Chapter 5: Discussion

5.1. Introduction

Instead of focusing on the individual outcomes of each case study presented in Chapter 4, this chapter is concerned with the aspects that are most likely to influence the sustainability of the low-cost sanitation programmes.

The ***institutional framework*** in which the programmes are developed is seen here as the primary factor for the achievement of programme's objectives. A clear definition of institutions and their responsibilities towards the programmes – based on a consistent and realistic assessment of capability – is therefore believed to directly influence the aspects leading for sustainable sanitation programmes.

Those aspects identified for discussion here were: the social and managerial parameters for ***technology selection***; the technical parameters for the ***design*** of the systems; the approaches adopted for ***implementation*** of the programmes; the ***O&M*** arrangements; user ***acceptability*** and ***satisfaction***; and financial aspects, i.e. the systems' ***affordability***.

In addition, long-term ***social and health improvements*** should follow as a direct consequence of sustainable sanitation programmes. This is illustrated in Figure 5.1.

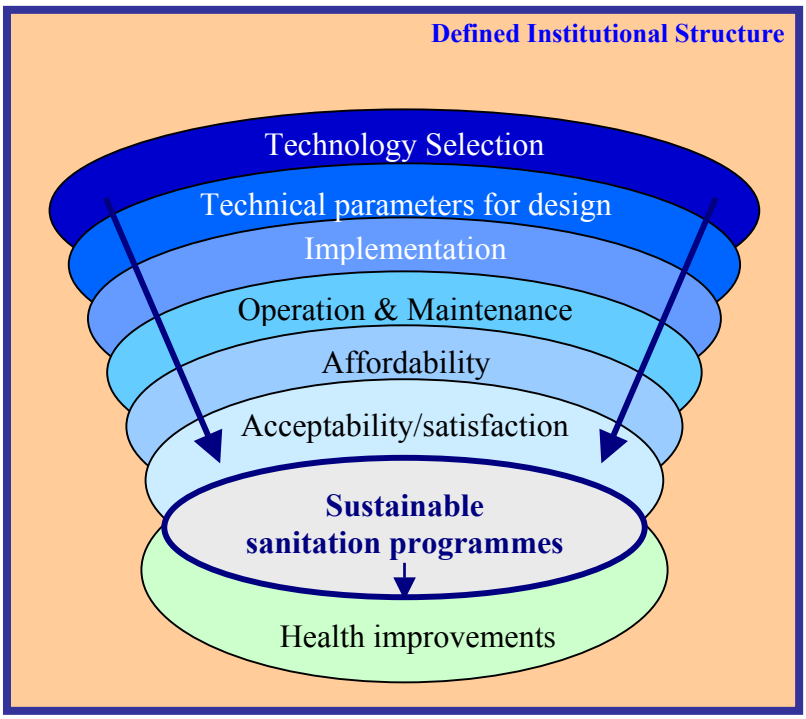

Figure 5.1.- The main aspects influencing the sustainability of sanitation programmes (there may, of course, be feedback loops within this diagram – such as, for example, from affordability (or O&M) back to technology selection; this would occur when a technology that was too expensive (or too difficult to operate and maintain had been selected).

5.2. Technology selection: Social and Managerial Parameters

That sanitation technologies must be appropriate is a general consensus. However, as according to Kalbermatten *et al.* (1982), the concept of technological appropriateness is *"a relative one, which can only be applied within a particular context"*.

Whilst general guidance is available for the first stage of technology selection (such as algorithms and decision support systems – Franceys *et al.*, 1992; Loetscher, T. URL-20, 2000), the final decision must be based on locally supported, site-specific data.

Based on the case studies, the main aspects considered for appropriate technology selection would lie among technical, social and managerial parameters (Figure 5.2.).

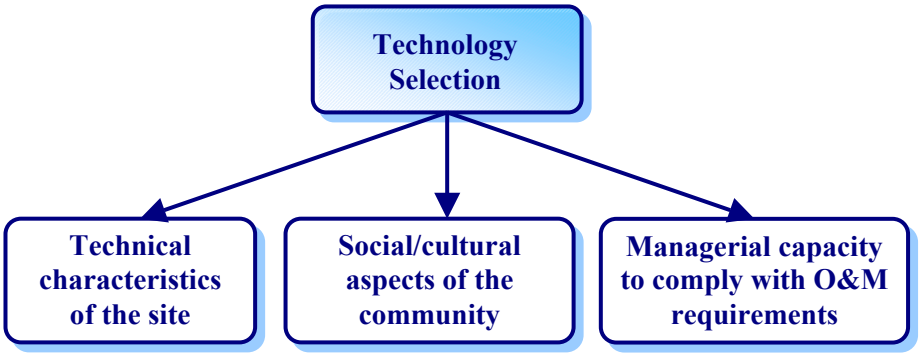

Figure 5.2.- Technology selection

5.2.1. Technical Characteristics of the Site

The main technical characteristics of the localities considered for selection of on- and off-site sanitation systems have been mostly based on the level of water consumption, the population density and the soil infiltrative capacity.

- ***Level of water consumption***

Considerations on the volume of water consumed can be viewed from two main angles. For on-site systems, the main parameter assessed is the infiltrative capacity of the soil (if the wastewater flow discharged into the system is not going to exceed the soil's capacity to absorb liquids); and, for sewerage systems, the community's level of water supply service (if the availability of water is reliable and in enough quantity to guarantee the transportation of solid particles into the sewers).

In Case Study 2, the on-site system of Aero Rancho had a projected wastewater flow of 96 litres/capita/day (80 percent of the per capita water consumption adopted for the site's water supply system). During this study, approx. 53 percent of the households

discharged all wastewaters (excreta and sullage) into their leach pits, thus, just over half of the pits were receiving a theoretical wastewater flow higher than the values traditionally indicated for the adoption of on-site systems (50 lcd in Kalbermatten, 1982). Nevertheless, 82% of the leach pits surveyed had not yet required maintenance (mainly emptying) services even after 6 years of system operation (designed for 5 years design life).

For the SISAR programme (Case Study 6), the selection of a condominial sewerage system was supported, as far as water consumption was concerned, by the provision of an in-house service level of water supply, with at least one tap located inside each house. Nevertheless, the great majority of the households did not have cistern-flush toilets (10 litre capacity buckets were mostly used to discharge water for flushing), and, in spite of almost 100 percent of the residences having their toilets connected to the system, the sullage connections were low (in these rural households a common practice was to use the sullage for watering plants or simply dispose it off in the sandy backyards). Therefore, among the four condominial sewerage cases studies, Case Study 6 presented the lowest wastewater flow being discharged into the condominial sewers, but even so this system had the lowest percentage of households requiring O&M services in the condominial pipeline (85 percent never needed any service and 12 percent rarely had O&M services required). Suggesting, therefore, that condominial systems would be able to work well with minimum discharges of wastewater.

- ***Population density***

The influences of population density on the selection of sanitation technologies are closely linked to the availability of physical space and to the cost viability of the programmes. Poor periurban housing areas such as the ones presented in Case Studies 1 (Olinda), 3 (Natal) and 5 (Recife) are typical of Brazilian favelas (population densities of 385, 345 and 279 people per hectare, respectively). In such high-density areas, the provision for sullage disposal is also a very desirable requirement and on-site systems are usually not recommended.

Nevertheless, in the specific situation of Case Study 1 (VIP latrines plus micro-drainage systems for sullage collection) the high population density could not be identified as a factor contributing to the failure of the programme. The few latrines built were in fact located among the poorest households, where problems related to space

availability were most evident. Also, as the system had been planned to be mechanically emptied, there would be no need for space to build another pit or to bury the sludge (the lack of relation between small size plots and their inadequacy to on-plot sanitation has also be indicated in a study in Mozambique and Ghana – see Cotton & Saywell, URL-33, 1998).

Low-cost off-site systems (mainly condominial sewerage, because settled sewerage system also requires space for interceptor tanks) usually do not have problems related to the availability of space. Even in higher density areas, at least one of the alternative layout (backyard, front yard or sidewalk) can be physically well integrated to the household characteristics, as observed in all four case studies based on this technology. Moreover, the costs of condominial sewerage have been reported to decrease as the population density increases, becoming – in the case of Natal (Case Study 3) – cheaper than on-site systems at population densities above 150 persons per hectare (Sinnatamby, 1983).

