface sources. While it is possible to improve the quality of surface water sources through the use of natural infiltration wells and sand filter wells, abstraction of large quantities of water often necessitates extensive treatment, involving storage, sedimentation, filtration and disinfection. Although most installations can be fabricated from local materials, they are still expensive. Since these plants have shown considerable economies of scale and since they also require skilled operation, the option should always be considered of constructing one plant to serve the largest possible consumption area.

Surface sources used to supply rural and small urban settlements may be adequately and cheaply treated by means of slow sand filters. They have the advantage of providing comparatively safe water, even if the chlorination system fails. (It is, however, desirable to chlorinate even after slow sand filtration, in order to protect the treated water from contamination in the distribution system.) Rural water supplies, in particular, require a self-reliant technology with a high level of process stability. Both these criteria are met by slow sand filters. Slow-sand-filtration technology is sufficiently developed, but great emphasis is needed in the promotion of the technology in developing countries.

Slow sand filtration as a means of treating surface waters has, however, the disadvantage that it requires considerable land area. As a result, rapid-gravity-filtration plants are usually adopted to treat surface water for distribution to large urban areas. Declining-rate filters, multi-media filters and plate settlers could be beneficial in reducing costs and increasing the capacity of existing treatment plants.

Sea water as a source has received increasing attention over the past decade, especially in Western Asia. The processes and plants required for large-scale desalination are, however, sophisticated and expensive. It is unlikely that this technology will be a cost-effective option in the near future for many developing countries.

Water-distribution networks constitute a substantial proportion of the cost of a water-supply system and may reach as much as half the overall system cost. In rural areas where wells and handpumps are

used, no distribution system is necessary, since water is collected directly from the wells. In urban areas, service levels vary considerably, ranging from low-pressure intermittent supply through standpipes for low-income areas to reliable supply and multi-fixture house connections for high-income areas. Although intermittent water supplies are undesirable from the point of view of contamination danger, supply to most low-income settlements in developing countries operates under such conditions. There are insufficient data to suggest that this practice is totally unacceptable, and investigations are required to establish how much contamination results from this practice and how distribution systems may be designed to minimize such contamination.

The provision of house connections, as opposed to standpipes, necessitates a comprehensive distribution network. Despite the high capital cost this implies, it has been found that the provision of house connections results in a reduction in water wastage and facilitates cost recovery. Leak detection in distribution systems provides a useful method of upgrading existing services and an opportunity for extending the service to new areas, since water loss due to leakages accounts for between 40 and 60 per cent of the total quantity of water distributed. The technology to facilitate leak detection has been adequately developed but needs to be transferred to developing countries in order that it may be applied as an integral part of water-management strategies in these countries. Countries such as Brazil, which have made significant advances in leak detection and control, have found such maintenance to be economically compensating.

C. Sanitation

Providing adequate excreta-disposal facilities in human settlements has as objectives the safeguarding of community health and the promotion of a safe environment. A range of appropriate on-site sanitation technologies, which can provide the same health benefits as conventional water-borne sewerage at a fraction of its cost, is available. Many publications which give details and indicate approaches to their application exist. Several demonstration projects have given initiative to the application of these technologies in rural and low-income urban areas, but it is necessary to replicate these experiments on a large scale in order to improve the coverage in most countries.

It is important to note that a majority of the on-site sanitation technologies, which cost only a tenth to a third as much as conventional sewerage, also require low levels of water use for their trouble-free operation. Water, being a scarce resource in most developing countries, can have a significant influence on the total economic cost of sanitation. Where the economic cost of water is high, the savings to be realized from designing systems with low requirements for flushing water are great. For instance, water-seal pour-flush toilets require a minimum of water, while cistern-flush toilets use an excessive amount, in the order of 50-100 litres of water per capita a day. These water requirements, common for sewerage and septic tank systems, imply that they cannot be achieved with the standpipe-level of water supply usually available to low-income settlements.

Soil conditions and housing densities may preclude reliance on on-site disposal technologies, and investments in off-site disposal technologies then become necessary. Most off-site disposal

technologies (except the vacuum-truck cartage technology) rely on some form of pipe network to convey wastewaters, and these networks show considerable economies in scale, as the density of settlement they serve increases. A majority of simple, on-site sanitation systems could be upgraded to off-site systems when settlement density, water supply and water usage increase.

Cultural, aesthetic, social and technical factors influence the selection of a particular sanitation technology. Over 20 systems for sanitation are available, and, of these, approximately a dozen have found successful application in different developing regions. The ventilated improved pit (VIP) latrine for example, is a simple sanitation option which has particular application in parts of Africa and Asia, especially in communities using bulky anal cleansing materials. They require little or no water as the excreta is deposited directly into the pit, and the ventilation column ensures that odours within the latrine are minimized. The VIP latrine is suitable for use in rural and low-density to medium-density urban areas. The capital, operating and maintenance costs of the latrine are low, and the many countries in Africa which have promoted the technology in low-income settlements have found a high degree of user acceptance.

The double-vault composting (DVC) latrine has been successfully adopted in cultures where the reuse of human wastes is common. Even though DVC latrines are a low-cost and ecologically sound method of excreta disposal, attempts to extend the technology to cultures which have little tradition in waste recycling have invariably proved unsuccessful. Operational rather than design factors, often based on a cultural reaction against handling excreta, have led to disappointing results in Africa and Latin America, but their use is common in East Asia. A high level of user motivation is required to ensure that conditions essential for proper composting, such as restricting moisture within the compost vaults, are maintained, but DVC latrines are cheap and, where accepted, may be used in rural and low-density to medium-density urban areas. No demand for water use is made by DVC latrines.

The pour-flush WC latrine has proved to be one of the most successful of all low-cost sanitation systems. Unlike other sanitation systems which rely on flushing with water for waste conveyance, such as septic tanks and aquaprivies, pour-flush latrines are inexpensive. They are widely used and promoted in the South Asian sub-continent, and, recently, efforts to introduce them in parts of urban Africa have had encouraging results. They are eminently suited for use in cultures where water is used for anal cleansing and may readily be applied in rural and low-density to medium-density urban areas. The capital, operation and maintenance costs of this system are low, and only 1.5 to 3 litres of water are required for purposes of flushing the latrine each time after use. India has perhaps the largest low-cost sanitation programme where the technology is promoted, based on the idea of converting bucket latrines into pour-flush WC latrines.

Communal toilets have been applied in many low-income settlements in developing countries, but the results have not been encouraging, owing to lack of user care. Planners of low-income urban sanitation facilities have consistently opted for this solution, especially in areas where densities are high. The ability to serve a large number of population with the facility lowers per capita costs but also gives rise to problems in maintaining the facility. Public motivation and

education programmes are often necessary to ensure the success of communal latrines. In India, communal toilets, operated by a non-governmental organization which levies a charge for their use, have proved financially self-sustaining.

