NON CONVENTIONAL (LOW COST)

URBAN SANITATION

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I. INTRODUCTION

It has been argued in many reports and publications that conventional urban sewerage and satisfactory sewage treatment and disposal is excessively expensive. It is often quite in-appropriate for rapidly expanding urban areas in developing countries with large communities of low income families and squatters. Yet politicians planners and even some engineers still stick to the outworn idea that the whole of every urban area should be centrally sewered.

The cost of conventional urban sewerage with elaborate pumping stations, complete distribution systems, individual household connections and treatment plants are estimated at about US 350 per capita. Beyond the urban core the cost can go up to US 1000 per capita. These cost are too high, not only from a financing point of view but recovery from beneficiaries is generally far below the level to pay for the operation and maintenance cost, let alone the investment cost. Therefore governments have tended to subsidise these schemes(and thereby the higher segment of the population) from the already scarce national resources at the expense of the lower income portion of the population.

In the past decades governments' and donors efforts have been concentrated on the development of new technological alternatives. Initially most of these efforts concentrated on the "on site" disposal of excreta. Pour flush (PF) Latrines and Ventilated Improved Pit(VIP) Latrines have in most cases been the technologies promoted, because they offer good service, including privacy and only a few odors, at a reasonable cost of less than US 100 per unit. Furthermore, the realisation, installation and functioning of these systems does not depend on the municipality or any other organisation.

All over the world people aspire to "the real thing"; waterborne sewerage/sanitation. Therefore, what has been missing is the promotion of an alternative /intermediate /non-conventional sewerage systems, which have all the advantages of the conventional system and which have the same service reliability. Research was committed by the World Bank and other organisations in the early eighties . A number of reports and papers were published in the early eighties on intermediate /non-conventional sewerage systems such as "Shallow Sewerage, Effluent Free, Small Bore Sewerage Systems(EFS/SBS/SFS) which costs about 20% less than conventional systems. A system of Simplified Sewerage has been tried in the Orangi Project in Pakistan. This system has proved to be as reliable as the conventional system but costs 30 % less. The Condominial Sewerage system has been developed and widely used in low income urban areas in Brazil: the cost of this system is about 70% less than the cost of a conventional urban sanitation system.

Although all these above indicated intermediate non-conventional urban sanitation systems are technically sound the 1993 edition of the WHO/UNICEF Water Supply and Sanitation Sector Monitoring Report, shows that - after these technologies became more

known from the early eighties- only 2% of the urban population had access to such a service. There are a number of reasons for this.
One of the reasons certainly is the lack of a proper Sewerage & Sanitation policy , lack of sector plans, not only from Central Governments, line Ministries and Implementing Agencies/Organisations, but also from International Lending Agencies and Donors.

Another reason is the lack of proper institutional development and support during project development and implementation on which hinges the successful implementation of these technologies. The organisational system/set-up used for the development of conventional sewerage systems, in which the central government plays a major role is not conducive for the development of systems where the local community/beneficiaries have to play a major role in order to create the required stakeholder ownership. Also the presently used organisational model may not be the most effective to give way to a review and/or change of the local sewerage design standards and practices in order to create new low cost sanitation technologies.

This paper tries to highlight some of the important policy and strategy issues related to the Sewerage and Sanitation Sector as well as to provide a proposal for organisational concept/framework for project development..

Chapter II provides some background information for the formulation of adequate policies based on the existing urbanisation trend, available financial resources for the water and sanitation sector. Furthermore, some attention is paid to the comparative cost of various sewerage and sanitation options as well as the relationship between density, soil conditions/water requirements and technical sanitation alternatives as well as project selection/identification.

In Chapter III deals with the technical aspects of some non-conventional urban sanitation solutions.

Chapter IV focuses on the organisational aspects of proper project development and selection. Most important is that more focus should be put on the process of project development. It is argued that more importance should be attached to the (equal) value/weight of the input given to the input by all participants (including the beneficiaries) "from the start to the "completion" of the project, than to the project outcome (mostly measured in physical components). It should be realised that the efforts to give equal weight of the low-income beneficiaries' input may well conflict with the actual democratic human rights position of this segment of the urban population in developing countries.

Finally some conclusions and recommendations are given in **Chapter V.**

II SANITATION & SEWERAGE POLICY

1. Urbanisation

Not long ago it was repeatedly stated that developing countries were predominantly rural. Around 90% of the population was said to be rural, contrasting with "developed " nations where people lived predominantly in towns.. Recent decades have seen a gradual but steady increase in the proportion of developing country populations living in towns. For example, in Sub Sahara Africa, the number of people living in towns increased from 14 % in 1963 to 22 % in 1980 and upto 27 % in 1987 (J. Pickford; Waterlines, Vol. 9, July 1990). In Zambia already more than half of the population lived in towns by 1987. According to John Briscoe (Environment NR. 7; Volume 35,number 4 , Mai1993), by 2000 there will be 21 cities in the world with more than 10 million inhabitants, and 17 of them will be in developing countries. Global urban population will be twice the size of rural populations. Developing country cities as a whole will grow by 160 % over this period whereas rural population will grow by only 10 %. According to WHO estimates approx. 60 % of Latin America was urbanised in 1983. Slums and squatter settlement, which house the majority of low-cost urban population, represented 30 % of the population

Like most global statistics, the urban population numbers and ratio's are by no means accurate. Definitions of what constitutes an urban area vary. Some definitions are linked to the number of inhabitants, other countries define towns by the form of local government, irrespective of population size. In part the increase in urban population in developing countries is due to rural-urban migration, in part it is due to natural growth.

After a number of years of intensified global effort to improve the water supply and sanitation coverage over the period 1980-90, only an additional amount of 1,347 million and 748 million persons were served with water and sanitation facilities respectively. The most dramatic increase took place for rural water, supply where the number of persons provided with facilities in 1980 increased by 240% by 1990. The number of rural inhabitants provided with sanitation facilities in 1980 also increased, though much less spectacularly by 1990 by 159%. The number of persons provided with facilities in 1980 , relative to 1990 were 150% each for water and sanitation.

However, despite the vast number of people provided with water supply, in most cases in absolute terms the amount of persons without proper water supply facilities remained unchanged; the efforts could only just keep up with the population growth in the rural areas. Only in a few regions increase in coverage could be achieved. For sanitation the situation just became worse. In absolute terms the coverage amounted only amounted to 72% for urban sanitation and 49 % for rural sanitation by the end of the Decade Carel de Rooy; Water International 16 ,1991; Source WHO).

2. Required funding of the Water Supply and Sanitation Sector.

The Global funding for the Water Supply and Sanitation Sector was estimated in 1990 among developing countries at $ 10 billion annually. Globally about 65 % of sector funding came (during the Decade) from national sources. For Africa and the least developed countries this proportion was only slightly in excess of 25 %, whereas in the countries of the Middle East , the figure was about 90 %.

One of the major reasons for the slow increase in coverage for water and sanitation during the Decade, apart from: lack of properly devised sector action plans for methodical guidance of their activities, lack of women's involvement and participation, the lack of promotion and acceptance of cost sharing mechanisms,(at government and community level), lack of active & systematic management as well as lack of trained personnel, has been the lack of external funding for low-cost technology projects. During the Decade low-cost technology projects only received 4% of the estimated total annual external funding of $3,000 million whilst governments' firm commitment to such projects increased by a six fold since 1980. Since the end of the Decade little progress has been made and many of the shortcomings still exist.

Carel de Rooy calculated the capital cost of complete coverage by the year 2000 using the following costing model (Water International NR 16,1991.) : US $350 for high cost technology (urban type sewerage systems with elaborate pumping stations and treatment plants) , US $ 25 for intermediate technology solutions (applicable to peri-urban solutions for on site sanitation, including technologies such as pour-flush and VIP Latrines) and US 20 for low cost technology solutions (similar technologies as chosen for intermediate technology). It was furthermore assumed that low-cost technologies would be applied to the entire rural areas; that 50% of the urban areas would have high cost technologies and the remaining half of the population would be equally divided into low-cost (25%) and intermediate technologies.

The outcome of his calculations showed that in order to raise the service coverage from the 1990 level of 72% for urban sanitation and 49% for rural sanitation to 100% for all by 2000 an investment of US 210 billion would be required over a period of 10 years. This would be about 10 times the 3 1/2 times the average annual investment into the sector during the 1980's. The calculation showed(, approximate as it is, that 30% of the total cost can serve 80% of the unserved , if the low cost option is emphasised. However, estimates indicate that allocation of funds to high-cost and low cost technologies is in the order of 80% and 20% respectively. Based on the above costing model a shift of US 1 million from the high-cost to the low-cost/intermediate technology category, would provide coverage to an additional 18,000 needy people (rural and peri-urban) at the cost of 2000 economically able people(urban areas). Finally it should be realised that the majority of the newly constructed high tech urban sanitation systems cannot be financed from the contributions of the beneficiaries. Government funds (in fact subsidies), in a number of forms are required to prevent the system from collapse within a short period of

time, thereby depleting even more the scarce resources to satisfy the sewerage/sanitation needs of the low-income portion of the population.