- ***Soil infiltrative capacity/groundwater table level***

These aspects, which affect mainly on-site systems, did not represent a high risk for the two on-site sanitation programmes reported. Although, in Case Study 1, the VIP latrines were built in an area with high groundwater table level, the risks from health hazards were diminished by the fact that the community was supplied with water from the city network, not using groundwater for consumption.

For the pour-flush toilet system, Case Study 2, the site presented a groundwater table level 4 m below surface and a good soil infiltrative capacity (40 to 60 l/m^2/day). This certainly contributed to the fact that 83 percent of the pits had still not required emptying even after 6 years of operation.

5.2.2. Sociocultural Aspects of the Community

The involvement of the community in the process of technology choice has been presented as a fundamental issue for the selection of the most appropriate sanitation alternative (Andrade Neto, 1999). The importance of this integration is strongly supported by the theory that allowing residents to make their own decisions reduces the chances of implementing a system that may be destined to fail due to specific habits of the local people. Moreover, the sense of ownership of the system by the residents is also

believed to increase when they are given the choice of the technology, contributing to their greater interest in preserving the system's component parts.

Despite wide acceptance of the above aspects, the application of methodologies allowing people to choose their sanitation systems still presents practical problems. Questions remain on where to draw boundaries defining the limits between decisions taken by technical experts and those by the communities. For this, suggestions have varied from having the community as a consultant giving them the last say, to having the communities as partners, with professionals and users working together from the beginning. In practice, however, the specific dynamic of each community (city or region) brings up sociocultural factors that can make methodologies successfully applied in one area be ineffective in another.

In all case studies, intensive activities to promote social development of the communities and their mobilisation towards the sanitation programmes were reported. Nevertheless, regarding the choice of technologies, users participation was more in a sense of acceptance of the option offered than in properly making choices.

In Case Study 1, the VIP latrine system was mainly selected by the technical team and based on the cost limitations of the programme. Considerations regarding the sociocultural aspects of the community were expressed by the adoption of toilet bowls, as the squatter position usually adopted for latrines was not locally accepted. However, the direct deposition of excreta (absence of water-sealed toilets) meant the system was perceived by the community as a "primitive" system, contributing to the limited interest of potential users (only 40 VIP latrines were built out of 240 households).

Another noteworthy aspect was the adoption, by law, of the condominial sewerage as the only sanitation option to be implemented in Recife (Case Study 5) and in Brasília (Case Study 4). In these areas, the choice given to the users refers to the layout of the system (backyard, front yard or sidewalk), rather than to which sanitation technology they would prefer.

Without disregarding the obvious criticisms on the existence of a law limiting the engineering provision of technological alternatives, the fact is that for residents of the majority of poor periurban areas in Brazil, a sewerage system is socioculturally well accepted as it may represent a step towards a "quality of life" approaching that of the medium and upper income areas of the cities.

Moreover, in Brasília, having such technology as a standard option strengthened the sanitation company, which adapted its structure (from the planning to the O&M

sectors) to work with condominial sewerage. The company also gained in confidence and experience enough to starting implement this "poor community" technology in the very rich areas of the Federal District of Brazil. CAESB is currently held in high regard in relation to its successful implementation of condominial sewerage.

5.2.3. Managerial Capacity to Comply with O&M Requirements

The conditions necessary to comply with O&M requirements must be assessed during the process of selection of the sanitation technology. This may sound obvious but factors connected to political interests and poor communication among institutions may overshadow definitions of responsibilities for the post-implementation requirements of the programmes.

In Case Study 1, the political momentum of the city of Olinda motivated the implementation of the sanitation programme. However, the arrangements designed for the O&M of the single pit latrines were shown to be unreliable. In fact, the prefecture had not provided services for the mechanical emptying of the latrines and most householders were unable to afford the costs of emptying services from private companies. Thus, resulting in the manual emptying of 23 percent of the latrines (53 percent were never emptied and 12 percent did not answer the question).

As mentioned previously, CAESB (in Case Study 4) reorganised its structure to provide all the conditions necessary to comply with the requirements of condominial systems. The company installed local maintenance offices for the bigger systems in the satellite towns around Brasilia and kept the other systems attended by a central office.

On the other hand, in Recife (Case Study 5) the systems did not present a well defined institutional relationship. Considering that the implementing agency (URB-Recife) had no structure to provide O&M services for condominial systems, an agreement was made for the state water and sanitation company (COMPESA) to be the institution responsible for O&M. Nevertheless, out of the 13 systems, 8 were not being officially serviced by COMPESA due to bureaucracy or design problems.

5.3. Technical Parameters for Design of Sanitation Systems

One of the main advantages of low-cost sewerage is that it allows the design of systems considering specific characteristics of the site. This may have a positive impact on the construction phase (favouring the local capacity for provision of materials and

labour) and also on the adoption of design parameters that most accurately reflect the specific requirements of the users. Based on the Case Studies, the main aspects regarding the design of the systems are now considered.

5.3.1. Design of Superstructures for Toilet Units

The two on-site (Case Studies 1 and 2) and the rural sewerage (Case Study 6) case studies included sanitary kits as part of the sanitation programme. These kits were, generally, composed of a toilet bowl and materials for construction of a pre-designed superstructure.

Regardless of the technology adopted for the systems, the superstructures had, as expected, a compact design. Although these designs were most appropriate for units constructed outside the house, some householders had opted for in-house construction or for the incorporation of the toilet unit into the house after it had been extended.

The privacy offered by the superstructures also stimulated the householders to use the toilet units as a shower area even in units that did not have a space so designated (in which case, householders would adapt the superstructures by opening holes to allow the sullage to drain from the units - Plate 5.1). Therefore, water containers, plastic showers or adapted shower-pipes could easily be identified inside the units (Plate 5.3).

Problems with the doors of the toilet were identified as being of two causes: quality and size. Regarding *quality*, a large number of units, by the time of the fieldwork, no longer had their original doors, with low-quality being a common complaint among householders in all three case studies (Plates 5.4). As for *size*, inconveniences caused to users by the small size of the doors - 50 cm wide - designed for the Aero Rancho programme (Case Study 2) constituted an adverse factor that militated against the acceptance and usage of the system.

Other problems identified in the superstructure were: the removal of ventilation openings and the vent-pipes in the VIP latrine system in Olinda (which is an educational, rather than a design, problem); and, dangerously cracked walls in a few units in the Ceará programme (a problem that deserves further investigation, but as was seen in a relatively few cases it was probably related to either construction or soil (or both) rather than design - Plate 5.2).