There are two options in the medium-cost sanitation- technology range - the aquaprivy and the vault toilet and cartage system. Aquaprivies, like pour-flush latrines, possess a waterseal, but the waterseal of an aquaprivy permits the discharge of bulky anal cleansing materials, and, hence, the aquaprivy has been successfully adopted in various parts of Africa. In practice, it has proved difficult to maintain the waterseal, because the discharge of large quantities of wash-water is required for this purpose. The effluent from aquaprivies is usually disposed of on-site by means of a soakaway, but the technology lends itself to easy upgrading by discharge into some form of sewerage system and off-site treatment. Given the problems that are known to have arisen from the loss of waterseals, aquaprivies are not recommended in areas without ready access to ample supplies of water.

The vault toilet and cartage system is only applicable to urban areas accessible to desludging vehicles. This system of storing excreta for up to six weeks and then conveying it for treatment by means of cartage vehicles is practiced extensively in Japan, the Republic of Korea, and other East Asian countries. Besides being cheaper than conventional sewerage, this option also offers the flexibility of being able to adapt easily to differing land-use requirements over a period of time. The need for competent management to operate the vacuum tankers limits the system in most developing countries, and, hence, it is rarely considered feasible.

Conventional sewerage and septic tank systems are two of the most expensive sanitation technologies. Both systems offer a degree of convenience which few other sanitation technologies match. They remove both excreta and all domestic wastewaters from the premises, but, because of their cost, conventional waterborne sewerage and septic tanks offer little hope for improving waste-disposal services to either the urban or rural poor in developing countries. The two systems also require levels of water use which are not usually available in low-income settlements.

Septic-tank systems, although suitable for rural areas, are often only considered for use in low-density to medium - density urban areas. As densities grow, it becomes necessary to convey, by means of sewers, the effluent from septic tanks for treatment off-site. Septic tanks, despite their high costs, are widely adopted in the middle-income and high-income areas of developing countries. The use of a single tank to serve many households has been found to reduce considerably the cost of this option, but poor construction and the uncontrolled discharge of tank effluents into stormwater drains have been known to promote insect breeding and give rise to odour nuisance.

As densities of settlements increase and water supplies become freely available, the ability of individual plots to retain and dispose of all wastewaters is reduced considerably. The use of some form of waterborne system, such as conventional or small-bore sewerage, becomes necessary. Small-bore sewers are designed to convey sewage which has been either settled or digested in a septic tank or aquaprivy; therefore, they can be laid at flat gradients and require less maintenance than conventional sewerage. Studies undertaken in certain developing countries have revealed that small-bore sewers are

often only marginally cheaper than conventional sewerage and are, hence, outside the range of affordability of a majority of the poor.

Recent research into low-cost sanitation technologies for use in low-income urban areas of high population densities has suggested an alternative known as shallow sewers. The system consists of laying sewers at a shallow depth (0.3 m cover), away from vehicular loadings and with small inspection chambers used to replace manholes. Such a system has been operated successfully in many low-income areas of Brazil and, recently, the system has been successfully applied by UNCHS (Habitat) in a large squatter settlement in Karachi, Pakistan. The shallow sewer system is the only form of sewerage which has been found to be more cost-effective than on-site systems in settlements above a density of 150-250 persons per hectare. While conventional sewerage systems require large quantities of water for trouble-free operation, shallow-sewer systems, when properly designed and constructed, have been successfully introduced in communities where the per capita daily water consumption was as low as 25 litres. Cost recovery has proved extremely good, because of the low costs involved and the high motivation on the part of urban communities to be provided with sewerage.

All forms of waterborne sewerage require some kind of treatment for the sewage. Waste-stabilization ponds are perhaps the only non-mechanical, cheap means of producing high-quality effluents with few disease-causing organisms in them.

D. Solid-waste disposal

Rural households tend to handle materials of all kinds very frugally and reuse most food wastes as animal fodder. They, hence, have few problems with refuse disposal. Community awareness is all that is often necessary to ensure safe and hygienic disposal of refus in these settlements.

Such is, however, not the case in urban households, and some means of waste storage, processing and disposal becomes necessary. Only a fraction of the urban areas in developing countries are provided with any form of refuse-disposal service, and, not surprisingly, such services have been confined to high-income areas. The limited capacity of low-income urban communities to pay for urban services and the fact that a majority of these communities pay little or no municipal taxes have often been used as arguments not to serve these communities. There are, however, a number of factors which favour the provision of refuse services to low-income communities. These include the fact that, because these communities use all materials sparingly, they only generate small quantities of highly organic refuse suitable for use as animal fodder (after separation) or for the production of organic fertilizer or compost. The potential to recover resources is often maximized in these communities, where metals, glass, paper and plastics are often retained for resale. It is also precisely in these settlements of high population densities and limited public amenities that refuse disposal becomes a prerequisite for a healthy environment.

Many who live in these settlements are engaged in recovering used materials for resale through the informal sector, and as much as 2 per cent of the population in developing-country cities is supported directly or indirectly by reutilizing refuse. These activities have generally been conducted on an ad hoc basis, and their contribution to urban services has rarely been recognized, but, in the light of

diminishing natural resources and increasing urbanization, the management and disposal of urban waste is assuming increasing importance. Many of the efforts to address the needs of low-income communities will, therefore, have to be founded on strategies geared to resource recovery.

The need for the adequate collection and disposal of solid waste in urban settlements is based on aesthetic and health considerations. Uncollected refuse accumulates in drains, roads and open spaces, causing disruption of community life and creating additional problems in the operation of other public services. Solid-waste dumps provide a favourable habitat for disease carriers, such as rodents and flies, and wherever domestic refuse is dumped it is subject to biological decomposition and unpleasant odours result. Solid wastes normally contain only low concentrations of disease-causing organisms, but, in low-income areas, where faeces are dumped together with refuse, the wastes are of greater danger to health than those in areas with sanitation coverage.

On average, the per capita quantity of waste generated in developing countries is only a third of that generated by developed nations, but, even within the cities of developing countries, the quantity and characteristics of the waste produced vary from one social group to another. For example, it is not uncommon to observe that the quantity of refuse produced in low-income slums and squatter settlements is only a quarter to a third of that produced by affluent communities. The composition of the refuse also varies accordingly: while the refuse from affluent communities contains large proportions of paper, plastics, metals and glass, the wastes in low-income communities are predominantly organic in nature, owing to the use of fresh and unprocessed vegetables. The density of the refuse generated by low-income communities is greater than that commonly found in high-income groups, owing to the absence of a large proportion of packing materials: in fact, the density of refuse in developing countries is on average 3 to 4 times greater than that observed in developed countries.

