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A new paradigm for low-cost urban water supplies and sanitation in developing countries

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Abstract

To achieve the Millennium Development Goals for urban water supply and sanitation ~300,000 and ~400,000 people will have to be provided with an adequate water supply and adequate sanitation, respectively, every day during 2001–2015. The provision of urban water supply and sanitation services for these numbers of people necessitates action not only on an unprecedented scale, but also in a radically new way as "more of the same" is unlikely to achieve these goals. A "new paradigm" is proposed for low-cost urban water supply and sanitation, as follows: water supply and sanitation provision in urban areas and large villages should be to groups of households, not to individual households. Groups of households would form (even be required to form, or pay more if they do not) water and sanitation cooperatives. There would be standpipe and yard-tap cooperatives served by community-managed sanitation blocks, on-site sanitation systems or condominial sewerage, depending on space availability and costs and, for non-poor households, in-house multiple-tap cooperatives served by condominial sewerage or, in low-density areas, by septic tanks with on-site effluent disposal. Very poor households (those unable to afford to form standpipe cooperatives) would be served by community-managed standpipes and sanitation blocks.

Keywords: Developing countries; Sanitation; Urban; Water

1. Introduction

To meet the water supply and sanitation targets of the Millennium Development Goals (MDG), huge numbers of people in urban areas require new services by the end of 2015: at least 300,000 people per day for water, and at least 400,000 per day for sanitation (WHO & UNICEF, 2000, 2004)—and this is for *every* day during 2001–2015. These figures, which may be gross underestimates (UN-Habitat, 2003),

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are very much higher than those for the numbers of people served in the 1980s and 1990s (urban water: 1980s, 100,000; 1990s, 130,000 people per day; urban sanitation: 1980s, 80,000; 1990s, 160,000 people per day). The 1980s and the 1990s, which were, respectively, the International Drinking Water and Sanitation Decade and "Safe Water 2000" (which, despite its name did include sanitation), failed to achieve their target of "water and sanitation for all" because the required change from a traditional (i.e. a mainly high technology and high cost) to a new (a more appropriate technology and much lower cost) approach was not adequately implemented—that is to say, because the mindset of most engineers and planners was not altered (or, at best, only to a very limited degree), with the consequence that there was insufficient change at the scale required to implement service provision for all the periurban poor.

To achieve the MDG "WatSan" targets, especially the target for sanitation, requires a major shift in the basic philosophy of WatSan provision (as well as, of course, much more money)—"more of the same" is very unlikely to be able to deliver them. A "new paradigm" is required.

2. The new paradigm

The new paradigm is very simply stated: water supply and sanitation provision in urban areas and large villages should be to groups of households, not to individual households. The justification for this new paradigm is the huge reduction in costs that has been achieved by provision to groups of households, rather than to individual households, as exemplified by the condominial water supply system in the city of Parauapebas in the northern Brazilian state of Pará (Table 1). Significant cost savings were achieved in Parauapebas because there was a much lower total pipe length for the public distribution network (287 km of streets served by only 43 km of pipes) which meant that substantially less "public" excavation was required. The condominial branches were routed along the pavements (sidewalks) at a depth of ~400 mm and a single entry point for each housing block ("condominium") provided (Melo, 2005). The block residents (i.e. the condominium members) purchased all the materials to complete the in-block distribution system and household connections (in this case for an in-house multiple-tap supply of 250 litres per person per day), as well as to fund the labour required for trench excavation and network installation.

Common reactions to this new paradigm can be expected to be that "it could not possibly work here as our situation is so very different" or "you just will not get poor households in this country to cooperate with each other". Such views are often held by local professional engineers and planners who seem to be unaware that what they currently do is, in general, woefully inadequate and that major change is

Table 1. Comparative costs[a] of conventional and condominial water supplies in Parauapebas, Pará, Brazil.