Plate 5.1. – Opening to allow sullage to drain from the units

Plate 5.2. – Cracked superstructure walls

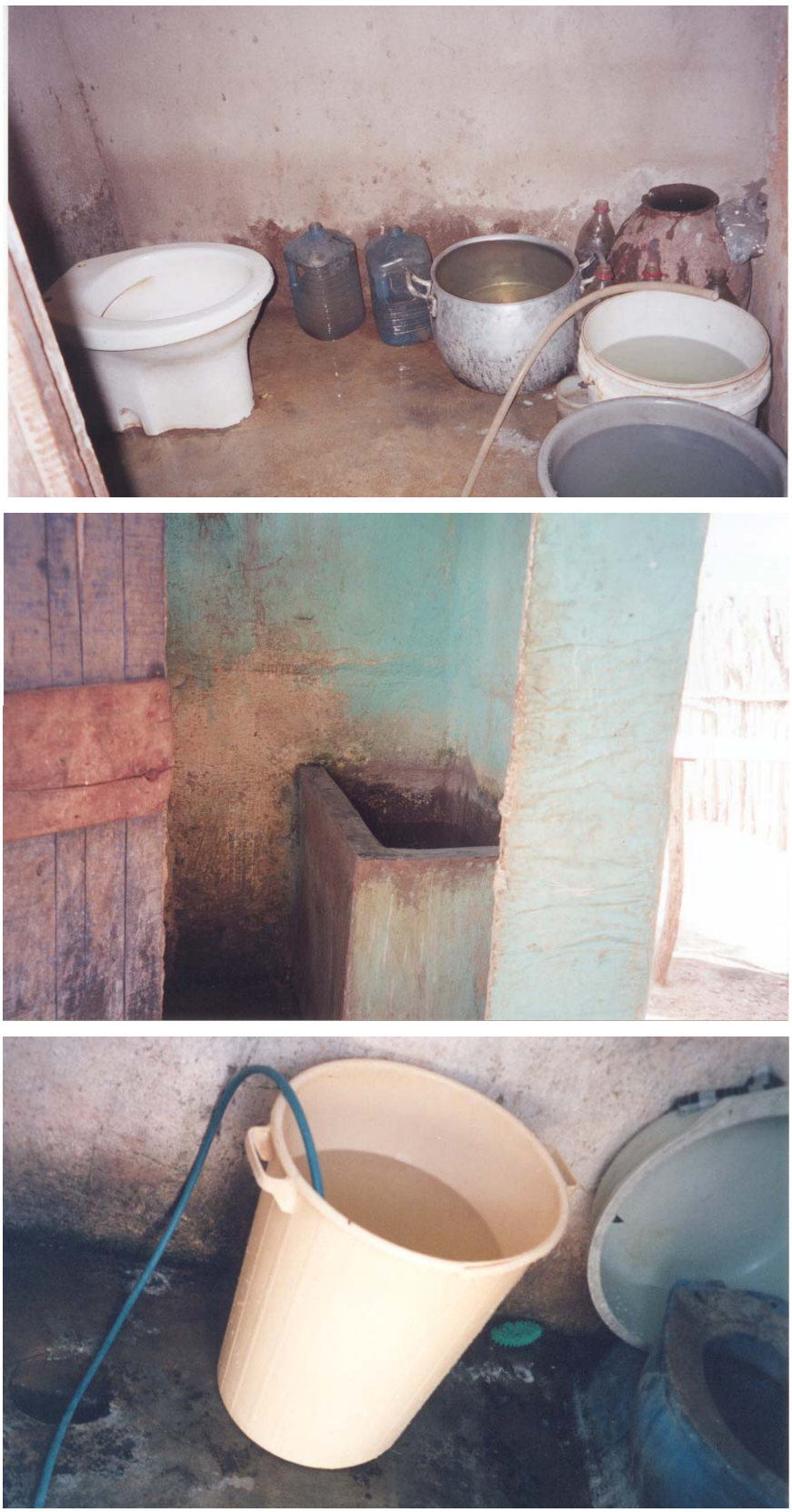

Plate 5.3. - Water containers inside the superstructure.

Plate 5.4. - Superstructure doors

5.3.2. Availability of Spare Parts

Attention should be given to the availability of spare parts for the sanitation technology adopted. Usually, materials used in low-cost projects are readily available; however, special care needs to be taken when recommending components that are not widely available or are new on the market.

Case Study 2 (Favela Aero Rancho), based on pour-flush toilets, adopted kits which comprised reduced-flush toilet bowls and reduced-volume cisterns (Section 4.3.3). These bowls and cisterns were industrially produced; however, in spite of the availability of more expensive models in the main capitals of the country, the low-cost model used in this sanitation programme was not available in the local market. As a consequence, households that had to repair these units were obliged to replace them with traditional, high-flush volume models.

5.3.3. Wastewater Flows

The three main parameters determining wastewater flow for sewerage systems are: the coefficient K_1 (peak daily factor), the return factor (percentage of consumed water returning as wastewater) and the per capita water consumption. The values traditionally applied for these parameters are 1.8 for the peak daily factor, 80 percent (0.8) for the return factor and 100 l/person*day as the water consumption for low-income communities (these values may reach 200-250 l/person*day in medium-high income neighbourhoods).

In spite of these values having been successfully applied in many Brazilian locations for condominial sewerage, they should be critically assessed as to their appropriateness for the characteristics of the community receiving the system. Factors such as community location (rural or urban areas), income and householder habits are likely to influence these parameters.

In the medium-low income community of Case Study 4 (Vila Planalto, Brasília), the parameters adopted for the design of the system were 1.8, 80 percent and 160 l/person*day for coefficient K_1, return factor and water consumption, respectively. Nevertheless, the water and sanitation company of Brasília is already using a return factor as low as 65 percent in low-income areas, and no technical problems have been reported (Luduvice, 2000).

For the experience reported in Case Study 6 (rural Ceará), the condominial sewerage systems were designed based on the typical values of 80 percent return factor and water consumption of 100 l/person*day, which the present study suggests that are too high for the conditions found in the field (see Section 5.2.1.). Although this does not have a great impact on the design and functioning of the sewers (due to the small size of the villages, the 100 mm was the only pipe diameter required), the much lower volume of wastewater actually returning to the sewer was problematic for the wastewater stabilisation ponds (some of the ponds were functioning with no effluent being discharged – see Plate 4.73).

Other contributing factors for the determination of wastewater flow are the stormwater and the groundwater infiltration (the latter was not investigated in this study, but is generally assumed as a given rate per unit length of sewer – Kolsky, 1998).

Regarding stormwater, Brazilian sewerage systems are designed as separate systems, not receiving stormwater, which is the case for all four condominial sewerage systems studied (Case Studies 3 to 6). In practice, however, the two case studies in which this variable was investigated showed a considerable percentage of stormwater connections to the sewers (although the sanitation companies responsible for the systems had officially banned the practice). Thus, in Case Studies 3 (in Natal) and 4 (in Brasilia), 24 and 26 percent, respectively, of the surveyed households were discharging stormwater into the sewers (usually via pipes, drains or holes on the inspection chambers).

As asserted by Mara *et al.* (2001), in practice, these systems actually work as partially combined systems. These authors also stress that such a practice should not be permitted (partially combined sewerage would require much higher values for K_1), but demonstrate that for the design practice of condominial sewers currently adopted in Brazil (min. peak flow of 1.5 l/s), there is an "inherent [safety] allowance for at least some stormwater". Additionally, stormwater is also likely to increase the requirements for O&M due to the amount of soil particles carried together into the sewer.

These facts make the study of the drainage characteristics of the area (i.e. presence of microdrainage systems, existing household stormwater connections) and the general aspects of the household yards (i.e. paved yards, discharges of roof water) factors also to be surveyed and considered for the definition of design parameters in condominial sewerage systems.

5.4. Implementation Approaches

More than just the introduction of new technological options, low-cost sanitation programmes also bring innovative processes for systems implementation and for the relationship among stakeholders. Some of these innovations are based on the new roles that users play for the establishment of successful infrastructure developments, especially, for the low-cost sanitation programmes.

5.4.1. Community Mobilisation

In the demand-responsive approach, the self-mobilised community should express its needs for the competent institution to act in response to such demand, i.e. with the provision of sanitation systems. In practice (at least for all six case studies), an external agent capable of inducing this process is frequently necessary to increase awareness and to assist the community in getting organised.

Having an external agent actively inducing the community mobilisation process does not sound like a genuine community-driven action. Amongst the main criticisms against such a strategy is the tendency to use "community participation" as a label to carry on programmes that are in fact delivering decisions already taken through an up-down managerial structure. Therefore, the balance for inducing the process of mobilisation without manipulating the participation of the community is the point that sanitation promotion institutions should aim for in the provision of sustainable services.

According to Andrade Neto (1999), the level of participation of a community in a sanitation programme depends on the degree to which the householders have been mobilised towards the programme. A range of social techniques is available for working "with" communities (DFID, 1998), but the choice must be based on the communities' particular characteristics.

Case Study 6 (Ceará) provides an example of rural villages that had to become organised in order to be included in the sanitation programme. Thus, the main action initially developed by the mobilisation team was to strengthen the community as an associative institution. This was also the case in Case Study 2 (in Favela Aero Rancho), where the dispersed peri-urban community had its mobilisation programme based on development techniques addressing issues such as citizenship, women's associations and alternative medicine.

Although this broad approach to strengthen community associations has produced good results for the small rural villages programme of Case Study 6, the community of Favela Aero Rancho (Case Study 2) does not appear to have assimilated well either the importance of residents' associations or the messages specifically directed to the sanitation system. Among the main factors for this would be: incomplete establishment of the community in the area, socio-economical factors influencing the settlement of the families in the community (as stated in Section 4.3.7, the economic condition of the families in March 2000 was worse than in 1996) and the lack of continuity of the educational programmes to reinforce the main aspects of the system.