The physical characteristics and composition of the refuse determine the most appropriate method for collection and disposal. In prescribing equipment to be used for providing refuse-disposal services to communities in developing countries, little attention has been paid to differences in the characteristics of refuse in these countries. Equipment developed and produced for industrialized countries has not always been appropriate, yet, for example, many developing countries have recently introduced compression refuse-collection vehicles. These were developed to increase the effective payload of refuse-collection vehicles in industrialized countries, where the density of refuse averages 100-150 kg/m3. After compression, the density can be increased to up to 500 kg/m3, but, in developing countries, the naturally-occurring refuse density varies from 300 to 500 kg/m3. As a consequence, after compression, the density of the refuse is increased to about 800 kg/m3, but few of the refuse vehicles are designed to cope with such high refuse loads. This, combined with the fact that the vehicles are expected to ply on poorly maintained roads, has led to premature breakdowns. Owing to the limited capacity of authorities to repair and maintain these vehicles, the quality of service deteriorates rapidly.

The level of refuse-collection service provided in urban areas of developing countries varies considerably. Door-to-door collection facilities are often provided in high-income areas, while communal

storage facilities are the norm in low-income settlements. In the past, masonry storage facilities were provided in these areas but these have rarely been used as intended. Refuse is usually observed to be scattered around the facility which acts as a focus for animals and insects. Recently, however, large capacity (5 to 10 m3) roll-off containers, capable of being loaded directly on to a refuse-collection vehicle, have been developed and successfully introduced in some countries. The containers are designed so as to discourage salvaging at the facility, in order to prevent the scattering of refuse around it. It has also been observed that the naturally-occurring refuse density in the roll-off containers is higher than that obtained when the refuse is manually loaded on to a non-compressing refuse-collection vehicle. The time required to hook on the container to the collection vehicle is only a fraction of the time required to load manually a refuse-collection vehicle. Hence, the roll-off container and vehicle system has been known to reduce considerably the time taken to load the vehicle and transport payloads of refuse for disposal.

Very little attention has been paid, in the past, to the use of appropriate containers for storing refuse within the house. The low level of awareness of the interrelationship between health, environment and hygienic disposal of wastes makes low-income communities pay little attention to providing adequate storage facilities for domestic refuse. Most fly breeding takes place in the domestic environment as a result of the ready access the insects have to partly fermented food. Thus, more insecticides are used for the control of flies than any other insect. A low-cost, fly proof, washable, domestic-refuse container, made from used car tyres, has been successfully developed for use in low-income areas.

A variety of refuse collection systems are used in different parts of the world. For instance, the block system, where residents bring their refuse to a vehicle parked at a predetermined point at given times of the day, has been used satisfactorily in some Asian countries, such as Burma. The kerbside refuse-loading system is often adopted in high-income areas, but, because good access roads are rarely available in low-income areas, it is often not possible to use this method of waste collection in such neighbourhoods. Vehicles, such as animal-drawn carts, handcarts and three-wheel cycles, have been used in these areas.

"Roll-off" refuse-container vehicles usually carry great payloads, as a result of the high density of refuse attained through compaction of the refuse under its own weight. Side-loading collection vehicles, widely used in many developing countries, are unsuitable for loading light refuse, because of their high load height and the fact that they rarely carry a reasonable payload. Also, the time required for loading side-loading vehicles can be substantially higher than for either the "roll-off" refuse-container vehicle or the compaction vehicle. The "roll-off" refuse-container vehicle is, however, only appropriate in areas where it is proposed to adopt communal storage facilities. Most motorized refuse-collection vehicles are designed and produced in developed countries and are unable to meet the heavy demands made on them in developing countries, especially when they are intended for use in low-income areas. Custom-made vehicles have, however, been successfully developed for use in low-income areas with narrow vehicle access in countries such as Trinidad and Tobago.

Open dumping, accompanied by burning, is the most prevalent form of refuse disposal in developing countries. Of the various processes available for waste treatment and disposal, only sanitary landfill and, in some cases, composting, are economically feasible in a majority of developing countries. Although landfill is the most common method, this has rarely been conducted in a hygienic manner that will minimize adverse environmental effects. In some urban areas, marginal land, subject to tidal flooding, may be reclaimed through appropriate landfill techniques utilizing refuse, but this option for developing marginal lands has not been much applied in developing countries.

The high organic content of developing-country refuse, which can reach up to two thirds of the total weight, makes processing into composting a possible option. While mechanization of composting plants has been common in developed countries, there are three low-cost techniques with little or no mechanization which have found particular application in developing countries. These are the force-aerated, the Chinese, and the window systems of composting. These systems make little demand on capital and are, therefore, ideal for use by private entrepreneurs in the informal sector who could be mobilized to produce compost for profit.

The potential to reuse all waste materials has yet to be explored in most developing countries, but, where efforts have been made in this direction, some results have been promising. In Cairo, for over 70 years, the Zabaleens have collected refuse from certain parts of the city, using animal-drawn carts for transport. The organic fraction of the waste collected is used to fatten pigs, and other materials, such as bottles, bones, tins, paper, rags and plastics, are sold to small recycling plants that absorb them as raw materials. Through the income generated by these activities and the nominal fee charged to the residents served, the Zabaleens have demonstrated the economic viability of private-sector waste collection. The presence of small recycling plants in many Asian and Latin American countries has resulted in establishing true resource values for the waste materials. Efforts to introduce and strengthen such small-scale industries in low-income communities could contribute substantially to community development through income generation and the provision of an essential urban service.

E. Drainage

The provision of adequate drainage in human settlements has as objectives the protection of life and property against flooding and the provision of a safe and healthy neighbourhood.

Drainage facilities are almost invariably provided along public accessways, but other infrastructural facilities interact with drainage in a manner which warrants integrated planning of all networks. For example, the provision of on-site sanitation systems for excreta disposal will automatically result in the discharge of other household wastewaters into the drainage system, but the flow resulting from this discharge may be minimal compared to the run-off from rainfall. Hence, in planning a drainage network, it is necessary to ensure the provision, at the invert of the drainage channel, of a small section which will ensure the conveyance of wastewaters at a rate adequate to prevent the stagnation of water during periods of dry weather. Failure to ensure an adequate rate of flow during this period could lead to the breeding of insects in the channel. In most developing country urban settlements, it is common to observe drainage

channels acting as the foci for refuse dumping. This is especially true in low-income settlements, where public awareness is minimal: there, the verges of main drainage courses are frequently used for this purpose. This means that, unless an effective means of refuse disposal is provided, it is unlikely that drainage systems will operate as initially intended.

Although such interrelationships between infrastructure services are frequently recognized, they are rarely taken into consideration at the planning stage and, hence, investments in infrastructure are rarely utilized to the optimum. Where rainfall is frequent and intense, the provision of stormwater drainage facilities will receive priority consideration, but, under such conditions, it is not uncommon that the same facility be designed to transport non-WC domestic wastewaters in areas using on-site sanitation systems. However, the same may not be the case in areas where rainfall is infrequent and the topography of the area is such that natural drainage is ensured: in such areas, it may well prove economical to take advantage of the natural drainage for removing stormwaters and provide some form of waterborne system for disposal of domestic wastewaters. The grading of roads, if individual properties can drain to these roads, could be done so that the right-of-way is used as the principal drainage channel to convey stormwaters.