3. Actual disbursements

According to the Water Supply and Sanitation Sector Monitoring Report 1993(data as of 31/12/91) prepared by the WHO, UNICEF and the Water Supply and Sanitation Collaborative Council, only 2 % of the low income urban residents had access to small bore sewers. Simple pit latrines still formed the most common method for excreta disposal for about 1000 million people. About 550 million people had access to through a house connection to a public sewer. According to the report the bulk of the funding has been directed to the better off population.

Moreover, Governments appear to give a higher priority to the funding of water supply than to sanitation. Governments provided approximately 50 % of the funding for new systems in urban high income areas, while they provided only around 30 % of the funding for sanitary facilities in these areas.

The WHO/UNICEF concludes that over the years 1990-94 sanitation has almost been neglected. The number of people deemed to be lacking adequate sanitation rose by 274 million. During the period , the population having access to safe sanitary means of excreta disposal grew by only 14 million, a growth far lower than that of the population , resulting in a reduction of coverage from 36 % in 1990 to only 34 % in 1994. The real set back occurred in the urban setting where coverage level during the period decreased from 65 % in 1990 to 55 % in 1994. Of the people who gained access to sanitation, 13 million or 93 % lived in rural areas.

Apart from the preference in spending for water supply over sanitation less money has been disbursed into the sector. According to UNDP-World Bank Water and Sanitation 1995-96 Report, disbursement dropped from US 15 million in 1992 to US 7 million in 1996; disbursements from UNDP own funds dropped from US 9 million to about US 2 million.

4. Sanitation technologies

- Technical options

Its is clear from the above observations that more attention must be given to the promotion of low-cost sanitation technologies. In a study carried out by the World Bank in 1982 a variety of on-site and off-site excreta and sullage disposal systems were identified. A descriptive comparison of sanitation technologies is presented in **Annex I.**

In general on-site excreta and sullage disposal systems are found to be much less expensive than off-site systems. However, there are some situations where on site systems are technically unfeasible. In such situations some form of off-site disposal system is required. Shallow sewer and similar sewerage systems are usually the most economic of all off-site disposal systems and are therefore an obvious option. However, before making a choice consideration should be given to the following conditions:

- Population Density
All on site disposal systems require adequate space within the plot. In most cases this space will be available in rural and low-density to medium density urban areas. However, when the density of settlement increases, the required space may not be available. Also some consideration should be given to possible opposition from the community for desludging required at some stage during their operation.
Where all forms of pipe networks demonstrate considerable reductions in unit household cost as the density of settlement increases (more houses are being served by the same length of pipe), on site systems have a constant unit household cost irrespective of changes in density settlement. The relationship between density, total annual cost per household and sanitation option has been illustrated in Figure I below.

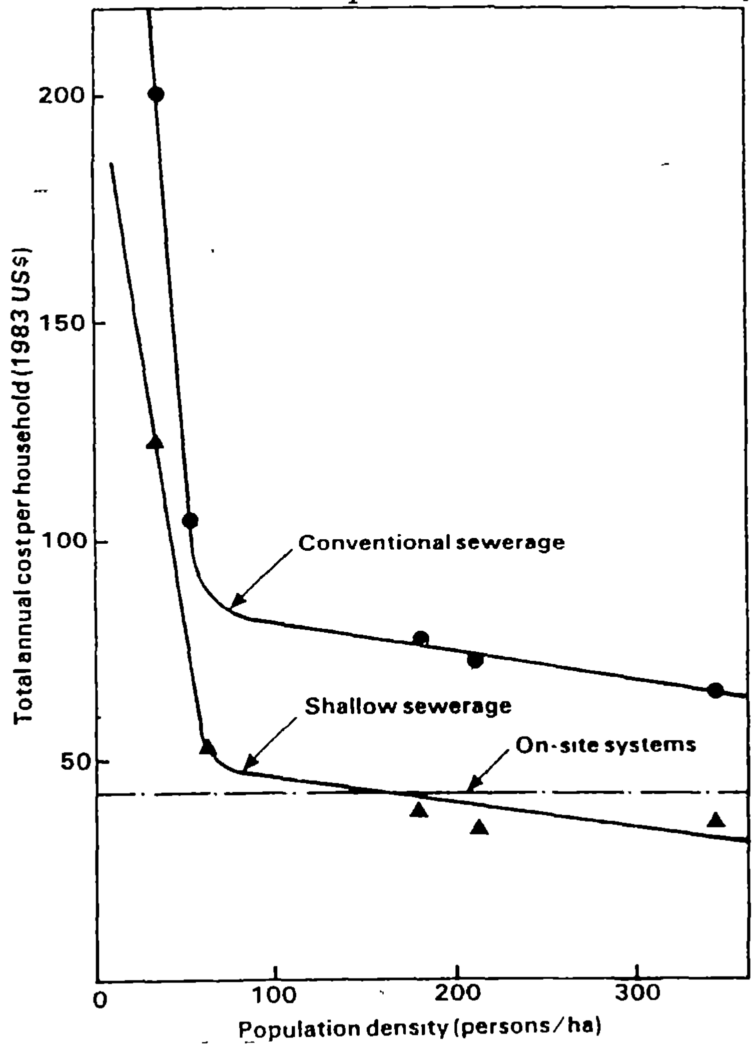


Fig. I: Variation in cost of conventional and shallow sewerage and on site sanitation with population density in Natal (Northeast Brazil)
Source: G.S. Sinnatamby: "Low cost Sanitation Systems for Urban Peripheral Areas in Northeast Brazil"; August 1983

At a certain density piped networks become more economical than on site systems. The point of transition depends on the physical conditions of the settlement (e.g. soil permeability, topography, etc.). For a certain settlement in Brazil this transition occurred at a density of 160 persons per hectare as illustrated above. It has even been proved that in areas with Shallow rock shallow sewers were more cost effective than on-site systems at population densities as low as 110 persons per hectare.

- Soil conditions

All on site and sullage disposal systems become less cost effective in case the absorption capacity of the soil is low, or in cases of shallow rock or a high ground water table where the chance of contamination is high when the water well is close to the latrine solutions.

- Water requirement

Communities with waterborne sewerage normally require more than 75 l/per person per day compared with less than 20-30 l/per person per day mostly used in may squatter settlements. (Cairncross/Feacham: "Environmental Health Engineering", 1991). Simplified sewerage is designed for a minimum flow of 25 l/ppp/d or1.5 l/s.

5. Project Selection/Identification/

5.1 Project Selection

Project selection appears to be one of the most complicated matters in the whole process of project/programme development . The factors affecting the prioritisation of projects/sewerage schemes is long, varies from place to place and over time, depending on the conditions prevailing when the analysis is being done. Generally the following common criteria can be considered. However, planners (and others) should feel free to add depending on the local conditions and circumstances.

- total projected population
- population density
- failure of on-site sanitation systems
- industrial pollution
- cost
- tourist impact
- environmental impact
- affordability/willingness to pay
-economy of scale
- institutional capacity
- health benefits

It has been observed that sometimes project selection is politically influenced too early in the selection process and does not take place on the bases of a numerical analysis but on rather subjective arguments without a weighting system. In such cases the selection rather illustrates a consensus of arguments by strong personalities together forming a "Project Selection Committee" than the result of a number of objective scoring exercises. An example of a numerical analysis has been illustrated in **Annex II**.

5.2 Project Identification

Sustainability

Before having identified technically feasible options for sewerage/sanitation which meets needs of the community, it is necessary to make an objective comparison which results in the selection of the most cost effective one. The most important considerations before making a choice is the requirement that the chosen solution should be sustainable; in other words that :

- it should be "replaceable", in that the solution/project can be copied in other communities. This means that the approach is technically suitable, socially acceptable , and affordable by the recipient community. If communities cannot repay the cost of the project (or a significant portion of it), then it is most probable that municipalities will not have sufficient funds to start/continue with new projects
- it should also be "maintainable". Projects cannot be maintained over an extended period of time, unless the responsible organisation is adequately funded, has sufficient numbers of well trained and well-motivated staff, and is equipped with appropriate and well-maintained equipment.

Cost-benefit Analysis

There is no completely satisfactory method for selecting the most cost effective sanitation system. Generally Economic Cost Benefit Analysis is being used to quantify the social advantages and disadvantages of each choice in terms of a common monetary unit. Benefits may be positive or negative (increase in water use for toilet flushing resulting from the provision of a sewerage system). However, it is impossible to quantify many of the positive benefits, such as improved health, greater well-being, higher productivity, etc., resulting from improved sanitation. Each alternative considered could give different benefits.

Despite its apparent deficiencies, cost-benefit analysis, if applied properly, will still provide a reasonable objective basis for comparison reflecting the cost trade-off corresponding to different levels of service. However, it appears that in too many cases the decision to approve the project proposal has already been made before the outcome of the Cost-benefit analysis is known. In those cases the underlying assumptions are adapted to suit a positive outcome of such an analysis.