In the programmes where community organisation existed (at least to some degree) prior to the implementation and where the mobilisation process could be more concentrated on the sanitation programme itself, the preferred approach was the mobilisation block-by-block. This had been proven to be an effective strategy for the programmes implemented in large communities, i.e. Case Studies 3 (Rocas/Santos Reis), 4 (Vila Planalto) and 5 (for the Mangueira ZEIS), where the results in having closer contact with smaller groups produced better results than approaching the whole community at once. Table 5.1. summarises the approach adopted in the Case Studies programmes.

Table 5.1. – Strategy adopted for community mobilisation

Case Study	Community Size (Households)	Mobilisation strategy
1	240	Whole community.
2	510	In groups of 50 households.
3	3,100	Pilot experience in a single block, then expanded block-by-block.
4	790	Block-by-block.
5*	3,098	Block-by-block.
6	50 to 600	Whole community.

* Based on the Mangueira projects

5.4.2. Implementation Approaches

Having the community mobilised towards the sanitation programme was the first step adopted in all six case studies for systems implementation. After this, one of the following three approaches was applied: complete implementation of the system in one step; progressive implementation dividing the community in sub-areas; or, implementation based on a pilot project.

The main lessons from these experiences were that to completely implement the system in a single step two main aspects are required: a high level of acceptability of the selected technology attained during the community mobilisation process and sufficient financial resources to avoid interruptions during implementation and so leave the system only partially built and not in operation (damaging users' confidence toward the programme). When financial resources are not completely guaranteed, a progressive implementation of the system is more advisable. In this case, the system should be designed such that one phase is in operation while the next phase is under construction or awaiting additional resources. This second approach can also increase the acceptability of the technology amongst users living in the area where the system will subsequently be implemented.

The third approach would be appropriate when the user acceptability and/or the suitability of the technology are still not assured; therefore, the use of pilot projects seems to the most appropriate approach.

Nevertheless, a fundamental factor which influences the appropriateness of any approach adopted is the capacity of the implementing institution in providing the necessary requirements to reach the final stage for the complete implementation of the programme.

5.5. Operation and Maintenance

A *well-defined* and *reliable* institutional and community structure to manage the O&M of low-cost sanitation programmes represents an important step for the adequate operation of the systems, as well as for preserving/improving users' satisfaction.

5.5.1. Operation

Based on the fieldwork, the main factors interfering in the adequate operation of the low-cost systems studied were the quality of the construction, the coverage of the systems and how the users had received and accepted the educational messages.

- ***Construction***

The low-cost on-site technologies studied (Case Studies 1 and 2) are of easy construction, only requiring basic skills for their execution. Pre-cast materials such as that for the superstructure (walls, roof and cover slab) and/or for pit lining were applied in both case studies. The utilisation of these materials can facilitate the construction and also support local production capacity, as was the case in the Case Study 1 (in Olinda).

The characteristics of the soil also deserve attention in order to avoid subsidence problems (that would result in cracks or even in the collapse of the superstructure), and to provide the lining necessary to secure the pit walls during excavation.

Condominial sewerage systems, on the other hand, require trained workers able to lay the sewers at the designed gradients. The minimum gradient adopted in the design of condominial sewerage is 1 in 200 for a 100 mm diameter pipe, which is a value much lower than that used in conventional sewerage (1 in 40 according to McGuire's rule (Marriott, 1994)). This emphasises the importance for training the workers in appropriate construction techniques able to ensure the right design requirements.

In Case Study 5 (ZEIS programme in Recife), the residents were initially responsible for the construction of the condominial branches. However, the quality of the construction was, in fact, sufficiently bad to encourage URB-Recife (company responsible for the implementation of the system) to change this initial agreement. Therefore, URB hired a private company to continue the construction and repair the pipeline sections presenting problems.

Nevertheless, another example (this one from the condominial system of Panacuí, Ceará – Case Study 6) shows that, in spite of having a company hired to execute the job, the system still presented major construction problems, thus demonstrating the need to select adequate personnel for the job.

In Brasília (Case Study 4), in spite of CAESB had had no major problems with the sewers under its responsibility, the company technicians had identified construction problems in the "household connections" of high-income areas. The houses in this neighbourhoods usually have long backyards, frequently requiring a long length of pipeline. As house connections are of the householders responsibility, they usually hire workers in the city (there are not many with experience in condominial systems) for such a "simple" task, which later results in the need for corrective interventions.

Thus, these examples emphasise the need for experienced workers and training in construction techniques to ensure the quality of sewers' construction in flat gradients conditions.

- ***Coverage of the Systems***

The concept of coverage has been defined in this study as the ratio between the number of households using the system and the number of households existing in the project design area. Therefore, Table 5.2. summarises the coverage rates obtained during the fieldwork.

As the household adoption of the sanitation facilities provided by the programmes were not compulsory for 5 out of the 6 case studies, the increase of usage was more dependent on the success of community mobilisation programmes and on the level of acceptance of the technologies by the residents.

Table 5.2. – Coverage rate of the sanitation programmes studied

	Case Studies	Data when the systems started functioning	Date of the fieldwork	Systems' Coverage Rate	Users that never had Functioning Problems
	1. Peixinhos Triangle – Olinda	1984	1999	17%	59%
	2. Aero Rancho – Campo Grand	1994	2000	70%	83%
	3. Rocas/Santos Reis – Natal	1980	1999	83%	40%
	4. Vila Planalto – Brasília [1]	1993	2000	99%	50%
Condominial Systems	5. ZEIS Programme – Recife	-	1999	-	-
	Vila Sao Miguel	1996		76%	
	Vila do Vintem	1994		100%	
	Poco da Panela	1996		95%	
	Mangueira	Jun/1998		66%	
	Joao de Barros	Dec/1995		97%	
	Beirinha/Rua do Rio	Jan/1999		71/30%	
	Mustardinha	Dec/1998		49%	
	Marrom Glace	Dec/1998		90%	
	Tamarineira	Ago/1994		90%	
	Agua Fria	1996		85%	
	Corrego Sao Jose	1996		59%	
	Coronel Fabriciano	1993		100%	
	6. SISAR Programme – Ceará	1993	2000	100%	77%

[1] – In Brasilia, households' connection to the sanitation system is compulsory.

With exception of Case Study 1, where problems with the acceptability of the technology where identified (17 percent coverage), the Recife ZEIS programme (Case Study 5) presented the lowest connection rate (Table 5.1), varying from 31 to 100 percent. Although the sanitation systems in some of the areas were "new" and residents were still expected to provide their connections, such variation in coverage rates was also influenced by the implementing company's changes of policy (providing household connections for some areas and not for others). Therefore, by the time of the update of this study, in January 2001, the company was then providing connections for the areas that were still presenting low connection rates (see Section 4.6.3).

Another usage aspect to be considered is the connection of household appliances to the systems. In Case Study 2, 26 percent of the residents did not connect their sullage (mainly the wastewater from kitchen sink and from laundry) to the pour-flush toilet system. The main reason for that was the misinformation that the pits would get full too easily. Therefore, householders constructed a second pit just to receive sullage and in spite of

having the two pits, they were being used at the same time (not following the double pit scheme as the technology was designed for).

In Recife, Case Study 5, another case of household resistance in connecting sullage to the sanitation system was observed. Among the users that had already invested in their house connections, over 20 percent had just connected one of the two household wastewaters (sullage or excreta – see Figure 4.47). On the other hand, in Case Studies 3 (in Natal) and 4 (in Brasília) nearly 100 percent of all household appliances were connected to the condominial sewers.

Cases of poor connection rates such as those reported above were actually highly influenced by poor understanding of the educational messages or disbelief of the users in the functioning and reliability of the systems.

➢ ***Problems related to systems' operation***

The most frequent problems reported for the VIP latrines in Case Study 1 were related to foul smell and presence of insects. However, 71 percent of the latrines were without a door and only 65 percent of the units still had a vent-pipe (of which 36 percent did not have a flyscreen). For the other on-site system (pour-flush toilets – Case Study 2), 83 percent of the users never had functioning problems. The "problems" reported by the other 17 percent concerned the pit getting full. In fact, among these, just 10 percent followed the programme's orientation in terms of constructing a second pit.

Among Case Studies 3, 4 and 6 on the condominial sewerage systems of Natal, Brasilia and Ceará, respectively, the most common operational problems were of blockage in the sewers (condominial and main line) and in household connections as illustrated in Figure 5.3.