The planning of new human settlements, in particular the allocation of plots, has, in the past, been frequently undertaken with little regard to drainage. As a result, drainage facilities superimposed on pre-planned housing layouts have often proved expensive. In planning housing layouts, it should always be ensured that public accessways in which drainage facilities are provided be set out with an adequate fall over their length. Failure to ensure this will result in increased depth and cost of the drainage system which, besides, may prove difficult to drain to receiving watercourses.

Many urban low-income communities are settled on marginal lands which are, in some cases, subject to frequent flooding. Upgrading these settlements and reclaiming low-lying areas for housing development through landfill is an expensive process, since suitable fill material, extracted from a surplus source, has to be used for this purpose. However, some success has been registered with the use of heavy-duty grit pumps to pump fill to areas adjoining rivers and estuaries. While filling completely to a point free from flooding is desirable, the cost is often prohibitive, and the use of a protective embankment and a compromise level of fill, which accepts a degree of flooding for a short period until the water level in the receiving watercourse recedes to permit its discharge, has often proved economical.

In squatter settlements, where the demand for land is great, it has been common to observe encroachment of housing units directly onto natural watercourses. Such encroachment, besides presenting a danger to the life and property of the encroacher, also presents an increased threat of local flooding. For this reason, upgrading of watercourses is often a priority consideration in the planning of these settlements, and, where watercourses have been upgraded, usually by lining the sides and, in some cases, the base, they have rarely been encroached on. A variety of materials is utilized for upgrading watercourses and constructing new drainage networks. Of these, brick and concrete linings are usually adopted for drainage systems, while stone has been used for upgrading main watercourses. The continued

use of natural channel verges for main watercourses in low-income settlements requires some means of discouraging encroachment and refuse-dumping.

F. Operation and maintenance

Operation and maintenance are closely related to cost-effectiveness and quality of service and are, in fact, determining factors of both. Agencies usually fail to budget for system maintenance, with the result that systems fail and fall into disuse, the quality of service suffers, and the need to replace service facilities is precipitated prematurely. Without adequate operation and maintenance, the intended benefits of the capital outlay are reduced or lost.

For example, inadequate maintenance has led to the failure of many rural water-supply projects using handpumps. Interruptions in the supply result in the community reverting to their traditional sources of polluted water and, hence, reduce the beneficial impact of the infrastructure intervention. It is, however, encouraging that emphasis is now being placed on improving operation and maintenance in both rural and urban programmes. Local-level training for skilled workers and community members is increasingly incorporated as an integral component of most infrastructure projects: the training of women in the maintenance of handpumps for rural-water supplly, for example, has proved exceptionally successful.

Projects that have, at inception, incorporated community participation have been able to pass on some of the responsibility for maintenance directly to the community. In Sri Lanka, for example, such responsibility is increasingly being assumed by local community development councils, composed of local community members. Maintenance work beyond local means to resolve it is promptly reported to the authorities for action. Such arrangements for local-level maintenance and vigilance have proved eminently suited for use in low-income communities.

III. INSTITUTIONAL ASPECTS

A. Sector planning

Most countries do not have a national policy and plan for infrastructure. Since the launching of the International Drinking Water Supply and Sanitation Decade 1981, some governments have drawn up national plans in the water-supply and sanitation sectors, but similar plans are rarely available for other infrastructure components. Even where plans exist, they are frequently prepared in isolation and, hence, fail to reflect human settlements policies and plans.

Despite universal recognition of the basic needs for safe water, adequate waste disposal and other essential services, these have not been allocated the level of priority they deserve in national plans. In the absence of comprehensive national policies and plans, urban and rural low-income groups have been systematically deprived of assistance to improve services in their neighbourhoods. Scarce resource investments have, in fact, been diverted away from these priority areas where infrastructure interventions would have had the greatest social impact. Too little emphasis has been placed on the catalytic nature of such interventions: in low-income rural and urban areas, they are often the start of community participation in a wide range of economic activities, including self-help improvements to housing.

While the need for these services is paramount, the reality that there are equally unsatisfied needs and investment opportunities in other sectors cannot be ignored. Therefore, if infrastructure coverage is to be increased in keeping with needs, an effort to plan within overall national development needs is called for. Within the overall framework of a government's objectives, the provision of infrastructure services should ideally be so ranked that installations maximize the net social and economic benefits per unit of investment. This, however, is difficult to do in practice, since many of the benefits of infrastructure projects cannot be readily quantified. Financial criteria alone have been predominantly used in the past to assess investment priorities, but this is an unsatisfactory method, since it ignores many social benefits. The final ranking of sector investments and beneficiary communities should, therefore, attempt to take account of social benefits. This becomes especially necessary in many developing countries, where the poor now subsidize the provision of infrastructure to the rich.

The absence of coherent sector plans and the scale of the problems in relation to the resources available have forced short-term or contingency planning and an *ad hoc* approach to problems as they arise. Donors desiring to commit funds to readily identifiable projects have perpetuated the project approach as opposed to a programme approach to the provision of services. The World Bank and many bilateral agencies have supported low-cost housing, sites-and-services and squatter-settlement upgrading projects in the past, including the provision of elements of infrastructure. However, owing to the lack of coherent policies and plans, these efforts have tended to be "one-off" actions rather than first steps in a strategy for large-scale action. Very few infrastructure interventions in poor areas have managed to extend their coverage or "scale-up" to broadly based programmes. This implies that a careful appraisal should be made of infrastructure projects in the context of long-term national

planning objectives, to ensure that infrastructure labour logistical support, operating and maintenance capabilities and other support services grow at a rate commensurate with the overall development programme.

A common problem resulting from the lack of infrastructure policy is the lack of even basic information about the various infrastructural elements in a country, and a special survey is frequently necessary to collect such information. These surveys assist in identifying possible development schemes and in recommending policies, institutional improvements and other measures necessary to help deal with the problems identified. They also serve to indicate the potential roles of different national agencies as well as those of United Nations agencies, bilateral assistance organizations and lending agencies. A World Bank/WHO Co-operative Programme was initiated in 1971 to carry out water-supply and sanitation element studies and to undertake the implementation of plans resulting from these studies. Such studies have been instrumental in the inclusion of water supply and sanitation in national development plans in recent years, and a similar effort is now required for promoting the development of drainage and solid-waste management elements.