	Conventional supply		Condominial supply	
Item	Total cost	Cost per connection[b]	Total cost	Cost per connection[c]
Excavation	454,000	88	101,000	19
Pipes	407,000	79	129,000	25
Total	861,000	167	230,000	44

[a]1997 USD.
[b]Individual household connection.
[c]Single condominium connection. The cost reported above is the cost to the local water supply service provider. Of course the total cost per household is higher as this includes a proportion of the costs of the in-block pipework and fittings.
Source: Melo (2005).

necessary if the MDG water and sanitation targets are to be met. A specific answer to the second point (which might appear to be facetious but is in fact sincerely meant) is that if you can get a group of Brazilian householders to cooperate, then you can get cooperation anywhere. Of course, the proper response to these local engineers and planners is that the whole idea of the new paradigm should be discussed with currently unserved communities and tried out locally at small scale. The results cannot be worse than what currently fails to happen.

3. Water supply

In both poor and non-poor urban areas groups of households may choose to form, or could be required to form, water supply cooperatives. There are basically three types, or "levels", of water supply cooperative:

1. standpipe cooperatives (i.e. one or two standpipes per group of member households) (Figure 1),
2. yard-tap cooperatives (i.e. one tap per member household), and
3. in-house multiple-tap cooperatives (i.e. individual "full" household connections for non-poor household groups).

Each group of households decides which type of water supply cooperative it wishes to form. Normally this will have to be done in collaboration with the local water supply service provider (WSSP) as the type chosen determines how much the cooperative will pay for its water consumption (see Section 3.2). Each cooperative receives a single-point supply from the WSSP (Figure 2) and pays for all materials and labour (or contributes its own labour) for the supply beyond this point (although the WSSP may choose to supply and locate the standpipes for type 1 cooperatives). Each cooperative is billed collectively for its water consumption. It is important to realise that the cooperatives are not service providers, but rather small "bulk" water purchasers, purchasing water from the local WSSP which is then distributed to its member households (this is in contradistinction to a recent World Bank model for provision by

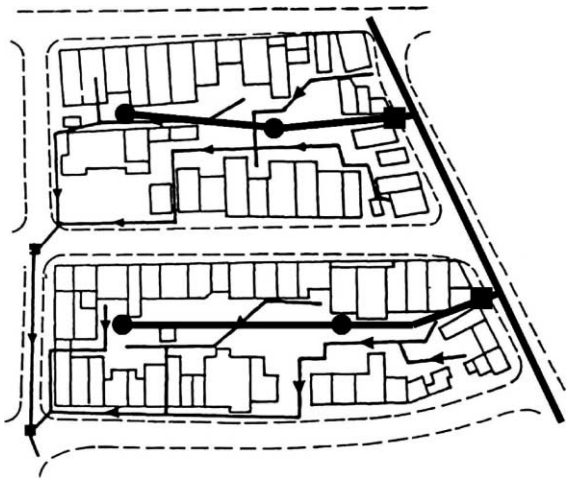

Fig. 1. Two standpipe cooperatives in an existing low-income periurban area. Each cooperative is shown with two standpipes (●) fed from a single supply point (■).

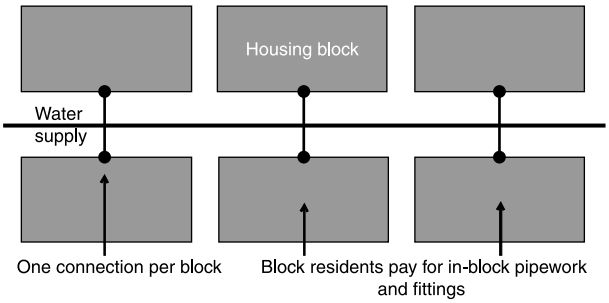

Fig. 2. Single-point water supply connections (●) for yard-tap or in-house multiple-tap water cooperatives (for the latter the supply is metered). Each housing block (or group of housing blocks) forms a separate cooperative.

"consumer cooperatives"—see Section 4.5). Over time, as households become less poor, they may wish to change the type of cooperative they form (from being a standpipe cooperative to becoming a yard-tap cooperative, for example). The local WSSP should not frustrate this desire for change (but, of course, should not compel it).

Households that are too poor to be able to form type 1 cooperatives have to be served by public standpipes. This can be viewed as a "social" supply and local and/or central government should contribute to the cost of these supplies by payments to the WSSP.