Shadow pricing

It should be stressed that sufficient attention is paid to "shadow pricing". Four shadow factors need to be incorporated in the economic costing of sanitation technologies: e.g.

- the opportunity cost of capital
- the unskilled labour wage shadow factor
- the foreign exchange shadow factor
- the shadow price of water, land and other resource inputs.

The shadow price of additional water use resulting from improved sanitation should be calculated at its current production cost and not , as is usual, at its marginal or future rate.

Incremental Average Cost

Conventional sewerage is capital -intensive, requires large quantities of water for flushing, with only a small proportion of the beneficiaries being served in the early stages of its operation. This system therefore has high incremental average costs., This , however, is not the case with no-conventional/shallow sewer systems, since they require no more than 3 litters per flush, make a limited demand on capital and serve a large proportion of, if not all, the households immediately upon completion of the system. With regard to the use of water for flushing , shallow sewer systems require no more water than on site sanitation systems such as pour- flush water seal latrines. In shallow sewerage the sullage provides the means of flushing.

The average incremental cost is often represented as the total annual cost per household (TACH) for purposes of comparing the cost of one sanitation option with another since life span, capital operation and maintenance cost differ from one technology to another. A summary of TACH for various sanitation technologies has been given in **Annex III.** From this Annex it can be concluded that shallow sewerage is indeed a low cost sanitation technology. Furthermore, it should be realised that the TACH of shallow sewerage decreases markedly as the density of settlement increases. The relationship between density and annual cost per household for conventional sewerage and shallow sewerage has already been given in **Figure I**

These data illustrate that the Total Investment Cost for Shallow Sewerage are only about 21 % of those for conventional sewerage while the percentage of low income is at a density of 160 persons per hectare the TACH of shallow sewer systems was found to be lower than the cheapest on-site waste disposal system.

Affordability

Economic costing forms provides a basis for selection of the least cost comparisons of sanitation technologies and thus is extremely useful to planners and policy-makers in identifying sanitation options. The beneficiary however, is most interested in financial cost, e.g. how much he will be expected to pay and over what period of time. These financial cost of a project to the consumer is greatly dictated by governmental policies, unlike economic costing, where distortions are ironed out by shadow pricing.

Financial appraisal differs fundamentally from economic appraisal. Whereas economic cost are based on the physical conditions of the community (for example, its abundance or scarcity of labour, water etc.) and therefore, are quite objective, financial costs are entirely subject to the interest-rate policy , loan maturity term, central-government subsidies and the like. The financial cost for a community can even be zero if the central government has a policy of paying for them out of a general tax fund.

Where investment is staggered and different capacity utilisation rates are likely to be encountered (as is usually the case with conventional sewerage)), the annual financial cost per household should be determined using the average incremental method.(See

"The Design of Shallow Sewer Systems; United Nation Centre for Human Settlements (Habitat), Nairobi 1986; page 56).

Affordability is being determined by comparing household incomes to the financial cost of the service. The financial cost per household and their implications for the affordability of a variety of sanitation options is given in **ANNEX IV.**
From this table it can be concluded that the cost of providing, installing, operating and maintaining shallow sewerage systems demands no more than 2 to 6 % of the income of average low-income households as compared to about 45% for conventional sewerage. This would indicate that shallow sewerage systems are affordable to these communities and should not require any subsidies. However, the fact that a certain sanitation option is affordable to a community does not automatically imply that the community is willing to pay for the system and this is especially true for low-income families. The community's priorities and its perceptions of the need for a certain sanitation technology will, to a large extend determine the level of acceptance of that technology and its willingness to pay for it. The fact that shallow sewer systems are waterborne and dispose of both excreta and sullage makes them especially attractive to low income urban communities served with some form of piped water distribution system. However, successful shallow sewerage programs require adequate institutional capacity(medium: as compared to high for conventional sewerage) and support to implement and administer it. It appears that this has been one of the main bottlenecks for a dramatic increase in the use of non-conventional sanitation systems.

What has been argued above not only applies to shallow sewerage but also to a number of other sanitation options such as Condominium sewerage and to a lesser extend to Small Bore Sewerage/Solids Free Sewerage.

III. NON CONVENTIONAL URBAN SEWERAGE

1. General

Apart from the lack of policy making, sectoral plans and the allocation of resources to low-cost urban sewerage, the lack of information on the advantages of such systems over so called conventional sewerage to the wider public, has been a bottleneck in the further (increased application of these systems. As early as 1985 various international funding agencies have initiated publications on design and application of various non conventional urban sanitation systems such as small bore sewerage, simplified sewerage , condominial sewerage. However, it appears that despite effort this information appears hardly been used for the design and implementation of low cost sanitation systems in developing countries.
The information below is particularly intended for politicians, planners and project developers operating in the sewerage and sanitation sector, illustrating the background for the design of these systems.

One of the most important ways to make sewerage systems more sustainable is to reduce the cost of its construction. Lower construction and investment cost can be translated in more optimal use of the system at an early date, better tariff returns and lower cost to the beneficiaries.

In most cases sewerage treatment alternatives are often considered as a way to reduce total wastewater facility costs, but alternatives to conventional gravity sewers are rarely evaluated, although the collection system can represent 65-90 % of the total construction costs of collection and treatment (Ducan Mara: Low cost Sewerage; 1996)

2. Codes of Practice/Laws/Bye laws

National and local codes of practice and local laws and bye laws govern most of the works of sanitary engineers.. Such laws and regulations have been created to promote high standards of health and ensure that the designed facilities are capable and able to carry out the duties for which they are designed. However, many of the codes of practices and laws/bye laws in developing countries were imported from countries with different needs and circumstances. The major point of difference affected by these codes and laws are: sanitary fittings, water consumption level on the one hand and , minimum pipe sizes and pipe slope, the location and depth of collector sewers on the other.

Sanitary fittings

It should be realised that the on-plot component of a sewerage scheme, including the sanitary fittings, can account up to 50 % of the construction cost. This fact has often been ignored by project planners and development in the initial stages of the project definition leading to poor connection rate and tariff return.
Current standards for sanitary fittings are often inappropriate for local conditions resulting in excessive water use and high cost of these fittings.

If the amount of water consumption can be minimised, the size of sewer pipes can be also be minimised and capital investment can be reduced subsequently. However, one of the main reasons for the construction of a sewerage scheme is the extended use of water to dispose of the additional use of water by extra installed water-using fittings. Many of the available fittings were not designed with regard for the minimal use of water. The installation of low-flush toilets, water saving taps, pressure reducing valves, etc. can reduce water use. However, the major savings in water use is most likely to be achieved from changing the attitudes of the community on the importance of saving water. The use of financial penalties for excessive use or charging an economic tariff can be used to reduce water use.

Flushing tanks with a volume in excess of 20 liters can be found resulting in about 40 of total domestic water use (Kalbermatten 1982). Flush volumes of 3 litters have been satisfactorily used in Botswana and Leshoto, while flush volumes of 4-5 litters have been widely recommended.

It is important that sewerage laws and bye laws facilitate and promote the local manufacture of pipes materials(vitrified fired clay, concrete pipes). Provided that locally made concrete pipes are properly manufactured and cured their use is recommended, since the manufacturing skill required to make them are low, the capital investment is small and the manufacturing plant can be small and portable. A disadvantage is that concrete sewer pipes require a fixed cement-motar joint which will fracture at any movement of the pipe resulting in entering of tree roots, silt and ground water.

Pipe size/gradient.

Except for drains from WC's Branch drains are designed to facilitate the drainage of peakflow from all appliances without siphoning out of liquid contained in the water seal. They are generally designed to carry the peakflow at 50 % half full.
House and the remaining part of the collection system are designed to carry gross solids. Furthermore, maintenance requirements play an important role. Minimum pipe size is based on experience and not on theory. Generally 75-100 mm and 100-150 mm pipes are described for house sewers and the upper part of the collection system respectively. Lower down the pipe size will be determined by the volume of sewage and the hydraulic capacity of the pipe.
The cost of a sewerage collection system is heavily influenced by the sewer diameter. World bank calculations indicate that by reducing the (minimum) diameter from 200 mm to 150 mm, the cost of branch sewers, which constituted 12 % of the total costs, was reduced by 43 % (Wright/ Bakalian; Infrastructure Notes July 1990).
After determination of the pipe size the gradient is selected to ensure a "self cleansing velocity" (about 0.75 m/s). The British Standards specify gradients of 1:40 to 1:80 for house drains and 1:150 for collector sewers

Manholes.
One of the key factors that influence the cost of a sewerage collection system is the cost for manholes. In one World Bank project, manholes accounted for 23.4 % of the total costs; by reducing the average sewer depth from 2.5 m to 1.5 m, the cost of manholes was reduced by 73 %(Wright/ Bakalian; Infrastructure Notes, July 1990).