Projects in urban areas, in particular water supply projects, continue to absorb the largest amounts of external assistance flowing into infrastructure development activities. Even so, very little of this assistance is filtering through to the urban poor. While the disparity between the urban elite and the rural poor has, for some time, been recognized, and investment allocations have been made to take account of this fact, little attention has been paid to the inequities that exist within cities. The intention must not be to shift attention of national plans away from rural to urban areas but to emphasize the profound inequalities amongst city populations.

Despite the recognition that full benefits from improvements to a single component of infrastructure will not support the level of community development which could be achieved if a combination of components were to be upgraded, there appears to be a continuation of the skewed application of investment resources amongst infrastructural services. For example, full benefits from improvements in water supply cannot be achieved without concomitant improvements in sanitation. Even so, in the African region, many countries have re-oriented their policies to place emphasis on providing water for the urban poor and the rural population, but sanitation is given little attention. Likewise, improvements to drainage systems cannot be fully realized unless a concomitant improvement is provided to the disposal of solid wastes, to prevent blockage of the drainage network with refuse.

There is little doubt that human settlements require the integrated development and upgrading of all infrastructure components, if satisfactory living conditions are to be achieved, and social and economic development of the inhabitants promoted. Sound co-ordination between the various agencies is called for, in attaining this objective and in optimizing national resource investments. It is not uncommon to see the digging up of a newly laid road pavement, for example, for purposes of laying another service, such as a water supply for sewer network. A considerable proportion of sector funds are wasted as a consequence. Besides the intrasectoral co-ordination necessary, there is also a need for authorities to expand upgrading programmes for low-income settlements and to co-ordinate the

activities of the agencies concerned with infrastructure and other human settlements elements.

Traditionally, the planning of infrastructure services has been heavily influenced by engineers. It may involve a financial analyst but rarely an economist and almost never a behavioural scientist. Terms of reference prepared to investigate the feasibility of providing an infrastructure element usually confine the study to a few conventional systems which have proved successful in middle-income and high-income areas. They are, however, unlikely to be effective in low-income areas.

The main problems with this customary process are obvious. In the conventional procedure, the most appropriate technologies may never get considered: no checks are made to ensure that the technical solution designed and costed is socially acceptable: by excluding meaningful economic comparisons, the usual method gives no guarantee that the solution offered is one of least cost for the economy. The decision-makers are presented at the end with a proposal that has not taken into account their own economic priorities or the ability of their constituents to pay for the improved service.

The planning, location, design and construction of facilities have traditionally been carried out by governmental agencies and officials, without the involvement of the eventual users and with limited, if any, consultation with them. Infrastructure systems planned for low-income communities, by outside agencies familiar with local needs, customs and aspirations and without community involvement, have frequently proved to be inappropriate for and unacceptable to the users. Consequently, these systems have rapidly fallen into disuse, and communities have had no interest in the continuing success of what they perceive as a governmental responsibility. Community interest and involvement are implicit in user participation and essential for project success. Experience from many countries indicates that infrastructure systems are best maintained, least abused and most financially successful where the communities to be served were selected because they expressed a real interest in having a new or improved system. The best evidence of such interest is willingness to contribute to construction costs and to pay an adequate fee for usage. However, meaningful community involvement is more than the supply of free labour and local material or, even, cash contributions. It is involvement of the community at all stages of project development, from initial conception and planning to construction, operation and maintenance. Where public awareness of the need for a given service is low, for example, refuse disposal, the use of special promoters can prove useful in mobilizing community support. The process of consultation with the users requires time and the recruitment of additional personnel, but the returns, in terms of reduced resource wastage, outweigh the implied increase in planning costs.

In the past, the role of women in all aspects of the development and operation of water, sanitation and refuse-disposal systems has often been neglected. The role of women as a vital link in the water-sanitation-refuse-health chain, at the most basic level of primary health care, has not been fully realized and used to the benefit of infrastructure programmes. WHO has recently reported that governments in some countries are now making a special effort to increase women's participation. For example, Nepal, Thailand and the United Republic of Tanzania are promoting the inclusion of women in village water committees; in Burkina Faso, Ethiopia, Honduras, Panama

and the Philippines, women's organizations themselves have been instrumental in promoting, organizing and implementing service improvements; in Kenya, a consortium of non-governmental organizations, assisted by Government, supports women's drinking-water initiatives and is providing assistance to substantial numbers of rural inhabitants. Women are also increasingly being trained as caretakers of infrastructure systems; in countries such as Angola, Bangladesh, Bolivia, India, Lesotho, Malawi, Nepal, Sri Lanka and Thailand, women take care of and maintain handpumps used for water supply.

Planning of infrastructure in the past has often concentrated on the provision of the ultimate desirable service level. Since the cost of providing this level of service is often very high, the all-or-nothing approach to planning has meant the shelving of many projects for lack of funds. To ensure coverage of the greatest number within available budgets, a basic-needs approach will be necessary in selecting elements of infrastructure and levels of service. This will often result in adoption of lower standards for low-income communities than allowed under existing building codes, with the intention that standards can then be gradually upgraded in a sequential manner, consistent with the socio-economic development of the beneficiary community. Fortunately, a majority of essential infrastructure services lend themselves to this form of incremental upgrading.

B. Institutional deficiencies

Institutional weakness is probably the most important single problem in infrastructure delivery. This weakness manifests itself in various ways, particularly in the use of a multiplicity of ineffective agencies, with sometimes overlapping jurisdictions and competing interests, and an inadequate framework for encouraging and supporting local initiatives and community participation. Much effort has been directed in recent years towards the creation of strong, competent and financially autonomous institutions with streamlined responsibilities: countries which have taken such initiatives include Brazil, Burkina Faso, Chile, Cote d'Ivoire, India, Malawi, Nepal, Pakistan, Peru, the Philippines and Sri Lanka. The objective of these changes has been the creation of an institutional framework that allocates authority and responsibility for policy formulation, financial-resource mobilization, planning, implementation and operation, so as to ensure continuity of effort in the sector. These legally supported institutional reforms have, however, only been confined to the water-supply and sanitation sectors of large cities of some developing countries. Refuse disposal and drainage still tend to be combined with other municipal and social sectors.

Although some independent agencies have been created in urban areas, a majority of these have maintained traditional institutional structures and conduct planning and implementation activities in a conventional fashion. Few of these structures reflect the special needs of low-income groups, yet approaches and technologies for the provision of services to these groups differ vastly from those traditionally adopted for conventional development. Special units within existing institutions are required to plan and manage appropriate infrastructure systems for low-income groups.