3.1. Initial considerations

In any one water supply area the following questions need to be addressed at the pre-feasibility stage:

1. Is the supply to be based on public standpipes, a standpipe cooperative, a yard-tap cooperative or an in-house multiple-tap supply cooperative?
2. If based on public standpipes, how many standpipes are required? Will the community agree to manage them? If not, is the supply feasible?
3. If based on standpipe, yard-tap or in-house multiple-tap cooperatives, how many households should there be in each cooperative? (The answer need not be one figure; a range is preferable to allow for variations caused by topography and housing density.)
4. What should be the design water consumption for standpipe and yard-tap cooperatives? Is 50 litres per person per day (Gleick, 1996) locally sufficient?
5. Will the cooperatives contribute labour and/or money to reduce the costs of implementation? If not, will the scheme be viable?

3.2. Tariff structures

Water supply tariff structures are important as they will clearly influence the decision by a group of households regarding the type of cooperative it wishes to form, as well as setting out how much they will pay for their water consumption and how the amount they pay may change with the amount of water consumed. Each type of cooperative could typically be charged as follows (Mara, 2005):

1. Standpipe cooperatives: the supply is unmetered and the cooperative pays a "nominal tariff" (i.e. a fixed monthly charge equal to a small percentage of the local minimum wage (say, 1–2%) × the number of member households);
2. Yard-tap cooperatives: the supply is unmetered and the cooperative pays a "minimal tariff" (i.e. a fixed monthly charge equal to a slightly larger percentage of the local minimum wage (say, 3–5%) × the number of member households);
3. In-house multiple-tap cooperatives: the supply is metered and the cooperative pays for its consumption on the basis of a block tariff structure.

These are only examples of how the different types of cooperatives could be charged for their consumption. However, they are simple to implement as the WSSP computer used for preparing the monthly water bills can be straightforwardly programmed with all the required information. In fact in Brazil it is common for poor urban households served by an unmetered yard tap to be charged a minimum tariff equal to 5% of the minimum wage, so what is being proposed here is not "revolutionary": the only change proposed is that cooperatives are billed, not individual households.

Of course, governments are free to subsidise water supplies to the extent they wish. For example, in South Africa every household receives a "free basic water" allowance of 6 m^3 per household per month (equivalent to ~25 litres per person per day). An excellent example of how this policy has been successfully implemented is in eThekwini in KwaZulu-Natal (WIN-SA, 2006), although there are some inconsistencies in the ways other local councils apply it (Smith & Green, 2005).

Connection fees should not be levied as each cooperative will have paid for all the materials and labour required to install the water supply beyond the single WSSP supply point. Cooperatives will generally require loans to enable them to do this work; this could be provided either by the WSSP or a local bank/microcredit agency, with the loans being repaid over a period of, for example, 3–5 years (see Varley, 1995).

The WSSP will have to agree with its customer cooperatives how it should treat those who do not pay their bills (e.g. cut off the supply immediately or after 2–3 payment defaults). It may be sensible for the WSSP to collect payments only 10 times per year, rather than 12 (each payment then being 20% more than the actual monthly charge) in recognition of local needs (such as expenditures for the principal local holiday or festival and at the start of the school year)[1]. Each cooperative is responsible for collecting payments from its members; it could do this weekly, fortnightly or monthly, at it wished. Arrangements should then be made by the WSSP to receive partial payments at these intervals, even though it would only formally bill each cooperative monthly. Each cooperative will also have to decide how to treat those of its member households who do not pay their contribution to its monthly water bills.

In large urban areas the WSSP will have a mix of the three types of cooperative and large consumers (industries, hospitals, schools, prisons, etc.), as well as "social" supplies to very poor households (i.e. those unable to form standpipe cooperatives). However, in small urban centres the number of in-house multiple-tap cooperatives will be much lower than in large urban areas, and therefore in these areas the WSSP's main customer base will be standpipe and yard-tap cooperatives. It is likely to be more difficult for the WSSP to maintain its financial viability with a large proportion of poor, unmetered customer cooperatives. Aggregation (the grouping of several small urban centres; see ERM *et al.*, 2005) may be a solution (or, at least, a partial solution) to this through the sharing of fixed costs.

[1] In England, for example, local government taxes (the "council tax") are paid in ten instalments per year.