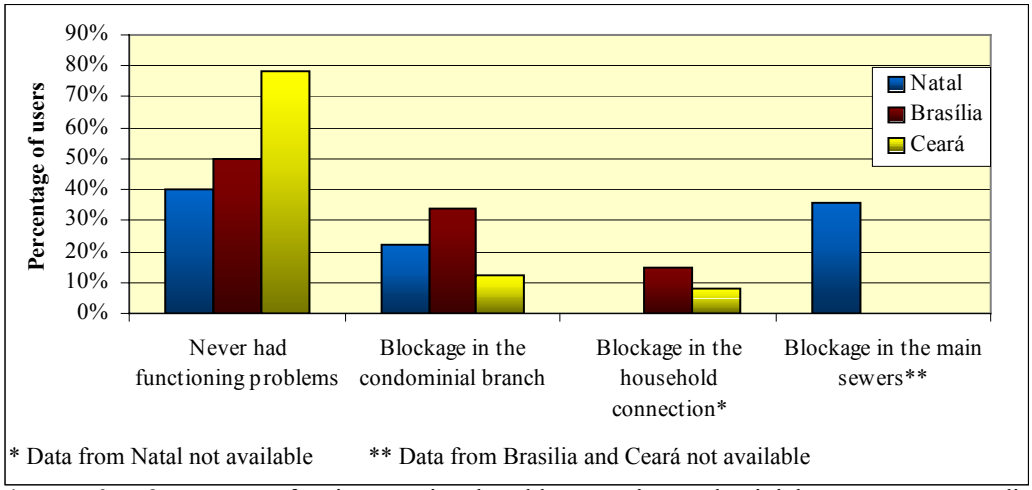

Figure 5.3. – Occurrence of main operational problems on the condominial sewerage case studies

Although some of this functioning problems were caused by poor construction (as already discussed), the majority was due to poor usage of the system, mainly, the presence of solid waste and soil (sand, silt) into the pipelines.

- ***Importance of educational messages***

Many of the functioning problems occurring in the systems are actually problems related to poor understanding (or no understanding at all) of messages explaining the functioning demand of the technology (i.e. emptying intervals, importance of ventilation tubes, how double pit schemes work, why stormwater should not be connected to the sewerage, etc).

Although all the sanitation programmes included here had reported extensive educational activities, some of them did not adequately concentrate on explanations regarding the demands of the systems' functioning and on how the users should proceed in cases of repair or substitution of spare parts.

5.5.2. Maintenance Performance

Cotton (2000) suggests 8 key areas that should be covered by performance indicators (PI) for the evaluation of O&M of water and sanitation systems. These areas are: User's opinion and satisfaction, Community management, Financial, Level of Service, Materials, Personnel, Equipment and Work Control.

Some of these aspects have been covered in this discussion; however, "Level of Service" is an aspect that is still to be taken into account. Thus, two levels are to be considered: services realised by users and services provided by the companies.

Although users were responsible for the backyard condominial branches in all condominial sewerage case studies, much less than half of the households were actually executing such tasks (an exception is the Joao de Barros ZEIS in Case Study 5 – see Section 4.6.8). Therefore, in Case Study 4 (Brasilia) only 24 percent of the households reported to undertake maintenance tasks, and in Case Study 3 (Natal) 19 percent of the users said they carried out maintenance services on the condominial sewers (although another 39 percent do cleaning services for the inspection chambers).

Regarding services provided by the institutions, the main concern was with the company's efficiency in responding to calls for service (for reasons of both user's satisfaction and lowered health hazards). As to this efficiency, Figure 5.4 shows that users reported satisfactory levels of service in Case Studies 3, 4 and 6, with the

companies responding to the majority of calls in less than 24 hours. For Case Study 4 (ZEIS Mangueira), data were gathered from forms which recorded O&M services and showed that 94 percent of the calls for services were attended within 24 hours.

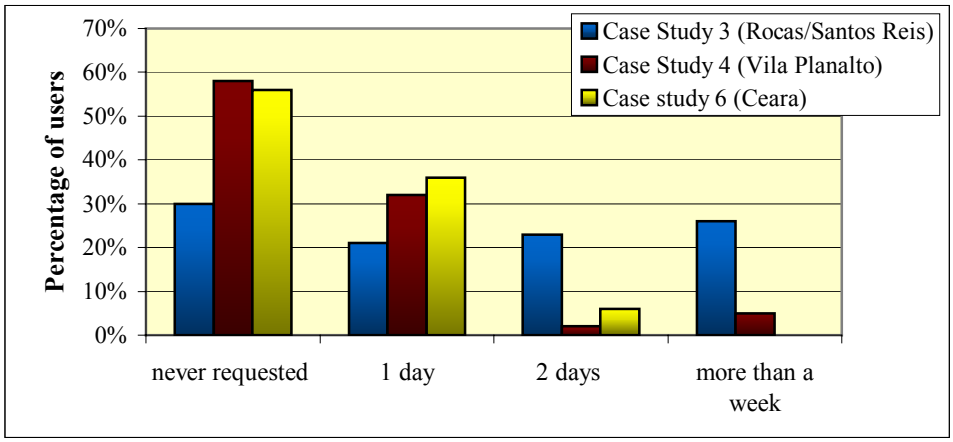

Figure 5.4. – Time for companies to respond a call from users to execute O&M services

5.5.3. Institutional Arrangements

As discussed in Section 5.2.3., O&M is a requirement that should be planned at the beginning of the selection process; that is, adopting technologies that can have their O&M services provided by an institution which is, in fact, physically and managerially capable of doing so.

A wide set of institutional arrangements was observed for the case studies, as shown in Table 5.3. The main aspect in common among these arrangements is the inclusion of users as active participants with defined responsibilities on the systems' O&M.

There were large differences in the level of requirement for O&M between the on-site and the off-site systems. The on-site technologies have the advantage of allowing a programme be designed not relying too much (or not at all) on governmental or private institutions for the provision of the necessary O&M services. Despite this low requirement, the two on-site case studies were, in different ways, adversely affected by the institutions' non-provision of O&M activities. For Case Study 1, the only O&M aspect under the responsibility of the local institution was the provision of emptying services for the VIP latrine's pits at 5 yearly intervals; however, the emptying service was never provided. The other on-site system, Case Study 2, had its O&M designed to be independent of institutional services; however, neither the educational messages regarding users actions for the system's O&M was effectively disseminated, nor was a programme to reinforce such messages developed.

Table 5.3.- Institutional arrangements for the case study programmes

Case Study	Institutional Arrangement for O&M	Observations
1. Peixinhos Triangle (Olinda-PE)	- Local government - Householders	- Implemented by the local government, this institution was responsible for the emptying of the VIP latrines; however never provided the service. Users should maintain the system's units; however, the majority of the units were damaged or destroyed.
2. Aero Rancho (Campo Gd-MS)	- Householders	Implemented by the state government, this pour-flush toilets system relied on the households to upgrade the systems to double pit scheme and carry on the O&M of the system; however, users appeared not to have understood the message.
3. Rocas/Santos Reis (Natal-RN)	- State Government - Community	- Implemented by the state government, this system is also O&M by the same institution. The community is responsible for the maintenance of the condominial sewers; however, workers from the state company were also observed to be developing maintenance services for the condominial sewers and household connections.
4. Vila Planalto (Brasilia-DF)	- Federal District Government - Community	- Implemented by the Federal District government, this system is also O&M by the same institution. The community is responsible for the maintenance of the backyard condominial sewers; however, users can request this service from the company by paying a fee for this.
5. ZEIS Programme (Recife-PE)	- State Government - Communities	- 13 systems implemented by the local govern. O&M transferred to the state government company, which had three different models of service provision (decentralised, centralised and participatory) and had 8 systems under transitory, undefined or rejection situations. The community participation varied from a system to the other, having since a community fully in charge of the O&M of the sewers (participatory model) to systems relying on the company to maintain even the condominial sewers.
6. SISAR Programme (Ceará)	- Joint Community-based Organisation	40 systems implemented by the state government and O&M by a joint community organisation created under support of the state government and the donor agency to manage the systems.