A successful modification to a traditional institutional structure, to provide-water supply and sanitation services to low-income communities, was instituted by the Rio Grande do Norte State Water and Sanitation Company (CAERN) in Brazil. CAERN created a

special low-cost technology unit within the institution that has, over its six years of existence, been instrumental in modifying conventional technologies to suit local requirements and promoting cost-effective and affordable services to low-income groups. The unit has brought about changes in the traditional tariff structures in direct response to the needs of the poor and with the objective of promoting an equitable service charge compatible with the level of service and technology provided. The unit has also introduced water-saving devices and flow measuring, through the use of communal water meters serving groups of houses, as a means of conserving scarce resources, promoting equity in tariff charges and increasing coverage. Similarly, Indonesia, Lesotho and the United Republic of Tanzania have all established special units to plan and manage on-site sanitation programmes. These units have already proved their worth in addressing special needs of the poor. Service agencies often use traditional engineering approaches in project design and implementation; their organizational pattern is not such as to encourage community involvement; there is little support between the agencies and the community; and no attempt is made to build up community competence. The creation of special units, which encourage such participation and promote the use of cost-effective appropriate systems, is proving to be the only means of meeting the special needs of low-income groups.

The problem of institutional deficiencies is greatest in rural areas. The problem is particularly marked in the water-supply and sanitation sectors. In contrast to urban water supply and sewage disposal, small towns and rural areas cannot take care of their own needs because their inhabitants generally are not able to support financially the institutions capable of providing adequate services. While the provision of drainage and, where applicable, refuse disposal is usually combined with other municipal or social sectors, the provision of water supply and sanitation may be entrusted to an independent agency. Successes and failures have been reported for both organizational approaches, and the final choice will normally depend on local circumstances.

Rural water-supply and sanitation programmes may be undertaken in any of the following ways:

a) As part of a national or regional water-supply programme, including both urban and rural elements;

(b) As a rural water supply programme;

(c) As part of a regional integrated rural-development or similar multisectoral project.

Each of these requires a different administrative approach.

Where rural water-supply and sanitation programmes are included in national or regional development programmes, with both urban and rural elements, best use may be made of scarce technical and administrative skills, and sector policies may be applied consistently. There is, however, a need for devolution of authority and expansion to new unserved areas. Countries such as Brazil, Ghana and Tunisia are examples where this approach has been successfully adopted. Brazil, in fact, uses an effective two-tier approach: broad policies and financing arrangements are decided at the national level, while state water companies are responsible for detailed planning, construction and operation. The national plan, called PLANASA, is administered by the Brazilian National Housing Bank, the central

agency for the water and sanitation sector. The institutional framework for water and sanitation includes establishing revolving funds at the state level and creating state water companies which operate as autonomous utilities. In a bid to provide a rational and consistent framework for water-supply and sanitation development across Brazil, the National Housing Bank establishes policy, sets national targets, develops guidelines for project-design, economic-evaluation and procurement procedures, and encourages water companies to set water and sanitation tariffs which are fair and which recover costs. In this way, financial autonomy can be achieved by the company and services for low-income users can be subsidized. Low-interest loans for water supply and sanitation are made to the states and communities which have least resources. Within each Brazilian state, the revolving fund is operated by the state bank and the state water company. In the initial years, when the state water company was not financially self-sufficient, the Housing Bank provided direct grants by sharing project costs with matching funds, but, as the state water companies achieved financial autonomy, direct grants stopped and subsidies were provided through reduced interest rates. Eventually, the state water companies have become financially autonomous, by using tariffs to finance their maintenance and extension programmes and repayments of loans. This approach has proved successful, having brought about economies of scale, centralized procurement, national training programmes and co-ordinated planning. In addition, outside international agencies, such as the World Bank, are able to extend loans to a single co-ordinating agency, rather than to several small ones.

Where rural water supply and sanitation are to be implemented under an independent agency, it is often necessary to strengthen staff and facilities. To undertake such a project would, however, require considerable institution building, and a careful study would be necessary to assess the relative merits of building up a rural agency or of amalgamating it with an urban agency and strengthening the combined organization.

A third approach to the provision of services to rural communities and one which has demonstrated considerable success is the combination of various economic and social components in rural development projects. In such integrated development projects, the social components benefit from the organization, management and, possibly, the income of the project's economic components. However, as a general rule, an agency that has been specially organized to provide support to small communities is preferable to a multisectoral institution because of the former's ability to respond to community goals.

Often, the reasons for the choice of an organization are historical. The present-day organization of refuse disposal in many developing countries is a good example of how the organizational structure is the same as that adopted under colonial systems. The responsibility for refuse disposal under these systems is usually entrusted to the medical officer of health and the public health inspectors or sanitary officers who manage solid waste, amongst other duties, such as the control of epidemics, insects, food inspection, slaughterhouses, meat inspection, public health education, immunization, sewage and nightsoil disposal. Hence, it is not surprising that they are only able to devote very little attention to solid-waste disposal. Moreover, such a structure is completely out of context when applied to newly emerging large urban areas: a special department, exclusively for providing the service of refuse disposal,

is needed in many countries. It is essential that such a department be concerned solely with refuse collection and disposal and should be endowed with specialist staff who have no other duties. There must be a single-minded application of various skills to create and sustain a sound service and establish a functionally efficient department.

The creation of an intersectoral or interagency co-ordination committee, to function as an advisory body and influence sectoral plans and priorities, has proved useful in improving the effectiveness of infrastructure activities in various countries. The committees provide a forum for intersectoral consideration of the management of urban and rural services, and provide opportunities for health authorities to promote health objectives within infastructure programmes and for housing authorities to co-ordinate shelter and infrastructure planning and delivery.

A recent attempt, by the housing authority in Sri Lanka, to plan and deliver all infrastructure facilities under the slum-upgrading component of the Million Houses Programme found that, while this approach proved feasible for developing a few sites on a short-term basis, it could not maintain impetus and bear the onus of operating and maintaining the service facilities. The approach could, therefore, not be extended to cover the whole programme in general. The need to devolve responsibility to specialized utility agencies soon became apparent, with the mounting costs of providing, operating and maintaining these services and with no procedures to recover capital and operating costs. A co-ordinating committee is now used to interface infrastructure delivery through specialized agencies and shelter-upgrading activities.

Most developing countries have a well established informal sector which provides basic services to urban areas, especially deprived areas. These include the transport and sale of water, removal of wastes and recycling of refuse. Personnel engaged in these activities derive their principal incomes from them and also provide a useful service to the community. For example, a well-organized highly efficient entrepreneurial garbage-collection system in Cairo is run by the Zabaleens (see chapter II, section D) who collect refuse from vairous parts of the city, independent of the city's own small system. The system is financially autonomous, and those engaged in these activities earn between two and three times the average income in Cairo.

Many low-income communities also house small-scale cottage industries that manufacture a host of products consumed by service industries: a variety of waste-recycling industries is also located in these communities. The existence of informal service and manufacturing sectors has not been adequately recognized in the past, and no institutional arrangements have been made to utilize their contribution to the various service sectors. Given the potential of the informal sector to contribute to the delivery of services in developing countries and also generate incomes for the poor, efforts to harness the productivity of these groups will no doubt have a positive bearing on the overall development of low-income communities. The co-ordination of the activities of these informal groups with the general delivery of services, and the provision of low-interest loans to equip these groups will greatly enhance their productivity.