If non-poor consumers choose not to form in-house multiple-tap cooperatives, then the WSSP should increase their monthly water bills by including a "standing charge" to cover the increased fixed costs of additional billing (meter reading, computer time, bill delivery, receipt of additional payments, etc.). The standing charge should be high enough to encourage these consumers to form cooperatives[2].

3.3. Engineering aspects

Apart from the basic hydraulic design of the water supply network, there are three principal engineering aspects that need to be considered:

1. The use of flow-control valves at the single WSSP supply points to restrict consumption to a predetermined level (to be decided in discussion with the cooperatives—see below);
2. The provision of adequate drainage facilities at every standpipe (see Erpf, 2003);
3. The provision of laundry facilities adjacent to at least one standpipe in standpipe cooperatives; and
4. The use of water-saving plumbing fixtures (Mara, 1989) in houses in in-house multiple-tap cooperatives (this could be voluntary or mandatory—see below).

The flow-control valves should permit a peak flow approximately equal to twice the daily flow (i.e. $2 \times$ (design water consumption, litres per person per day) $\times$ (the number of people in the cooperative)/(24 $\times$ 60), 1 min^{-1}). The design water consumption is a minimum of 50 litres per person per day (lpd), which would be suitable for standpipe cooperatives and yard-tap cooperatives, although the latter may prefer more (e.g. 80 lpd)—but, if this is the case, then the "minimal water tariff" should be set at a higher percentage of the local minimum wage (e.g. 5% for 50 lpd and 8% for 80 lpd). Of course, a cooperative could initially opt for 50 lpd and then "upgrade" to 80 lpd later (but it would have to pay the full costs of doing so, including the cost of a new flow-control valve and its installation).

The use of in-house water-saving plumbing fixtures (i.e. low-volume flush toilets and flow-control valves for showerheads and taps) should be encouraged by showing the consumers the advantages of using them (less wastewater, lower water bills, etc.). In water-short areas (and these will become more common in the near future) their fitting should be mandatory in all houses and commercial premises, both new and existing. In-house multiple-tap cooperatives whose member households refuse to install them should be charged a significantly higher tariff than cooperatives whose member households have installed them (thus each cooperative has a key role in persuading its member households to install them).

4. Sanitation

Sanitation is different from water supply in that each household should, wherever possible, have its own sanitation facility. A water cooperative can straightforwardly become a water-and-sanitation cooperative: its member households decide, with help and advice from the water supply and sanitation

[2] Cooperative action is not a new concept for non-poor households—for example, those living in apartment blocks share the costs of common services (security, cleaning and lighting of common areas, elevator running costs, etc.).

service provider (WSSSP), which household-level sanitation facility they will all have. This could be an on-site system, such as VIP latrines, pour-flush toilets, ecological sanitation toilets (Mara, 1996; Winblad & Simpson-Hébert, 2004) or an off-site system such as condominial sewerage (Neder & Nazareth, 1998; Mara *et al.*, 2001; Sarmento, 2001; Nance, 2005). A recently developed alternative to VIP latrines is the urine-diverting ventilated improved vault (VIV) latrine (WIN-SA, 2006). The availability of space on each housing plot, and whether or not an on-site system is cheaper than condominial sewerage, will generally be the deciding factors in this choice (the cost of on-site systems should include the cost of desludging them at the required intervals; similarly the cost of condominial sewerage should include the cost of wastewater treatment).

4.1. Condominial sewerage

We wish to draw attention to condominial sewerage as we believe it to be the periurban sanitation technology of first choice, especially in high-density periurban areas (and almost all such areas are high density). It not only has the cost advantages outlined below, but also the very important institutional advantage that it *is* a sewerage system and is one based on rigorous hydraulic design, so that sewerage design engineers in local WSSSPs are able to "relate" to it much more easily than to on-site sanitation systems (which they frequently believe to be "nothing to do with them" but, rather, to be the sole responsibility of the environmental health department of the local council).