3. Non conventional low cost sewerage collection systems

In literature over the past 15 years in principle 3 types of non conventional low cost urban sewerage are identified, e.g. :

- **Small Bore Sewerage or Solids Free Sewerage**
- **Simplified Sewerage**
- **Condominium Sewerage**

However, Duncan Mara prefers in his publication "Low cost Sewerage" published by John Wiley & Sons, 1996 the following terminology :

- **Settled Sewerage**, to describe the system in which wastewater from one or more households is discharged into a single -compartment septic tank (solids interceptor tank) , the settled (or solids free) effluent from which is discharged into shallow, small bore gravity sewers.

- **Simplified Sewerage**, to describe shallow sewerage and in its block variant sometimes called backyard or condominium sewerage. This system does not convey pre-settled sewage, but is comparable with conventional sewerage without its conventional (over cautious) design requirements, which have been in force for over a century.

In this chapter this newer terminology will be used.

3.1 Small bore sewerage/Solids free sewerage

Technical Features
Small Bore Sewerage(SBS) also known as Solids Free Sewerage (SFS) is a hybrid between a septic tank and a conventional sewerage. Its distinctive feature is a solids interceptor tank located on the plot between the house sewer and the rest of the sewerage system,. Typically, there is only one such interceptor tank for each house sewer. This one chamber tank retains the solids in the incoming sewerage and attenuates variations in the incoming flow. It furthermore replaces the grease trap; also primary treatment takes place in the interceptor tank. The cost savings from this system are primary derived from reduced water requirements, reduced excavation costs (pipes can be placed below hydraulic gradient) lower material costs for smaller pipe sizes and simpler/smaller pumps and lower treatment costs (because anaerobic treatment ponds are not needed at the treatment works).

Minimum diameters of 100mm (4 inches) are commonly used downstream of the interceptor tanks; in some places pipe diameters of even 50 mm have been used satisfactorily. Cost savings of up to 30 % have been reported from the use of this system while applying conservative design criteria.. Additional cost savings can be achieved at the treatment plant where the absence of solids in the sewerage renders the use of primary treatment plant obsolete.

Importance of solids removal
The sewerage downstream of the tank is free of solids. Therefore, there is no need to adhere to conventional sewer design practices like self cleansing velocities and sewer slopes can be flatter, leading to shallower depth and savings in excavation. According to M. Wright/A.E. Bakalian (Infrastructure Notes ; Water and Sanitation, July 1990) a 50 % reduction in the minimum velocity results in a 75 % reduction in the slope; the minimum diameters can also be reduced because the risk of solids deposits is negligible and therefore there is no need to maintain a minimum diameter to facilitate dislodgement of solids from the sewer. For the same reason, manholes are not that important anymore and can now be spaced at much wider intervals. In many cases they can be replaced by simple clean-outs.
The attenuation of flow via the interceptor tank can result in a reduction in the peak flow factor by as much as 60 % or more (reductions from 11 l/hour to 4 l/hour have been reported). This allows for a further significant reduction in sewer diameters.

Operation and maintenance
Operation and maintenance requirements consists mainly of answering service calls and making new connections as well as inspections and pumping out of solids of the interceptor tanks. Periodic inspection and cleaning by hydraulic flushing has been recommended for the collector main. However, in the United States this has not been deemed necessary by most Utility Companies. Minimum pipe diameters of 50 and 100 mm have been used successfully in experimental schemes in Mt. Andrew/Alabama (R. Otis/D. Mara; TAG 14; UNDP).
According to findings by Wright/Bakalian(July 1990) many large systems in Australia have been in operation for over 30 years without any flushing of the collector mains. Nevertheless, for long flat sewer sections, with peak flows less than .015 m/s, regular flushing is still recommended. Also, pumping stations should be inspected on a daily or weekly basis preferably. Utility Companies normally use a truck-mounted centrifugal suction pump for the maintenance of the SBS/SFS systems.
An advantage is that SBS systems are not dependent on a good and reliable water supply system to function properly
The most frequent encountered problems are odours and blockages within the building sewers up-streams of the interceptor tank (on the plot). The causes of these blockages are similar to those experienced by users of conventional sewerage system; they are the responsibility of the home owner. Most Utility Companies are willing to assist in cleaning them up.

Application
SBS/SFS systems were first used in Australia and Zambia in the 1960's. The system was then introduced in the United States in the mid 1970's. More than 160 systems have been installed in 34 States. SFS has also been used in a number of Latin American countries including Brazil, Columbia and Argentina. SBS/SFS systems have been included in World Bank supported development projects in Columbia (Cartagena), India (Tamil Nandu Project), Bangladesh, the Philippines and Indonesia.

3.2 Simplified Sewerage

Technical features
Project areas are defined as individual drainage basins. Each basin may have its own collector/s and treatment facility. As soon as additional funds become available, the individual drainage basins may be connected by a common interceptor sewer to a regional treatment plant. The sewers care usually constructed in already developed areas, in order to minimise the depth of excavation and restoration of pavement cost. They are mostly installed under the sidewalks. To save pipe and excavation cost the sewers are extended only to the last connection rather than to the end of the block. the design is based on the saturation population for a particular drainage area instead of on a design period based on population growth. In condominium sewerage individual households are responsible for maintenance of the feeder sewers; the formal agency only tends to the trunk mains. The saturation population is based on 5 persons per dwelling unit. In case the saturation population method for calculating the system cannot be used a design period of generally 20 years is being used. This relatively short period minimises the problems related with the difficulty in predicting population growth and water consumption as well as the high cost of operating/maintaining large under-utilised sewers.
Design flows are based on water consumption (meter readings) and assumed population saturation. In case no data on actual water consumption is available, a minimum flow of 1.5 l/s in each section is recommended. Pipe gradients are calculated on the basis of " tractive tension" principles. Pipes are kept filled between 20-75 % of the sewer diameter.
In Brazil 100 mm diameter laterals or branch sewers are being used inn residential areas to a maximum length of 400 m. These pipes are in most cases located under the unpaved streets of per-urban areas
Because of lack of traffic pressure sewer depths are approximately 0.65 m below the sidewalks, about 0.95 -1.50 m below residential streets depending on the location of the pipe in relation to the centre line of the street and the amount of traffic. For heavily travelled streets a depth of 2.5 m is being used.
In case buildings are too low to make a gravity sewer connection the property owner should try to connect to the sewer on the other/lower side of the block, provided easement can be obtained.

Manholes

One of the biggest savings of the simplified sewerage system is obtained via the replacement of expensive manholes (which can account in conventional sewerage for 25 % of the cost of the system) by "simplified" manholes, clean-outs, or small buried boxes. It has been observed in Brazil that conventional manholes are often not used and therefore unnecessarily expensive. The simplified manholes are 0.6-0.9 m instead of 1.5 m in diameter for conventional manholes. Due to the shallower depth of the system manholes can be less deep and are only constructed at major junctions. At direction changes or slope changes simple boxes are constructed. Inspection boxes are constructed under the walkway so that a jetting hose can enter the system under a 45 degree angle for cleaning purposes. These simplified constructions account for about 25 % of a sewer system.

Cost

In Brazil (Sao Paulo), where the first simplified sewerage projects were executed, a reduction in cost of 30 % has been realised. However, after a number of years authorities calculated the reduction close to 40 %. In Brazil cost savings generally range from 20-50 % . In the city of Sao Paulo cost savings over conventional sewerage of 35 % have been reported by the state water and sewerage company (SABESP). SABESP estimates the cost for simplified sewerage at US 80-150 per capita as compared to conventional sewerage (excluding treatment and house connection cost) at US 150-300 (1988 dollars) per capita.
(Duncan Mara: Low cost sewerage; Wiley & Sons, 1996)

Application/Operation and Maintenance

Since the first implementation of simplified sewerage in the state of Sao Paulo and Parana no significant problems have been reported. The system has also been constructed in Bolivia, Colombia and Cuba.
In Sao Paulo only 75 obstructions per 1000 km of sewer each month has been reported. This underscores the opinion that the construction of expensive manholes as required for the conventional sewerage system should be limited. It may be more economical to add a few manholes arising based on the need for it arising from frequent required clearing of obstructions in a certain location.

Detailed design information on the above described sewerage/sanitation systems can be found in References Nrs.. 8,9,13,16 and 19

IV PROJECT DEVELOPMENT

1. The Project Cycle

Projects and programs are an important mechanism for the development of the Water & Sanitation Sector. Whilst there has been an increasing emphasis on the establishment of the right policy framework for the utilisation of the scarce financial and human resources at the same time protecting the environment as much as possible, the practical actions to implement these policies are generally undertaken through project or programs. These projects/programs should consists of sets of activities which require the investment of financial and human resources over a period of time to create physical or institutional assets, assuming that these will yield benefits in the future.