While conventional development of shelter and services in a majority of urban centres is undertaken by the formal construction industry, a large proportion of developmental activities in low-income

settlements is confined to the informal sector. Small-scale subcontractors are largely utilized in the informal construction sector, since the overheads incurred by small subcontractors is much less than those of large subcontractors of the formal sector. Construction using small subcontractors is, therefore, inexpensive, and small subcontractors also have the benefit that they cover localized areas and are, hence, able to relate closely with the needs of the communities they serve.

In some of the slum and squatter-settlement upgrading projects in Sri Lanka, communities, dissatisfied with the standard designs utilized for service facilities, such as communal wells and toilets, and the quality of construction commonly produced by subcontractors, requested permission to tender for these works. When tenders for constructing these facilities were awarded to community construction groups, the performance and quality of construction were far superior to contractor constructions, and the designs adopted after community consultations proved exceptionally acceptable to the community. Little effort has, in the past, been devoted to utilizing the skills of this informal construction sector, but, if adequately trained and assisted, the informal construction sector could serve as a useful vehicle for replicating appropriate service-facility designs in specific communities.

C. Trained labour

Shortage of of trained workforce at all levels has been a serious constraint on institutional development and, therefore, the delivery of services, but it is unlikely that investments in labour alone can reap maximum benefits without a great measure of institutional development. Stable, autonomous institutions, offering career opportunities that attract competent staff, can establish financial and tariff policies that can enable the institution to undertake long-term development programmes without interruptions and undue political interference. The most important two ingredients for the success of service agencies are competent employees and sufficient funds.

Large labour turnovers precipitated by political change lead to loss of motivation and reduced effectiveness. In addition to simply attracting competent staff, an organization should offer salary increases and related benefits to minimize staff turnover, and should provide training programmes to increase staff skills. Because public institutions are often unable to offer staff compensation equal to that prevailing in the private sector, trained staff members often leave public service after relatively short periods of employment. Any training given to such staff members still provides an overall economic benefit to the country, but it follows that, for the public institution, training programmes must be continuous to ensure the availability of qualified candidates and to minimize institutional disruptions.

Few countries make adequate provision for the training of service personnel. Traditional academic training in service sectors is often based on advanced technologies and approaches which are inappropriate for and insensitive to the needs of the poor. Sector-oriented programmes have been found to have the advantage over traditional engineering programmes that they are sector-related and, hence, personnel following this form of training are likely to remain involved in the sector. In Africa, nationally accredited diploma programmes in water engineering for technicians have been introduced in Botswana, Kenya and Nigeria.

Many courses aim at the technical aspects of the provision of services and completely overlook administration, software (communication), operation and maintenance: few training courses include elements related to rural-service delivery. Programmes developed in China and the Philippines, in which thousands of rural operators are trained, tested and certified, lay emphasis on these neglected facets of training, especially operations and maintenance. Ideally, programmes, should be integrated with a national training effort and include the whole range of skills, implying a multisectoral approach to training.

Many training programmes tend to be abstract in nature, and the trainees are rarely able to identify themselves with the curriculum and have little opportunity to apply it in their routine work. On-the-job training has been found to be very effective, especially in the provision and upgrading of services to low-income rural and urban communities. The importance of the role of sector-trained sub-professional personnel has not always been fully recognized. As far as providing services to the rural and urban poor are concerned, sub-professionals are often able to identify more closely with the needs and aspirations of these communities than professionals, and the development of a well-trained cadre of sub-professionals has proved indispensable in the planning and implementation of infrastructure programmes in low-income settlements.

Little advantage has also, so far, been taken of the possibility of training local artisans for replicating standard service-facility designs within communities. This mode of expanding services was recently adopted for providing on-site sanitation facilities amongst low-income communities in India, Pakistan and Thailand. Many of the operational problems associated with the servicing of urban fringe areas can be attenuated with the increased use of sub-professional and community auxiliary staff, such as artisans. They could be trained and relied upon to prevent wastage, and report and correct breakdowns and defects in service systems.

In integrated rural development projects, advantage may be taken of training facilities established for other components of the project that, in many cases, also give instruction in operation and maintenance of simple mechanical systems. A comprehensive series of 45 tape/slide training modules, covering the social, economic, technical and managerial aspects of providing appropriate water-supply and sanitation systems has been produced by UNCHS(Habitat), in conjunction with the World Bank, UNDP, CIDA and other international organizations.

IV. FINANCIAL ASPECTS

A. Resource mobilization

Increasingly, national or urban water-supply and sanitation utilities aim to achieve and maintain financial viability. Four potential sources of funds exist for water-supply and sanitation development programmes. These are the government budget, foreign loans, institutional funding within the country and the beneficiary communities themselves. The obvious source of funds would be a revolving fund, sustained exclusively by the contributions of beneficiary communities at a level adequate to ensure reapplication of investments for expanding coverage and for operating and maintaining existing facilities. In a number of countries, however, both governments and consumers have the attitude that good water supply and adequate sanitation are a social service, for which charges should be kept to a minimum. It is only recently that, on the insistence of international lending agencies, such as the World Bank, there has been an attempt to improve the financial performance and autonomy of infrastructure agencies in many countries.

Institutional lenders within a country, as a source of sector funds, have been largely untapped so far, primarily because a majority of these institutions are relatively undeveloped but also because a majority of the sector agencies, with their weak institutional frameworks and cost-recovery procedures, are still not creditworthy. It is, therefore, not surprising that most water-supply and sanitation development activities in developing countries are funded from government budgets and foreign loans, both of which are determined by the government on the basis of national priorities.

The proportion of national budgets allocated to water-supply and sanitation can reach as much as 10 per cent, although it is usually within the range of 3 to 6 per cent. The proportion of external funds to national funds for capital investments remains high, but heavy reliance on external funding, inevitable as it may seem if progress is to be achieved in the short term, is unlikely to be a prescription for long-term development, in view of the limited external resources available. Internal financing for water-supply and sanitation development ranges from 25 to 50 per cent of the total, but it is essential that efforts be made to ensure that 85 to 90 per cent of the funds needed for capital investment, operation and maintenance be generated internally. Implicit in this requirement is the need to improve the financial self-sufficiency of the water and sanitation agencies, through recovery of revenues from user communities.

There are water companies that have lived up to these expectations. The Tunisian national water company, with responsibility for urban water supply throughout the country, has steadily increased both the levels of its annual investment and the share internally financed entirely from cash generation, customer contributions and borrowings. Brazil has also gone a long way towards the creation of financially autonomous water-supply and sanitation agencies,and capital cities in Cyprus, Nicaragua and Singapore have also turned in a strong financial performance. Inadequacies in the level and structure of tariffs in many other countries have been responsible for a disappointing record: the wide spectrum of consumers served provides opportunities for cross-subsidization within

a satisfactory structure and overall level of tariffs, but the maintenance of financial autonomy also necessitates appropriate tariff revision from time to time.