In the city of Natal in northeast Brazil, condominial sewerage was found to be cheaper than on-site sanitation (pour-flush toilets) at population densities above the relatively low level of ~160 people per ha (Sinnatamby *et al.*, 1985). The charge for condominial sewerage was a 40% surcharge on the water bill and, as the households were on an unmetered yard-tap supply for which they paid the minimum tariff, the monthly charge for condominial sewerage was very low, equivalent to US$1.50 in 1983. Currently CAESB, the water and sewerage company for Brasília and the Federal District in Brazil, surcharges the water bill as follows (Neder & Nazareth, 1998):

- households with "back-yard" sewers: 60%, and
- households with "front-garden" sewers or sewers in the public pavement/sidewalk (i.e. non-poor households): 100%.

The water and sanitation cooperatives' responsibilities include, in the case of on-site sanitation systems, the construction of the chosen system for each member household and arranging for the pits to be desludged at the appropriate frequency (the cooperative can collect a little more money each month from its member households to pay for desludging).

In the case of condominial sewerage, the cooperative pays for the construction of the condominial sewers and their connection to the WSSSP street sewer; it can choose whether or not to contribute its own labour for excavation. The WSSSP is responsible for the construction and maintenance of the street sewers and for wastewater treatment. It should also be responsible for supervising the construction of the condominial sewers and for training local contracting firms to lay small diameter sewers at flat gradients (e.g. 100-mm sewers at 1 in 200) correctly—only contractors who have been trained should be permitted to install condominial sewers. As in the case of cooperative water supplies, the WSSSP and/or a local bank or microcredit agency should be prepared to lend water-and-sanitation cooperatives money for the

construction of sanitation facilities. WSSSPs have to work effectively in partnership with the cooperatives they serve, or else success may be elusive (Watson, 1995).

Very poor households which obtain their water from public standpipes are unlikely to be able to afford individual sanitation facilities; this may also be true of some standpipe cooperatives. There are also the homeless: street children, for example, and "pavement dwellers" in India. These communities are best served by SPARC-style community-managed sanitation blocks[3]; full details are given by Burra *et al.* (2003) (see also Water & Sanitation Program, 1995).

4.2. Water supply and sanitation combinations

The choice of sanitation system depends on the level of water supply service, as illustrated in Table 2. The combination of public standpipes and condominial sewerage, as noted in Table 2, is perfectly feasible. Sinnatamby *et al.* (1985) described a very poor area in Orangi, Karachi, Pakistan, where the water supply of ~27 lpd was from public standpipes, which was successfully served by "Brazilian style" condominial sewers. For in-house multiple-tap cooperatives conventional sewerage would be technically feasible, but its costs are *very* high (Kalbermatten *et al.*, 1982) and only very rarely recovered from the users, even if their water bill is surcharged by 100%, which is commonly the politically acceptable maximum (if non-poor households are served by conventional sewerage, the unsewered poor often end up paying more for their water as the WSSSP tries to recover its sewerage costs by increasing the price of water for everyone—the new paradigm seeks to avoid this inequitable situation).

CAESB currently installs condominial sewerage in both poor and non-poor (including very rich) areas of Brasília and the Federal District, and this prompts us to ask if there are now any circumstances in which conventional sewerage should be used in urban residential areas. Given CAESB's experience, we do not believe that any such circumstances exist. This view is supported by recent costs in South Africa: in 2002 the cost of conventional sewerage was ZAR 6,000–7,000 per connection, whereas the cost of condominial sewerage was only ZAR 2,500–3,000 per connection (National Sanitation Task Team, 2002) (average exchange rates in 2002 from oanda.com/convert/fxhistory were ZAR 1,000 = US$ 87 = €100).

4.3. Changes to national sewerage design codes

For condominial sewerage to be considered as an acceptable technology by local engineers, national sewerage design codes (which are design codes for conventional sewerage) and any restrictive municipal by-laws generally need to be altered, particularly regarding the minimum permissible sewer diameter (100 mm for condominial sewerage; 150 mm or more in national design codes). This was done in Brazil and Colombia (ABNT, 1986; Mara *et al.*, 2001; Arévalo-Correa, 2003), and in the Indian sewerage design manual condominial sewerage is at least mentioned (Ministry of Urban Development, 1993). Additionally large numbers of local engineers will need to be trained in condominial sewerage design procedures; currently this lack of trained engineers is a major constraint to the implementation of

[3] SPARC (The Society for the Promotion of Area Resource Centres) is an Indian NGO—www.sparcindia.org.