Many people still think of projects as activities undertaken specifically in co-operation with multilateral and bilateral funding/assistance agencies. These agencies have been very prominent in developing project methodologies.
A project is often described as passing trough a number of stages which form a cycle. One of the early models of a project cycle was developed by Baum. In this cycle the project moves throng the following stages:

- identification
- formulation
- appraisal
- implementation and
- evaluation

It is the idea that evaluation of the project and its development leads to the identification of new ideas, which can be worked out in a new cycle. Later on many variations of this cycle have been developed, in varying degree of complexity and highlighting different features. The strength of this model it simplicity. However, the disadvantage is that it perceives projects from the perspective of development agencies and financiers point of view, who are still mainly concerned with the actual project phase, because that is the phase their involvement is greatest. Projects viewed from the perspective of beneficiaries do not form a cycle; activities start with the project phase and continue over some period when the project assets are in use to yield benefits and services.

The disadvantages of this simple model is that the project is at the centre of focus. As a result:
- it does not account for the interaction between the various phases
- it does not illustrate how sector goals/objectives, purposes, outputs and activities are meeting the needs of the beneficiaries and how this is going to be achieved
- it does not indicate the roles of the various stake holders
- there is a low priority for monitoring; generally only the implementation phase is monitored

- finally, little emphasis is placed on the management/organisational requirements to achieve the project objectives.

2. The logical Framework

Projects and the project cycle have been a feature of project development for some period of time, but some new and important new project approaches have become more widely used in recent years.

The logical framework increasingly applied to assist in the planning of all types of projects, although to a lesser extend for sewerage and sanitation projects.

The most common format of the logical framework consists of a four-by-four matrix.(See picture below).

Its most important feature is that the four horizontal rows link the activities of the project(bottom row) , to the project outputs, which are the facilities or assets to be created by the project. The use of the project outputs contribute to the purposes of the project which in turn, contribute to the wider objectives or sector goals (top row). By focusing more on these relationships, the logical framework assists stakeholders to think through the linkages between projects and polices of the sector. Furthermore, it achieves that a particular project fits more rationally within a policy framework.

The four vertical columns link the activities, outputs and purposes of the project to the monitoring indicators which can be used to monitor its achievements. Going through the motion of making a logical framework is a good exercise for planners and managers alike and may lead to changes in project design and different management approaches for the solution of particular problems.

Logical Framework

Project Summary	Objectively verifiable	Means of verification	Risks and assumptions
Sectoral goals			
Purposes			
Outputs			
Activities			

Although the logical framework is often thought of as a tool which is particularly useful for development agencies, the logic is independent of the method of financing of a project ands its application is valuable at all levels and for all types of projects.

The disadvantages of this system are:

- the idea of constant improvement of projects through constant project evaluation and adjustment of ideas and results for the start of a new project cycle has been lost
- the roles of the various stakeholders has not been clearly identified; the value of the

input of the beneficiaries can easily been ignored
- little attention has been paid to the management/organisational requirement to execute and implement a logical framework exercise

3. Project Cycle Management/Project Development Cycle

The concept of project cycle has led to ideas of project -cycle management. This covers the whole range of approaches and methodologies for planning and managing a project, from its identification, through the stages of planning, appraisal and implementation, to its operation to yield benefits, and beyond.

3.1 Development Cycle

In the beginning project management was taken to refer to managing the stage of project implementation. Particularly in the building and construction industry, the stage of project implementation or construction is a very major undertaking, and its management needs to be correspondingly complex. In developed countries large infrastructure projects in the Water and Sanitation sector, were centrally planned and implemented. Project success then tended to depend to a large extend on careful and detailed planning, accurate construction of facilities according to the plans, and strict accounting for large amounts of public money, developing appropriate financing strategies, and devising suitable institutions for operation and maintenance. However, the success of water and sanitation projects in developing countries -more than in developed countries- depend for their success on a "process" of dialogue and partnership between all stakeholders throughout the period of project planning, development and implementation. Also the project cycle should allow for changes in plan and may also need to accommodate pilot and experimental phases. Below a full description has been given for a model of project development which includes, functional models, pilot solutions, etc..

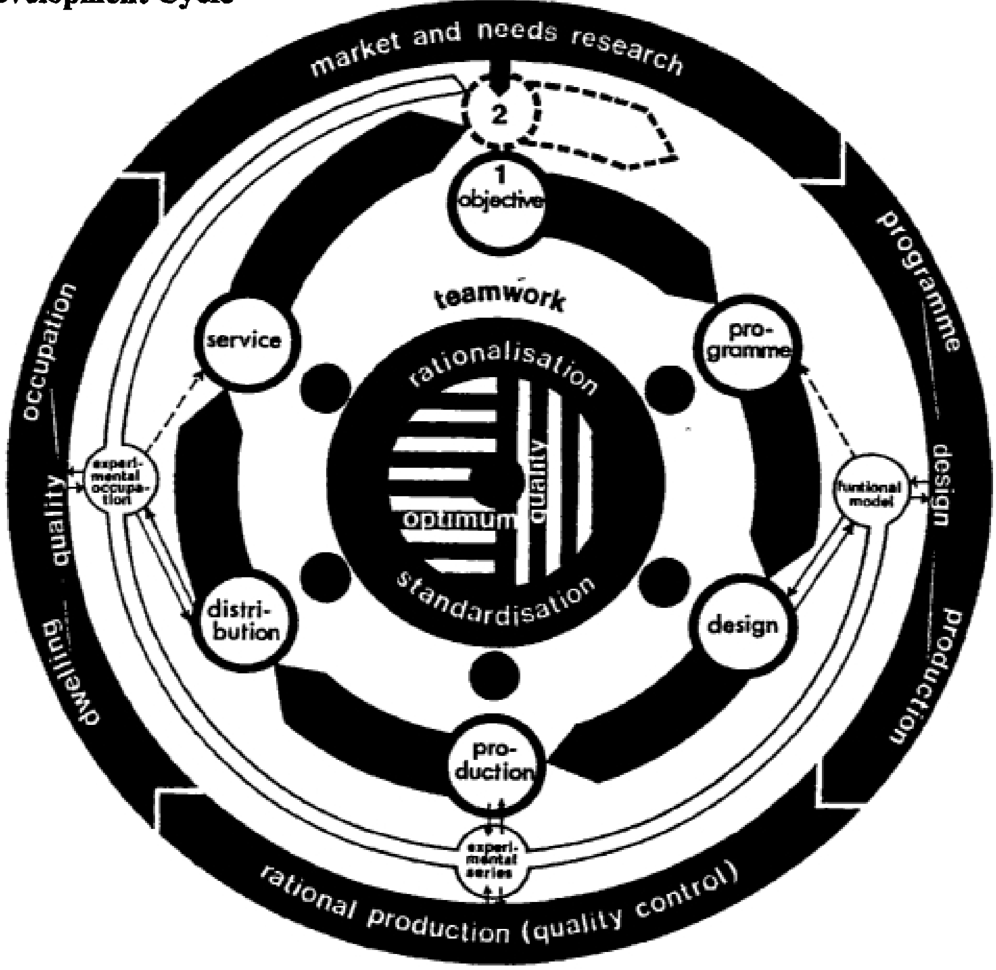
The total program development is divided into 4 main phases; e.g.
- market an needs research
- program production
- rational production/quality control
- use

During these phases 6 main steps or decisions should be taken e.g.
- objectives
- program of requirements
- design
- production implementation
- distribution/allocation
- service/maintenance

Although stakeholders/beneficiaries are represented and participate at all decisions it is still unsure whether the decisions taken can/will be acceptable and can/will be affordable to the beneficiaries. Therefore before finally deciding on the design, the actual product

and the allocation/use a functional model, a pilot project/series and a experimental allocation/use respectively is being executed and tested. Based on the evaluation of these tests design, production and allocation is being modified respectively. A technical secretariat directs the development, directs and assigns studies for discussion, controls organisational costs, etc. aiming to achieve an optimal quality through teamwork, standardisation and rationalisation. The above described model has been illustrated in **Figure II** below:

Project Development Cycle



3.2 Organisational Structure

This model has been successfully tested for the development and implementation of physical infrastructure projects in The Netherlands as well as in Developing Countries. It was developed in the Netherlands initially to serve the development of a number of low-cost housing projects from 1968 to 1974. At the same time it was successfully applied for the development of a number of low-income housing schemes in Argentine, Colombia, Thailand, India and Indonesia. For the development of the housing schemes a number of working groups were established, each taking care of different aspects of project development such as:

- project identification & planning
- design aspects
- construction aspects
- costing & implementation
- economical aspects, operation & maintenance

A number of 5 multidisciplinary working groups were created. All stakeholders were represented in each working group, though not in equal numbers, e.g. all "planners" were attending the meetings of the first working group and only one representative of them could attend the other working group meetings (not necessarily the same representative). Each working group was chaired by the chairman of a municipal council. The central government was represented in each working group. A Technical Secretariat directed the overall project development, took care of the co-ordination (distribution and exchange of minutes of the various working groups), performed the role of an independent moderator and also called -when needed- plenary sessions for necessary decision-making to achieve the required progress. The advantage of the above described methodology is that it is not possible that one single person (a particular strong personality) in one group has an overruling influence in the decision making process which is often the case in project development/planning g committees on national level.
For the development of low-income projects in developing countries the organisational structure was somewhat reduced but based on the same principle.