On the other hand, sewerage systems rely on water companies to safely remove sewage from households and adequately return the treated wastewater to the environment. In low-cost systems, however, O&M may be arranged with the users participating in the maintenance of the sewers located on their plots, as proposed by the initial "philosophy" of the condominial sewerage (i.e. CAERN - Andrade Neto, 1999). This user participation for sewers' maintenance leads to lower O&M costs, which is reflected in the users' water bills and can represent up to a 60% reduction on the charges related to wastewater services.

Nevertheless, such arrangements are not easily accomplished. People have a natural resistance in dealing with sewerage-related tasks. For example, in Brasilia users generally opt for the sidewalk layout of condominial sewerage, in which the tariff is higher than the backyard layout but the responsibility for O&M tasks is of the water and sanitation company instead of the householders (Luduvice, 2001).

Furthermore, users seem more likely to carry out the maintenance activities just when they are really attracted by the reduction in charges, and when the educational messages and the purpose of the task have been definitely understood and accepted by the community (usually with the help of strong residents' associations).

5.6. Affordability

According to DFID (1998), *financial sustainability* of water and sanitation systems refers to the ability of these systems in meeting their capital, operating and maintenance costs. Therefore, sustainable sanitation programmes must be designed under the perspective of affordability, which certainly includes the selection of a *technology* that users are *willing-to-pay* for (taking into account price, necessity and convenience), and a *charging policy* that is realistic to the financial demand of the system, as well as to the income limitations of the community.

5.6.1. Technology Costs

The costs for the implementation of condominial sewerage varied greatly between the case studies investigated. Nevertheless, all case studies presented capital costs significantly lower than those normally accepted for conventional sewerage in Brazil (as illustrated in Table 5.4).

Table 5.4 – Capital costs of conventional and condominial sewerage

	Capital costs per household (US$)	Date of the values
Conventional Sewerage in Brazil	1,500	
Case Study 3 - Natal	325	1983
Case Study 4 - Brasilia	110-170	2000
Case Study 5 - Recife (Mangueira)	346	Nov/2000
Case Study 5 - Recife (Mustardinha)	190*	Nov/2000
Case Study 5 – Recife (João de Barros)	147*	Nov/2000
Case Study 6 - rural Ceará	390**	Jan/1999

* values include costs of one pumping station
** value includes costs of treatment

In the case of Natal, the costs would reflect the pioneering characteristic of the system (in 1983) but, in general, the cost variations shown above may be a result of the different organisational structures of the implementing institutions towards the technology adopted.

In Recife (Case Study 5), the same institution implemented all the systems; however, the three values presented above still varied considerably. As the population densities of these areas were similar, the factor most probably influencing such variation is the different system management adopted during the implementation phase. For example, while the João de Barros system was smoothly implemented with strong community participation, the Mangueira system had a long period of implementation with interruptions due to both the lack of financial resources and an uneasy relation between the community and the implementing company (see Section 4.6.7).

5.6.2. Charging Policy

The capital and O&M costs in a sustainable scheme are usually targeted to be fully covered. Nevertheless, whereas the running costs of the systems must be covered independently of financial resources external to the community, the *partial* return of capital costs from the users would be an acceptable strategy when: social/health interests justify it, more affordable technological solutions are not appropriate, and a clear financing scheme to complement the coverage of the costs is adopted.

Table 5.5 summarises the arrangements for the recovery of costs in the case studies investigated.

Table 5.5 – Arrangements for cost recovery

	Return of capital costs	**O&M costs**
Case Study 1 – in Olinda	Only 37% of users remembered paying for the VIP latrines (payment being of 3 to 5 cement bags).	No community level service for O&M. Individually, 35% of users arranged for emptying their wet pits (only 12% did it mechanically).
Case Study 2 – in Campo Grande	Users prepared to be charged in the first months after implementation. However, decision was made to not carry on with the charging plans.	Programme designed with no need for community level O&M; however, orientation for the construction of the second pit was generally not followed.
Case Study 3 – in Natal	Costs designed to be recovered over a 30 year period by surcharging the monthly water bill.	Users charged monthly.
Case Study 4 – in Brasilia	Users charged for capital costs during the first months after implementation.	Users charged monthly.
Case Study 5 – in Recife	No capital costs were recovered from users.	Just 5 out of 13 systems were charging users.
Case Study 6 – in rural Ceará	No capital costs were recovered from users.	Users charged monthly. "Non-payers" were 37% in Nov/2000**.**

Although the on-site programme of Case Study 2 was designed to recover capital costs from the users in the first few months after implementation (and the users had agreed to this), the implementing company decided not carry on with the charges claiming that the costs to produce the bills and collect the payments would be higher than the amount to be paid by the users. The users were not informed of this decision and during this fieldwork a common worry among them was the possibility of being charged now, approx. 7 years after implementation.

Regarding the condominial sewerage systems, a policy to recover capital costs was implemented in only two out of the four programmes studied. Different approaches were adopted by the two programmes for charging the users: in Natal, costs were collected monthly over a 30 year period, whereas in Brasília the charges were made during the first few months after implementation, allowing reinvestment of the revenue in other areas.

The tariff system to cover O&M costs of the condominial sewerage programmes is mainly based on a surcharge on the water bills with values set according to the level of participation of householders in the maintenance services. Among the case studies, the only exception to this was the SISAR programme (Case Study 6), which was initially just charging users for the water supply system and only in Dec/2000 was about to start the charging of a fixed value for the sanitation systems (see Section 4.7.2.).

5.6.3. Willingness-to-pay

The general rule of considering users willingness-to-pay towards water and sanitation services to be 3 to 5 percent of their income has for long been considered inconsistent (DFID, 1998). Willingness-to-pay is considered to be a function of convenience/reliability provided by the service, socio-economic characteristics of the community as well as of the charging policy adopted, and therefore, is very site specific.

In Case Study 3 (Natal), 46 percent of the users perceived the prices they were paying for the sanitation system as reasonable (Figure 5.5a shows the variation of users' opinions according to their income stratum); however, 28 percent (overall average) of the users expressed that the system should be available free of charge (Figure 5.5b). In fact, 29 percent of users demonstrated ability to pay for the service up to 2 reais and 14 percent up to 4 reais, which represent, respectively, up to 1.3 and 2.7 percent of their minimum income.

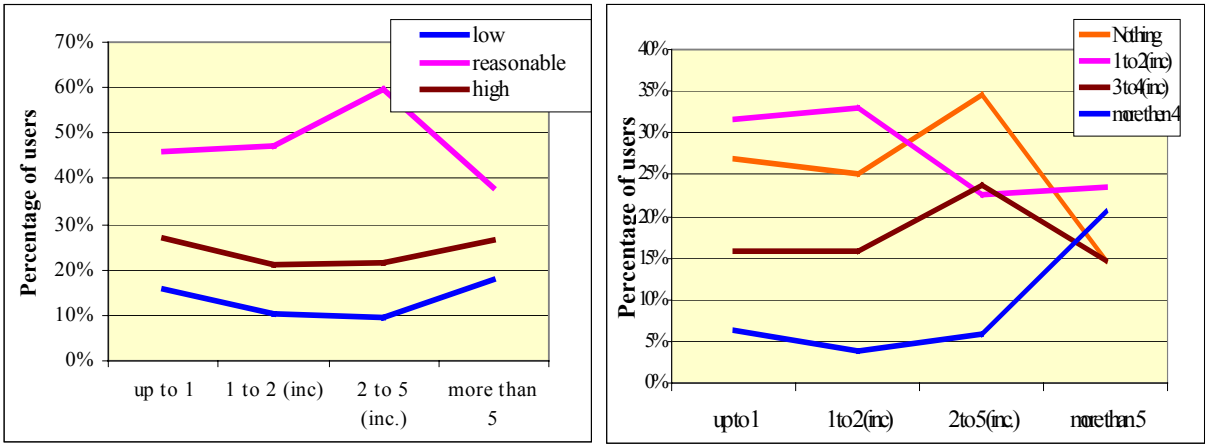

Figure 5.5. – (a) Percentage of users according to their perception of the value of sanitation services varying with the income stratum; and,
(b) Percentage of users according to the amount of money they were willing to pay for the sanitation service. Figures from Case Study 3 (in Natal).

Case Study 5 (ZEIS programmes in Recife) the results showed that the income level of the users was in general dropping linearly (Figure 5.6a). Nevertheless, their willingness-to-pay for the service declined considerably from the first to the second category (Figure 5.6b), with the overwhelming majority of the householders willing to commit only about 2 percent of their minimum income.