Municipal funds, raised through municipal taxes assessed on the size or value of the property being served, are the usual source of funds for drainage and solid-waste-disposal investments. Low-income communities, especially urban squatter communities, because of their illegitimate status, pay no municipal taxes, and this has often been used as the principal argument against providing these communities with municipal services. It, therefore, follows that the issuance of land title deeds or, at least, a declared intention to provide titles, is necessary before municipal revenues may be derived from these communities. It is often assumed that squatter communities are unwilling to pay for urban services, however, recent experience in Brazil and Sri Lanka indicate that these communities often consider that the payment of municipal taxes and service charges is a positive means of obtaining government recognition of the existence of their illegitimate plots.

Investments in adequate drainage have often been easily justified on the basis of preserving life and property: this, however, is not the case with refuse disposal. Up to 20 per cent of municipal budgets are expended on refuse collection and disposal, and management of urban waste is assuming increasing importance in many developing countries. Once again, the wide spectrum of populations served provides opportunity for cross-subsidizing the services for low-income communities, but, unlike the drainage sector, the refuse-disposal sector offers approaches which can operate independent of municipal finance. The most successful of these is private-enterprise operation based on a system of recovering resources for reuse.

B. Cost recovery

Inadequate cost-recovery procedures have, time and again, hampered the ability of infrastructure agencies to become self-financing. The historical evidence is that coverage has lagged further behind need in cases where water supply and sewerage has had to depend on governmental subsidies, either because the consequent loss of financial discipline has encouraged inefficiency or because the subsidies have been cut in the face of governmental budget constraints. The establishment of an adequate and equitable tariff structure and of effective mechanisms for assessing and collecting charges are a prerequisite to reversing the trend. Many countries, which have incorporated cost-recovery mechanisms as a part of the overall process of strengthening infrastructure institutions, have found such reforms to be beneficial in increasing the performance of agencies.

Although there exist cases where the entire capital cost of a water-supply or sanitation system is met by a single downpayment, it is most common to reduce the burden on the community by charging a monthly tariff to cover debt servicing and operating and maintenance expenses. There is little point in setting tariff levels which are beyond the means of the beneficiaries to pay: on average, 3 to 5 per cent of household income (based on the official minimum wage) for either water supply or sanitation or a combined service charge not exceeding 7 per cent of household income is considered affordable.

The cost of sanitation, especially sewerage, is often collected as a percentage of the water tariff. Water tariffs should ideally be

established on an incremental basis, where the initial quantity of water to be consumed for basic needs 3/ is charged at a nominal rate, but the rate increases with the overall quantity consumed. Consumption of water closely follows income levels, and, unless progressive rates are charged, the share of income devoted to water declines as income rises. Progressive rates also act as a conservation measure and give the opportunity to cross-subsidize low-income communities with revenues from wealthy communities and industry. Since long-term costs tend to rise as cheap water sources are fully exploited and costly alternatives must be developed, pricing should be in accordance with the long-term marginal costs.

Tariff charges are easiest to apply when water can be metered. Where water metering is not practical, either because water pressures are too low or because costs are prohibitive, the same basic principles of incremental cost can be applied with rates based on other measures of water use, such as the size of the service connection, the number of fixtures in the house or the size and value of the property served. Although the initial capital outlay in providing water meters may be high, countries which have introduced meters in urban areas have had positive results. In Sri Lanka, for example, the introduction of water meters, user charges and efficient billing and collection procedures has, in less than one year, increased cost recovery from the original 5 per cent to 25 per cent. The use of a single water meter to serve an entire block of houses and the distribution of charges equally amongst its residents are being tried in low-income communities in north-east Brazil, as a means of reducing the investment in and reading costs of water meters.

In addition to regular tariffs for the amount of water consumed, a connection charge is often levied, but this connection charge is frequently set at a level unaffordable to low-income communities, which also discourages connections. Loan financing of the cost of connection as an extension of the capital cost of the system safeguarded by the application of a charge based on the value of the property served, is an effective means of encouraging low-income communities to benefit from essential services, while levying appropriate charges on high-income properties.

Urban residents who receive water from communal standpipes or from courtyard connections that serve a number of households do not generally pay charges related to use, because of the administrative difficulties of charging. Although countries such as Cote d'Ivoire and Indonesia charge through an attendant for each bucket filled, it is usual to rely on property taxes or general municipal revenues, rather than direct charges. The use of standpipes often leads to water wastage, and some form of initial evaluation is necessary to assess the potential economy in providing standpipes as opposed to private connections.

3/ This minimum quantity (essential for drinking, food preparation and personal hygiene) is usually established between 5 and 10 cubic metres per month per household.

Financial self-sufficiency remains a distant goal for rural communities. Rural needs can generally be met at low per capita costs, corresponding to low standards of service, but low levels of income, the absence of industrial and commercial users and the attachment of villages to their traditional sources of supply lessen the prospects for recovery of any significant part of capital costs. Substantial capital subsidies from central government or urban users are, therefore, necessary to extend service to rural areas. It is, however, increasingly common for agencies to insist on a 10 per cent community contribution in kind, in terms of local labour, land and materials. There is also an increasing trend to transfer the responsibility for operating and maintaining service facilities to the communities themselves.

V. CONCLUSIONS

In order that a concerted effort may be made by national governments to provide safe drinking water supply, adequate sanitation, improved refuse collection and disposal, and improved drainage, countries may consider any or all of the following options.

(1) Develop specific sector policies, plans and programmes within an overall human settlements programme which give emphasis to abating present day inequities in services to various sectors of the population.

(2) Ensure the co-ordination of water-supply, sanitation and other service planning with overall human settlements planning as well as with overall economic development planning.

(3) Adopt appropriate, cost-effective standards and technologies for infrastructure that are consistent with the resource constraints of the country and with the overall objective of optimizing service coverage.

(4) Examine legislative and administrative instruments concerning the provision of infrastructural services, to see that they permit and promote the use of appropriate, cost-effective technologies among all sectors of the population.

(5) Review the institutional structure for infrastructure to ensure autonomous self-financing operation of sector departments under an overall co-ordinating umbrella institution.

(6) Incorporate, in each department, a specialized unit to meet the needs of the poor and to encourage community and informal-sector participation.

(7) Adopt policies and strategies for providing and strengthening sector-related training to professionals, sub-professionals and local skilled artisans.

(8) Adopt pricing policies and other incentives that will promote the increased use of local resources for sector development while taking due account of social objectives.

(9) Promote improved operation and maintenance of service facilities, giving priority to harnessing local efforts towards this end.

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