3.3 Applicability for non-conventional sewerage
The above described method of project development appears very suitable for the development and introduction of non-conventional urban sanitation technologies which require some form of review of existing design standards. The representation of the Central. Regional and or Local Government, representatives of the Engineering society, Bureau of Standards in working groups as well as in the plenary sessions makes these representatives less vulnerable, problems and possible solutions are discussed in all openness before a decision is being taken. The Chairman of a working groups or the plenary meeting can be approached in case no sufficient backing can be acquired. Furthermore, the testing of the plans in "models" during the various stages of development is another way to widen its approval from all stakeholders including the beneficiaries. It is expected that the Project Development Cycle organisational approach is particularly suited for they introduction of innovations and review of standards as is required for the design and implementation of the above described non-conventional low-cost urban sanitation solutions.

Although the ideas of project cycle management assist project stakeholders to see the project as a whole through all its development stages, rather than focusing on one particular stage in isolation, the importance of the (equal valued) input of the various stakeholders is not yet secured. A key feature of many projects in the water and sanitation sector is that success depends on the attitudes of the people served, and the interactions

between human behaviour and physical facilities. This is particular true for providing clean water and sanitation to the low-income peri-urban population. To achieve "stakeholder ownership" more attention should be paid to the "development process". The understanding of process should be that there is a dialogue and interaction between stakeholders and participants and that inputs by all are equally valued. Input of beneficiaries should take place via "structured learning", taking into account the level of understanding of the participants and beneficiaries. At important decision points -before major investment decisions are taking place- stakeholders analysis is required to test if the needs of the beneficiaries are satisfied.

The traditional project cycle as described under 3.1 does not explicit allow for the need for dialogue, participation of stakeholders and a stakeholder analysis. Ideally this should precede even identification, since different stakeholders may have different ideas about what type of project is needed . There are countless examples of projects which failed to deliver their expected benefits for the simple reason that the beneficiaries had a different set of motivations and incentives from those planning, developing, funding and implementing the project. The real ownership of projects developed for the low income urban population has generally been very low, if at all existing and this is perceived as one of the major reasons why the majority of these projects have failed, thereby discouraging the financiers even more investing in these type of projects.

It should be pointed out that it takes considerable time to build this stake-ownership, and really involve the beneficiaries, particularly among low-income households, because the formal education levels of this group is generally (very) low and a lot of explanation is required before actual participation can be expected. It therefore becomes extremely difficult to plan/predict the outcome of the low-income participation as well as to plan/predict the progress of the project development. Both factors are generally not in the interest of financial institutions, bilateral donors as well has the host government which are committed to careful financial planning of their scarce financial resources. It still appears that financial institutions and donors do not have the time for proper project development and/or have difficulty in allowing process oriented project/program development resulting in rather unpredictable need for financial support. However, in fact many centrally developed, planned and implemented projects are faced with huge project time/cost overruns resulting in the same unpredictable cash-flows while at the same time many of these so developed projects fail to deliver the promised benefits on the short or medium term resulting in a waste of scarce resources.

Furthermore, when asked to participate there may be even a certain scepsis from the low-income community or beneficiaries, in the beginning about the intentions of the (local) governmental representatives, No's, social/community experts who contact the community on the intentions of the government. This scepsis may be based on the non kept promises of the (local) government in the past, or the failures of previous well intended similar projects.
Another reason for the scepsis may be related to the actual lack of interest low-income households generally receive from their government in developing countries. It appears

that if their opinion is being requested at all, this serves more to satisfy their formal democratic rights than to make a real impact on government's decision making.

It is therefore recommended that financing agencies as well as bilateral donors while developing projects should focus more on project cycle management and the "process followed " to develop projects, monitoring the total project development, ensuring equal valued inputs from all stakeholders (including low-income households) rather than project outcomes/ and/or physical components. By doing so support is being given to the development of equal rights in a democratic society, which is an underlying requirement for sustainable development of the country as a whole.

Although the application of the Development Cycle methodology described above started on the national level it is possible to use the same methodology for medium size towns/communities. It may be even easier to introduce changes to design standards on the local level as long as sufficient multidisciplinary support can be acquired and teamwork can be realised for the changes in design. It is recommended that each professional discipline be represented by more than one person. Exposure of e.g. the Bureau of standards and the professional engineering association are limited if design changes are approved and tested at local level. Sufficient attention should be paid to the early involvement of beneficiaries. It is advisable to ask for the support of a municipality or public works department which has already successfully realised non-conventional urban sanitation systems. A "twinning arrangement" for the execution of the activities of the technical secretariat is recommended.

V. CONCLUSIONS AND RECOMMENDATIONS

1. A lack of policy and strategy for the water and sanitation sector has not directed sufficient funds towards the solution of sewerage and sanitation problems of the low income sector of the urban population. In actual fact the coverage for sanitation has decreased and in absolute terms disbursement of funds for water and sanitation has been steady going down over the period 1990-94. Preference for investing in water supply over sewerage and sanitation continues and governments as well as financing agencies still are willing to support the implementation of high cost (mostly non sustainable) urban sewerage systems at the expense of the already scarce financial resources.

Policy and strategy changes are required not only of governments of development countries but also from donors and financing organisations to ensure the allocation and disbursements of funds for the ever increasing sewerage and sanitation problems of the low-income urban population. Medium national as well as sector plans should be made to address this special problem.

2. Project selection and project identification does not always takes place on the basis of rational (numerical) arguments. Often shortcuts are being used. It appears that as a result of the lack of National/Sectoral Development Plans political considerations play a role too early in the selection process.
Project selection seems sometimes influenced by disbursement targets from donors and multinational financing organisations as a result of the lack of National/Sectoral Plans as well as sometimes the lack of capacity of the National Planning Institute and line Ministries to formulate well documented project proposals acceptable to these organisations.

Project Selection Committees should be multi-disciplinary with more than one person representing each disciple. Committee members should demand at all times full information on the argumentation on project selection and identification. Procedures and guidelines for project selection and identification should be improved.

3. Politicians, planners and engineers have been rather conservative in trying to use innovative low cost sewerage technologies -such as small bore/effluent free sewerage and simplified sewerage- which have proved to provide satisfactory solutions elsewhere. These systems cost a fraction of the conventional sewerage system and have proved to function satisfactory in a number of countries for over a period of more than 30 years.

It is recommended that these technologies be given a try, at least in pilot schemes before being dismissed. Twinning arrangements could be made with municipalities where these systems have been implemented and function satisfactorily.

4. In the past most of the attention was focused on the development of "projects". As a result donors focused their attention on expenditure/disbursements over time whereas recipient governments focused their attention mainly on the realisation on physical project components. This attitude has only slightly changed with the introduction of the "logical framework" as a tool for project development. However, despite this, project sustainability has little improved.

It is recommended that more attention is focused on the organisational aspects of project development in order to ensure that the beneficiaries are contributing in a process of dialogue to the project development from the start. A Project Development Cycle organisational approach is suggested to replace the centrally governmental/utility company approach. A number of multi-disciplinary working groups contribute in teamwork to rational project development. A central technical secretariat provides co-ordination, directs the development as an objective moderator and monitors the progress and development expenditure. Decisions should be taken in plenary sessions; major decisions are tested in a functional model, pilot project(s) and experimental use. It is expected that this approach is particularly suited for the introduction of innovations and review of standards as required for settled and simplified sewerage.

Table 1. Descriptive comparison of sanitation technologies

Sanitation technology	Rural application	Urban application	Construction cost	Operating cost	Ease of construction	Self-help potential	Water requirement	Required soil conditions	Complementary off-site investment[a]	Reuse potential	Health benefits	Institutional requirements
Ventilated improved pit (VIP) latrines and Reed Odorless Earth Closets (ROEC'S)	Suitable	Suitable in L/ M-density areas	L	L	Very easy except in wet or rocky ground	H	None	Stable permeable soil; groundwater at least 1 meter below surface[b]	None	L	Good	L
Pour-flush (PF) toilets	Suitable	Suitable in L/ M-density areas	L	L	Easy	H	Water near toilet	Stable permeable soil; groundwater at least 1 meter below surface[b]	None	L	Very good	L
Double vault composing (DVC) toilets	Suitable	Suitable in L/ M-density areas	M	L	Very easy except in wet or rocky ground	H	None	None (can be built above ground)	None	H	Good	L
Self-topping aquaprivy	Suitable	Suitable in L/ M-density areas	M	L	Requires some skilled labor	H	Water near toilet	Permeable soil; groundwater at least 1 meter below surface[b]	Treatment facilities for sludge	M	Very good	L
Septic tank	Suitable for rural institutions	Suitable in L/ M-density areas	H	H	Requires some skilled labor	L	Water piped to house and toilet	Permeable soil; groundwater at least 1 meter below surface[b]	Off-site treatment facilities for sludge	M	Very good	L
Three-stage septic tanks	Suitable	Suitable in L/ M-density areas	M	L	Requires some skilled labor	H	Water near toilet	Permeable soil; ground water at least 1 meter below surface[b]	Treatment facilites for sludge	M	Very good	L
Vault toilets and cartage	Not suitable	Suitable	M	H	Requires some skilled labor	H (for vault construction)	Water near toilet	None (can be built above ground)	Treatment facilities for night soil	H	Very good	VH
Sewered P1 toilets, septic tanks, aquaprivies	Not suitable	Suitable	H	M	Requires skilled engineer/ builder	L	Water piped to house and toilet	None	Sewers and treatment facilities	H	Very good	H
Sewerage	Not suitable	Suitable	VH	H	Requires skilled engineer/ builder	L	Water piped to house and toilet	None	Sewers and treatment facilities	H	Very good	H
Shallow sewerage	Not suitable	Suitable	L	L	Requires skilled engineer builder	M	Water near toilet	None	Sewers and treatment facilities	H	Very good	M

Source: J.M. Kalbermatten, and others, Appropriate Sanitation Alternatives: A Planning and Design Manual (Baltimore, Johns Hopkins University Press, 1982), p. 180 (modified to include shallow sewerage).