Although in general, the condominial sewerage programmes presented high usage rates (see Table 5.1.), a threat for their financial sustainability is the non-payment of the bills. For example, during the first year of the SISAR programme "non-payment" rates were of approx. 55 to 60 percent. To reduce such values (as described in Section

4.7.6), the management team introduced a financial reward for the community with the lowest "non-payment" rate in one full semester and also promote a football championship among the four with the lowest "non-payment" values. As a result in Nov/2000, the non-payment rate fell to 37 percent (average among the 27 communities).

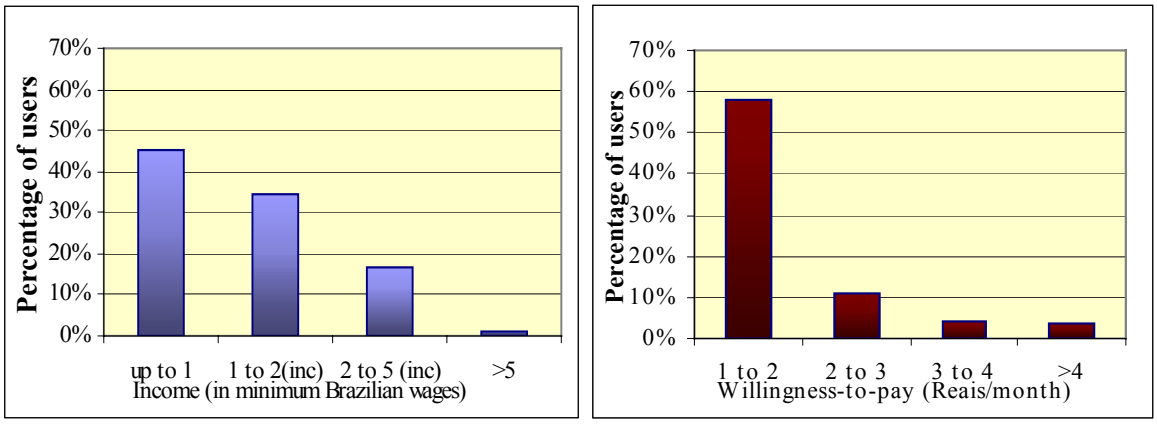

Figure 5.6. – (a) Percentage of users distributed according to their income; and,
(b) Percentage of users according to the amount of money they were willing to pay for the sanitation service. Figures from Case Study 5 (Recife).

5.7. User acceptability/satisfaction

5.7.1. Cultural Acceptability

Considering household needs for the disposal of wastewaters, particularly excreta, the "non-acceptability" of an improved sanitation solution may not in the first instance appear to be a likely situation. Nevertheless, lack of acceptability had already been reported and is frequently indicated as a contributing factor for low levels of utilisation of sanitation facilities. Cultural aspects (i.e. religious beliefs, requirement for privacy, position for defecation, material used for anal cleaning, and user behaviour regarding children/women/men sharing the same facilities) are usually the main factors to be considered prior to decisions influencing in the acceptability of the systems. Nevertheless, two other aspects that should be assessed are: community politics and the technological characteristics of the systems.

Communities with more than one leader (or influential resident) should have their internal organisation well understood in order to do not leave any groups out of the implementation process, and therefore risking that the programme runs into an internal political dispute. This kind of problem is more likely to occur in large communities, such as, for example, the Mangueira ZEIS (Case Study 4) where the mobilisation team

was, however, able to identify the community leaders and minimise the political dispute generated about the sanitation programme (see Section 4.6.7).

Technological aspects of the systems may also interfere with acceptability. On-site technologies more usually adopted for rural communities may not be well accepted in poor urban (peri-urban) areas, as in Case Study 1 for example (where the community refused the direct deposition of excreta in VIP latrines - see Section 4.2.8).

Another example is concerned with the condominial sewerage systems, in which households would be reluctant to collaborate with the O&M requirements of the backyard variation of the system (where sewage from the neighbours houses passes through the backyards). Problems related to this lack of collaboration are likely to cause O&M failures and consequently decrease acceptability and satisfaction. These problems may be minimised by giving users the choice of the layout of the system to be implemented in their block. Case Studies 4 and 5 are examples of systems which householders could choose the layout they prefer (being, therefore, previously informed and having accepted the O&M duties as well as the respective charges of each layout option).

5.7.2. Level of Satisfaction

The measurement of satisfaction among users of a sanitation system can be used as a "thermometer" for the sustainability of the systems. The importance of this parameter is associated with the response from the community in relation to the utilisation of the technology, providing inputs to increase awareness about problematic operational aspects and to improve managerial capacity.

Considering the on-site case studies, two opposite responses were obtained in regard to the level of satisfaction. While the peri-urban community of Case Study 1 (VIP latrine) had a low acceptability of the technology, with 78 percent of the householders suggesting actions for better disposal of the sullage as a way to improve the sanitation of the area (29 percent suggested to clean the drainage channels; 20 percent to cover the channels; and, 29 percent to have a sewerage system), 77 percent of the community of case study 2 (pour flush toilet) were satisfied with the system.

In the condominial sewerage case studies, the householders were asked to classify their level of satisfaction with the sanitation programme as high, reasonable or low. Figure 5.7 shows that, on average, 73 percent of the users reported a high level of satisfaction towards the sanitation programme, compared with only 10 percent that expressed a low level of satisfaction.

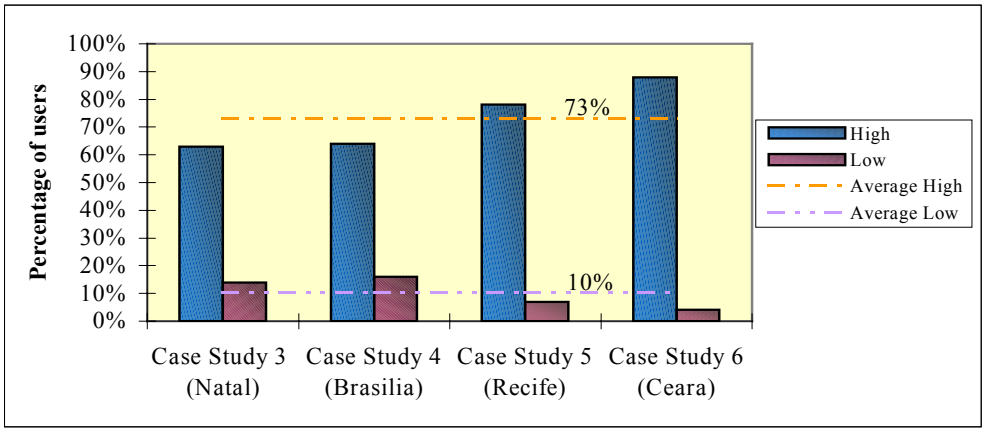

Figure 5.7. – Level of satisfaction among users of condominial sewerage

5.8. Health improvements

The methods available for epidemiological studies associating sanitation interventions with health impacts are highly susceptible to biases and have inherent difficulties in controlling confounding variables (see Section 2.7).

Bearing in mind such problems, and without the intention of performing an epidemiological investigation, this study collected data on aspects brought by the implementation of the sanitation systems that were considered likely to contribute to improvements on health, such as hygiene behaviour and educational programmes.

5.8.1. Behaviour and Health Indicators

Behavioural changes towards better hygiene practices are already accepted as a major factor in achieving higher health standards especially, when complementing water and sanitation interventions. Considering that diarrhoea-related diseases and helminthic infections are the two main diseases targeted by water, sanitation & hygiene programmes, this study obtained information on handwashing & availability of water, diarrhoea & helminthic infections, and familiarity with oral rehydration therapy.

- ***Handwashing of and availability of water***

Although water availability is not the only parameter to be considered in hygiene promotion, the proximity of the water source to households is likely to influence better hygienic practices (Curtis *et. al.*, 1995). Users are more likely to remember washing their hands after defecation if they have water and soap close to their latrines or toilets. The same analogy can be made for food preparation. When the individuals responsible for meal preparation (most commonly housewives or daughters) have enough water

available in their food preparation place, they probably will feel more motivated to adopt better hygienic behaviours.