Table 2. Feasible water supply and sanitation combinations.

Type of water supply	Sanitation options	Notes
Public standpipes	Community-managed sanitation blocks	It is assumed that individual household sanitation facilities are unaffordable.
Standpipe cooperatives	Community-managed sanitation blocks, on-site systems or condominial sewerage	Choice depends on space availability and costs.
		The combination of standpipes and condominial sewerage *is* feasible (see text).
Yard-tap cooperatives	On-site systems or condominial sewerage	Choice depends on space availability and costs.
In-house multiple-tap cooperatives	Condominial sewerage	In low-density non-poor areas on-site septic tank systems may be used.

condominial sewerage. Demonstration projects will generally be required to provide not only visible "proof" of the effectiveness of condominial sewerage, but also to determine its local costs.

4.4. Community-managed sanitation blocks

Very poor households which obtain their water from public standpipes are unlikely to be able to afford individual sanitation facilities; this may also be true of some standpipe cooperatives. There are also the homeless: street children, for example, and "pavement dwellers" in India. These communities are best served by SPARC-style community-managed sanitation blocks; full details are given by Burra *et al.* (2003) (see also Water & Sanitation Program, 1995).

4.5. The World Bank "consumer cooperatives" model

Our concept of WatSan cooperatives, as described above, is different from the World Bank model for water and sanitation "consumer cooperatives" (Ruiz-Mier & van Ginneken, 2006). Under this World Bank model the "consumer cooperative" is in fact a WSSSP owned by its users (i.e. by those receiving the water supply and sanitation services provided by the cooperative). This model is not a new paradigm model as water supply and sanitation services are not provided for groups of households (i.e. to cooperatives in the sense we use herein). In our model whether the WSSSP is owned (or operated) by a public or a private sector utility (or even by a user-owned utility as in the World Bank model), is not in fact philosophically relevant, although we recognise of course that in any given set of circumstances the type of WSSSP ownership may have important institutional implications for both utility performance and how well (or badly) it serves poor households in its area of operation.

5. New paradigm, new partnerships—better planning, better governance

From the foregoing it is apparent that there needs to be a transparent partnership between the WSSSP and the cooperatives. WSSSP staff (engineers, sociologists/social scientists, financial analysts) need to

work *with* the cooperatives, especially its low-income cooperatives (i.e. those with standpipe and yard-tap supplies), so it can understand their water and sanitation needs and respond to them in a sympathetic, professional way. The role of sociologists/social scientists in this is very important as they are generally able to interact in a more sympathetic way with WSSSP customers (the cooperatives) than are most engineers (in Brazil, for example, many, if not all, state water and sewerage companies employ sociologists/social scientists for this purpose). Without such partnerships (and it is not difficult to develop them properly) the water supply and sanitation "improvements" are unlikely to meet fully the communities' needs or to be operated and maintained properly (Watson, 1995). Planning water supply and sanitation improvements for low-income communities should follow the detailed principles developed by Eawag (2005) for urban environmental sanitation; these planning principles are wholly compatible with the new paradigm. Eawag (2005) also details how local institutions need to change and develop in order to respond effectively to local demands for improved water supplies and sanitation; these principles are directly applicable to the new paradigm.

WSSSPs are frequently unconcerned about water leakages that occur beyond the water meter (i.e. once they have sold the water). Water and sanitation cooperatives can be expected (and should be encouraged) to be concerned about such leaks in order to reduce their water bills. They will also be aware of and motivated to remove any blockages in the condominial sewers. The new paradigm, by promoting water supply and sanitation services only to cooperatives, thus improves the governance of these systems by devolving to the cooperatives the responsibility for operation and maintenance of the non-public (i.e. the condominial) parts of the overall system (if non-poor water supply and sanitation cooperatives are unwilling to take on this responsibility, the WSSSP should charge a premium rate for providing this service).

We believe that the new paradigm is likely to be the only way the MDG targets for water and sanitation can be achieved in urban and especially periurban areas. However, time is running out—quickly. If we take it that developing country governments and international, multilateral and bilateral agencies are indeed sincere in their agreement to achieve the MDG WatSan targets, then we believe that they all need to "change gear" (in fact, several gears) now and embrace the new paradigm without delay.

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