Notes: L, Low; M, medium; H, high; VH, very high

a. On- or off-site sullage disposal facilities are required for nonsewered technologies with water service levels in excess of 50 to 100 lcd, depending on population density.

b. If groundwater is less than 1 metre below the surface, a plinth can be built.

ANNEX II

Numerical analysis of need and viability criteria

Having decided which criteria affect the <u>ranking</u> of a group of proposed sewerage aschemes it is necessary to determine which of the schemes should have priority over the others for implementation. Below is an example of a numerical analysis (Abstracted from Reference Document nr. 19)

. each communitry is awarded a 'score' for each of the criteria included in the <u>ranking</u> process. For each criteria, a high score indicates that the provision of sewerage to that community is important while a low score indicates that it is less critical;

. not all the ctiteria are of equal importance. It is necessary to weigh the scores so that important criteria have a larger impact on the final result than minor ones;

. a weighted score is produced by multiplying the score by the weight;

. the total score for a community is the sum of the weighted scores given for each criterion; and

. communities having the highest scores are most favoured for the immediate implementation of a sewerage scheme.

The magnitude of the scores is unimportant: only the <u>ranking</u> of the community matters. An example of the selection process is shown in table II.1

Table II. 1 : Example of a matrix for prioritising the provision of sewerage

Town	Projected population			On-site sanitation failure			Polluting industries			Unit cost of construction		
	Sc	Wt	T	Sc	Wt	T	Sc	Wt	T	Sc	Wt	T
A	10	1	10	1	3	3	1	1	-1	4	2	8
B	9	1	9	7	3	21	10	1	10	7	2	14
C	6	1	6	1	3	3	10	1	10	5	2	10
D	3	1	3	1	3	3	1	1	1	2	2	4
E	2	1	2	1	3	3	1	1	1	3	2	6
F	2	1	2	1	3	3	10	1	10	5	2	10
G	2	1	2	1	3	3	5	1	5	2	2	4
H	2	1	2	1	3	3	5	1	5	1	2	2
J	1	1	1	4	3	12	10	1	10	10	2	20
K	1	1	1	1	3	3	1	1	1	2	2	4
L	1	1	1	7	3	21	10	1	10	6	2	12

Sc = score (the impact of a criterion on a town).
Wt = weight (the importance of a criterion in the selection process)
T = total (the multiple of the score and the weight).

The table concentrates on technical and financial criteria. It is assumed that other considerations such as health and the environment, which could be included, will be dealt with seperately. It is also assumed that the schemes are all designed and constructed using the same criteria.

Scoring for individual criteria

The range of the scoring system for individual criteria and whether the scale from high priority to low priority is ascending or descending is immaterial, provided a consistent system is used for all criteria. In the example shown in table II.1, a scale of 1-10 has been used, with 1 being minimum importance and 10 being maximum. Other ranges are equally valid but they should reflect the level of accuracy with which criteria can be measured, bearing in mind that all the criteria must be measured using the same scale. As an example , the method used for determining the scores for each of the criteria used in table II.1 now follows

Tourist impact			Consumers' ability to pay			Annual unit O & M cost			Total score
Sc	Wt	T	Sc	Wt	T	Sc	Wt	T	
1	3	3	4	2	8	5	1	5	38 (8)
4	3	12	7	2	14	10	1	10	90 (1)
4	3	12	7	2	14	10	1	10	65 (5)
10	3	30	10	2	20	5	1	5	66 (4)
2	3	6	4	2	8	10	1	10	36 (10)
3	3	9	7	2	14	10	1	10	58 (6)
4	3	12	4	2	8	5	1	5	39 (7)
4	3	12	4	2	8	5	1	5	37 (9)
5	3	15	10	2	20	1	1	1	79 (2)
1	3	3	1	2	2	10	1	10	24 (11)
3	3	9	7	2	14	10	1	10	77 (3)

Table II. 2 Projected Population

Population range	Score	Population range	Score
15 000–16 300	1	21 500–22 800	6
16 300–17.600	2	22 800–24 100	7
17 600–18 900	3	24 100–25 400	8
18 900–20 200	4	25 400–26 700	9
20 200–21 500	5	26 700–28 000	10

Table II. 3 Projected populations at the end of the design life for the towns used in table II.1

Town	Projected population	Score	Town	Projected population	Score
A	27 500	10	G	17 000	2
B	26 500	9	H	16 500	2
C	22 000	6	J	16 000	1
D	18 500	3	K	16 000	1
E	17 000	2	L	15 500	1
F	17 000	2			

The highest and the lowest numbers in the range shown in table II.2 correspond approximately to the largest and smallest community populations in town 'A' to 'L' in table II.1. Table II.3 shows individual community scores for projected population at the end of the design life. The ways that the other scoring ranges were determined are shown in tables II. 4-II.9.

Weighting
Although all the criteria included should be relevant to the selection process some will be more important than others. Applying a weighting system is a way of reflecting the relevant importance of the criteria in the selection process.

Table II. 4 On-site sanitation failure

Description	Score
On-site sanitation has already failed	10
On-site sanitation is very likely to fail during the design life	7
On-site sanitation may fail during the design life	4
On-site sanitation is unlikely to fail	1

Table II. 5 Polluting Industries

Description	Score
More than 50% of the effluent is generated by industry	10
25–50% of effluent is generated by industry	5
Less than 25[1] of waste effluent is generated by industrial sources	1

Note: As these guidelines relate only to sewerage the effect of industrial effluent strength on treatment costs has been ignored.

Table II. 6 Unit cost of construction

Unit cost	Score	Unit cost	Score
40 000–45 000	10	65 000–70000	5
45 000–50 000	9	70 000–75 000	4
50 000–55 000	8	75 000–80 000	3
55 000–60 000	7	80 000–85 000	2
60 000–65 000	6	85 000–90 000	1

Table II. 7 Tourist Impact

Description	Score
Over 80% of the community's income is generated by tourism	10
40–80% of income is from tourism	5
No significant tourism income	1

Table II. 8 Consumers' ability/willingnessto pay for sewerage

Description	Score
Community can/will repay the full capital and operating costs of the scheme	10
A 50 per cent subsidy is required on the construction cost	7
The community can only afford/is willing to pay operating costs	4
A subsidy is required to make operating costs affordable	1

The problem with weighting systems is that it is difficult to apply them objectively. In table II. 1 ' tourist impact', for example, is shown as three times more important than 'projected population'. This is a reflection of the importance of tourism to the national economy in which the example given was carried out. However, to say that it is three times more important is purely arbitrary. Criteria weights can only be decided upon after discussioins with all groups concerned. As they are so arbitrary it is important that a sensitivity analysis is carried out on the results.

Scoring and sensitivity analysis

The total score for a community ias the sum of all the weighted scores (as shown in Table II. 1). Communities can be ranked with the highest score being first and the lowest score being last. The high-ranking communities are those most favoured for sewerage. The results of ranking can never be completely objective because of the weighting procedure, but confidence in the results can be increased by carrying out a sensitivity analysis. This is done by looking at the effects on ranking caused by **chhanges in thge**

weighting. Select the criteria most open to subjective interpretation. Change the weights of those criteria slightly, recalculate the final scores and re-rank the communities. Comparison between the ranking order for different scoring and weighting scenarios will indicate the level of confidence that can be given to the results. Minimal changes in ranking order indicate a high degree of confidence in the results. Conversely, wide variatins in ranking indicated that the results should be treated with caution.
Table II. 10 shows the effect of reducing the weighting for 'tourist impact' from 3 to 2 and increasing the weight for 'unit cost' of construction from 2 to 3 (first re-ranking) and setting all the weights to unity (second re-ranking). Table II. 10 shows that, with the exception of town 'J', the change in weighting numbers has very little effect on the overall ranking of the communities; therefore, the results can be accepted with confidence. The actual numbers are of little relevance, only their relative size.