For five out of the six case studies, at least a yard tap level of water supply was available prior to the implementation of the sanitation programme. Case Study 6 (in Ceará) was the only one in which the community did not have water supplied to the houses, and therefore, the programme provided both sanitation and water.

The supply of water in all case studies was at least as reliable as that for higher income areas of the cities. In Case Study 3 (Natal), the percentage of households served by a yard tap decreased from 73 percent (prior to the implementation of the sanitation system – Sinnatamby (1983)) to 12 percent during this study (88 percent of the households had in-house connections).

In Case Study 1 (Olinda), 67 percent of the households that were still using the VIP latrines had a yard tap level of water supply, and in 76 percent of them there was no facilities for handwashing near the latrines (as shown in Table 5.6).

Table 5.6.- Level of water supply and presence of handwashing facilities in Case Study 1

Case Study 1 - Olinda	**Level of Water Supply**			**Handwash Facilities**	
	Yard Tap	**In-house**	**Other**	**Yes**	**No**
Group 1 (VIP latrine users – data on the VIP latrines)	67 %	33 %	0 %	24 %	76 %
Group 2 (ex-VIP latrine users – data on the solution adopted by the family)	11 %	78 %	11 %	67 %	33 %
Group 3 (never used VIP latrine–data on the solution adopted by the family)	14 %	78 %	8 %	58 %	36 %

- ***Occurrence of diarrhoea and helminthic infections***

Diarrhoea is considered the second main cause of mortality especially among children under 5 (see Section 2.3.2). Based on data collected during the household survey (where mothers were asked about the occurrence of diarrhoea among children under 5 in the previous 15 days), diarrhoea occurred at a rate varying from approx. 1 in 4 to 1 in 6 children per fortnight. The results are presented in Table 5.7.

Table 5.7.- Occurrence of diarrhoea among under 5's

	Occurrence of diarrhoea among Under 5's in the previous 15 days			
	Yes	**No**	**Didn't answe**	**Rate**
Case Study 2 – Favela Aero Rancho, in Campo Grande	23 %	77 %	0 %	1 in 4.3
Case Study 3 – Rocas/Santos Reis, in Natal	17 %	71 %	12 %	1 in 5.8
Case Study 6 – SISAR programme, in rural Ceará	15 %	85 %	0 %	1 in 6.5

Regarding helminthic infections, in Case Study 3 (Natal) children's faeces were said to have had been tested for helminths in the previous 12 months in 59 percent of the households which had at least one child under 15 years of age. According to the mothers interviewed, 31 percent of the tests had positive results with roundworm and giardia being the main parasites identified (see Figure 4.32) – according to a study presented in Wheeler *et al*. (1999), a developed country such as England showed an annual occurrence of infectious intestinal diseases of 1 in 5.

- ***Knowledge on oral rehydration solution (ORS)***

Oral rehydration is a life-saving therapy of fundamental importance in the fight against deaths due to diarrhoea-related diseases, which should therefore be implemented as a complementary action for more sustainable solutions such as improved water supply and sanitation systems (see Section 2.3.2).

In Brazil the spread of knowledge on the ORS has, therefore, been the focus of many educational campaigns in the media and also in the public health services. Among the three case studies surveyed for this variable, householders (mostly the female head of household) were familiar with the ORS at a percentage which varied from 88 to 97. When probed about how they prepared the solution, the values corresponding to proper preparation were in the range of 79 to 92 percent, as illustrated in Table 5.8.

Table 5.8.- Knowledge about ORS among female heads of household

	Have heard about ORS ? Where ?					**Knowledge on preparation**	
	No	**Yes, in the media**	**Yes, trough the health service**	**Yes, other**	**Total of Yes**	**Yes**	**No**
Case Study 2 – in Campo Grande	**12 %**	0 %	63 %	25 %	**88 %**	83 %	17 %
Case Study 3 – in Natal	**12 %**	27 %	57 %	1 %	**88 %**	92 %	8 %
Case Study 6 – in rural Ceará	**3 %**	0 %	91 %	6 %	**97 %**	79 %	21 %

Although no formal data were collected during the fieldwork, the availability of a "measuring spoon" for preparation of ORS was common in the houses. A ready-made mixture (distributed by the public health service) was also available in some houses.

5.8.2. Educational Programmes

Educational programmes were mentioned as part of the sanitation programmes in all of the case studies. However, the programmes presented low commitment with evaluation and continuity of educational actions after the implementation phase.

As already discussed (Section 5.5.1.), the operational arrangements of low-cost sanitation systems involve the participation of users. Therefore, households should be familiar with the proper operation of the system, as well as with the procedures necessary for maintaining the components under their responsibility. For that, effectively educational programmes are fundamental for the appropriate utilisation of the sanitation installations, avoiding not only technical problems, but also, the consequent health hazards.

Comparing the percentages of families that were already living in the communities by the time of implementation of the systems and families that said they still remembered the educational messages delivered during the implementation phase, differences varying from 34 to 55 percent could be identified (Figure 5.8). However, considerations should be made for the time difference between the implementation of each programme and the collection of data during the fieldwork of this study (nearly 20 years for Case Studies 1 and 2). Nevertheless, in the more recent programmes (Case Studies 4 and 6 were 8 and 7 years old, respectively), the differences between residents that received the messages and those remembering them are still high (or even higher).

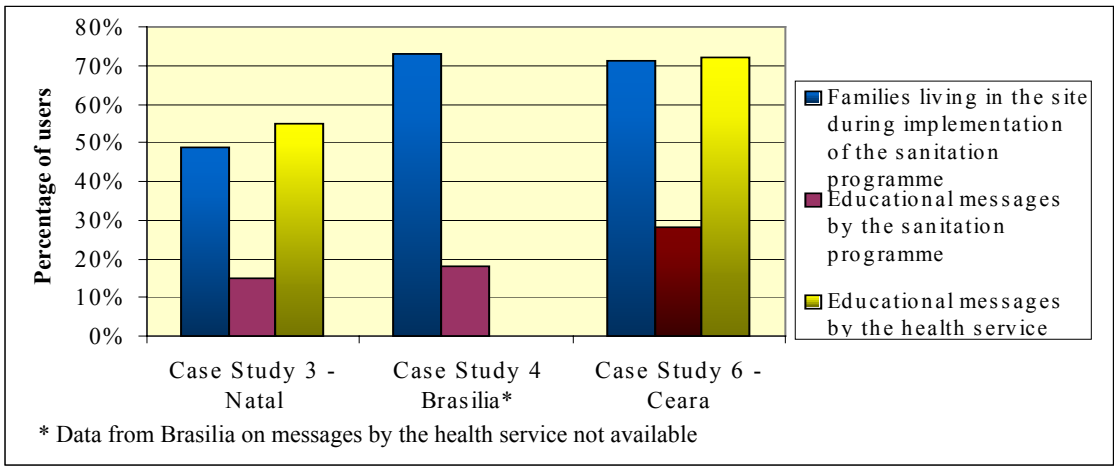

Figure 5.8. – Families remembering educational messages

- ***Health assistants***

Two main health programmes were identified in the case study communities. These, which were primarily sponsored by the Brazilian Federal Government, were the

programme to combat the dengue mosquito (*Aedes aegypti*) and the programme "Family health". Both programmes are based on health assistants that work in a pre-defined area making periodical visits to households (weekly or monthly according to residents).

The dengue programme is based on: the delivery of messages regarding the proper storage of clean water (avoiding adequate breeding conditions for the mosquitoes), the inspection of possible breeding places and the application of pesticides. The "Family health" programme, on the other hand, delivers messages about personal and household hygiene, on women's health and follows children's growth.

These two health programmes had been implemented in the majority of the case studies communities. However, no connections were found linking the educational programme of the sanitation systems to these health programmes. Figure 5.8. above, also shows the percentage of households that remember having received messages from these health programmes.

- ***Follow-up educational programmes***

None of the case studies monitored or evaluated the educational programmes executed during the implementation phase of the sanitation systems. Programmes targeted to reinforce or continue the educational messages were also not executed in the majority of the case studies.

Therefore, only Case Study 6 (rural Ceará) presented, in its managerial structure, a continuing social programme for community development and to re-inforce educational messages. Also, in Natal (Case Study 3), the group responsible for social/educational activities within CAERN was considering launching a programme for preventive O&M actions on condominial sewerage, which would be mostly concerned with educational messages for the better use of the system.