Table II. 10 Community ranking

Rank	Town in Table 3.1	Weighted score	1st re-ranking	Weighted score	2nd re-ranking	Weighted score	Pnority
1	B	90	B	93	B	54	
2	J	79	J	84	L	44	High
3	L	77	L	80	C	43	
4	D	66	C	66	J	41	
5	C	65	F	60	F	38	Medium
6	F	58	D	58	D	32	
7	G	39	A	41	A	26	
8	A	38	E&G	37	E&G	23	
9	H	37					Low
10	E	36	H	34	H	22	
11	K	24	K	29	K	17	

Conclusions

A martix is an excellent method for deciding the order in which communities should be provided with sewerage. By selecting communities using criteria based on need, benefit and cost, the steps in the process can be justified and the final results can be described mathematically. The method is not absolute. It will not select the single most needy community for sewerage. It will, however, segregate a group of communities into those which can cost-effectively obtain the greatest benefit from sewerage and those with less need or requiring greater subsidy. There will normally be a group in the middle (as has occurred in the example) for which the costs and benefits from sewerage make its provision optional. The individual ranking within that group is irrelevant
The selection process described here is primairily technical and financial. Environmental and health considerations also have a place in the selection process. These could be included in the matrix or considered separately. Reference may be made to World Bank (1991) for further details of these areas.

Total annual (economic) cost per household (TACH) of different sanitation technologies (USD at 1978 values)

Technologies	Observations (number)	Mean	Median	Highest	Lowest
Low-cost					
Pour- flush toilet	3	18.7	22.9	23.3	10.1
Pit Latrine	7	28.5	26.0	56.2	7.6
Communal Septic Tank*	3	34.0	39.0	48.0	15.0
Vacuum-truck cartage	5	37.5	32.2	53.8	25.7
Low-cost septic tank	3	51.6	45.0	74.5	35.4
Composting toilet	3	55.0	56.2	74.6	34.3
Bucket cartage (a)	5	64.9	50.3	116.5	23.1
Shallow sewerage	20	--	--	35.8	13.8
Medium Cost					
Sewered Aquaprivy	3	159.2	161.4	191.3	124.8
Aquaprivy	2	168.0	178.0	248.2	87.7
Jap. vacuum truck cartage	4	187.7	193.4	210.4	171.8
High-cost					
Individual septic tank	4	369.2	370.0	390.3	306.0
Conventional sewerage	8	400.3	362.1	641.3	142.2

Source: J.M. Kalbermatten and others;" Appropriate Technology for water supply and Sanitation in Technical and Economical Options,(Washington D.C. World Bank 1981; modified to include shallow sewerage)

* per capita costs were used and scaled up by cross country average of 6 persons per household to account for large differences in users.

N.B. Mean and median values of TACH have not been specified for shallow sewer systems because unlike a majority of other sanitation systems listed in the table the TACH of shallow sewerage extremely sensitive to the type of settlement and particularly, to its density of occupation. Computing of mean and median values will, therefore, have little meaning.

ANNEX IV

Financial cost per household of different sanitation technologies (USD $ at 1978 values)

Technology	Total investm. cost	Monthly recurrent cost	Monthly water cost	% of income of average low-income household (a)
Low - Cost				
PF toilet	71	0.2	0.3	2
Pit Latrine	123	-	-	3
Communal Toilet (b)	355	0.3	0.6	9
Vacuum-truck cartage	107	1.6	-	4
Low-cost septic tanks	204	0.4	0.5	6
Composting toilet	398	0.4	-	10
Bucket cartage (b)	192	2.3	-	6
Shallow sewerage (c)	85-325	0.2	0.3	2-6
Medium - Cost				
Sewered aquaprivy	570	2.0	0.9	11
Aquaprivy	1,100	0.3	0.2	16
Japanese vacuum-truck cartage	710	5.0	-	15
High Cost				
Individual septic tank	1,645	5.9	5.9	51
Conventional sewerage	1,479	5.1	5.7	46

Source : J.M. Kalbermatten and others; "Appropriate Technology for Water Supply and Sanitation in Technical Options"(Washington D.C., World Bank, 1981) modified to include shallow sewerage.

Notes:

a: assumes that average annual income is USD $ 180 per capita (6 persons/household)

b: based on per capita cost scaled up to household cost to account for multiple household use in some of the case studies.

c. depending on type and density of settlement

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Some of the reasons for the past and present low application of this technology could be:

- Lack of national medium/long term National Development Plans and Sector Plans which results in a rather ad hoe form of project selection, more initiated by donors and financing institutions than on plans m and projects covering the needs of the, various income levels of the population. Project implementation/results have suffered severely from lack of time project development with active participation during the project development process.

- Lack of funding for the low-income portion of the population. The sanitation sectors a whole and low-cost sewerage in particular. According to the WHO/W8SCC/UNICEFF 1993 Report of the available funding has been directed towards the better-off population. Governments appear to give a higher priority to the funding of water supply than to sanitation.

- Too much emphasis on "risk free/conservative thinking from politicians, planners and even engineers.

Remark: The design of "Shallow and Simplified Sewerage" systems require in most countries a review/adaption of existing (mostly imported) design standards which cannot he achieved by the present method of project development for sanitation projects in particular.

Issues that need more attention in the development of sustainable low cost sanitation systems are:

- Numerical analysis of need and viability criteria
- the organisational approach/set up to achieve a consensus and approval by the major players on central and local level
- the realisation of real partnership on equal footing of the beneficiaries of low cost sanitation solutions

In order to alleviate some of the above problems an organisational approach following the "Project Development Cycle" is being recommended. This "Project Development Cycle" is characterised by:

- A project development in four phases eg:
  - market and needs research
  - programme, functional model/design and production
  - rational production, experimental series/pilot project, implementation
  - experimental occupation, project implementation

- The establishment of a number of multi-displinary working groups with a representation of all stakeholders and a technical secretariat (both to he financed by donors)
- The organisation of "Plenary meetings for consensus building, decision making and progress control of the development of the project.

The promotion of the above indicated low-cost technology sewerage systems is crucial because as a result of rapid urban urbanisation the gap in coverage for water supply and sanitation and between urban and rural sewerage/sanitation services will grow rapidly. At the end of the Water Decade coverage was only 72% for urban sanitation and 49% for rural sanitation. On average 43% of the population was without proper sanitation. Based on the implementation rates, during the Decade global service coverage would fall short by 100% in actual numbers. Rapid urbanisation in developing countries will affect the sanitation coverage in a very adverse way. According to John Briscoe (1993) there would he 21 cities in the world with more than 10 millions inhabitants, and 17 of them would be locate, in developing countries. Urban population (of which 30% low income) in developing countries is expected to grow (I990-2000) by 160% whereas rural population will grow by 10% only. Therefore donors and financing agencies should focus their programmes on low-cost sanitation in favour of low cost water supply.

J. J. van Straaten

IRC

The promotion of non-conventional urban sewerage

Summary
It has been argued in many reports and publications that conventional urban sewerage, satisfactory sewage treatment and disposal is excessively expensive. It is often quite inappropriate for rapidly expanding urban areas in developing countries with large communities of low-income people and squatters. Yet Politicians, planners and even engineers still to the outworn idea that the whole of every urban area should be centrally sewered.

Apart from being too expensive (USD 350 per capita to USD 1000 per capita for systems beyond the urban core) the majority of the conventional sewerage systems in the developing countries do not function properly. The reasons are that the recovery of collection fees and users charges from users is insufficient to cover the operation and maintenance cost, let alone the investment cost.
To keep these systems into operation governments have tended to subsidize these schemes and thereby the richer portion of the urban population at the expense of the already scarce national resources. It would therefore follow that donors and international financing institutions, which focuss their programmes on "poverty alleviation" should not assist in the financial and realisation of these schemes unless there are good reasons to do otherwise.

One the sanitation options that is affordable to the low-income population is the Ventilated Improved Pit (VIP) latrine and much effort has been made to improve its operation. These latrines offer good service, including privacy and only a few odours at a reasonable cost at less than USD 100 per unit. However, the realisation and installation does not depend on the municipality or any other organisation.

All over the world people aspire to "the real thing" waterborne sewerage. What has been missing is the promotion of an alternative intermediate low-cost sewerage technology which has all the advantages of the conventional system and which has high service reliability.

However, such schemes have already been successfully in operation for some decades, though knowledge on their design, implementation and operation has been rather restricted even within the engineering community. For instance the capital cost for "Shallow sewerage/ Settled sewerage" is about 30% lower than for conventional sewerage, whereas on the capital cost for Simplified Sewerage" a cost reduction of about 40% can be achieved over conventional sewerage.

In order to promote the implementation of these systems, design guidelines were formulated by the United Nations Centre Rum Settlements for "Shallow/Settled Sewerage" Systems in 1986 under the Water and Sanitation Programme of the UNDP-World Bank on "Simplified Sewerage" in 1988. However, according to the Water Supply and Sanitation Sector Monitoring Report 1993, only 2% of the urban high-income and low: income residents had access to such a service.

Some of the reasons for the past and present low application of this technology could be:

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