1 **Reflexive Assessment of Practical and Holistic Sanitation**

2 **Development Tools using the rural and peri-urban case of Mexico**

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18 Abstract

19 Lack of sanitation affects the lives of billions of people worldwide. It is now generally agreed that

20 sustainable solutions to this complex problem require social and cultural factors to be addressed in

21 addition to the habitual economic and technical aspects. Increasingly, sector professionals view the

22 fragmented approaches to sanitation as a limiting factor. This refers to the fragmentation of the

23 knowledge on the subject among often hermetic disciplines and to the distribution of political mandates

24 on sanitation across many institutions, which independently tackle specific aspects of the issue. Holistic

25 approaches have often been suggested as a solution. This paper presents the development of such a

26 holistic approach, designed to assess sanitation development in rural and peri-urban settings. Tested in

27 three Mexican communities, it relies on qualitative research tools to identify critical influences to

28 sanitation development. This article presents generic results about micro and macro factors affecting

sanitation development in Mexican villages, and reflexively examines the research process as well as the strengths and limitations of the approach. The conceptual map developed for each case study successfully highlights the interconnectedness of all factors affecting sanitation development. Despite some weaknesses, these maps constitute a practical assessment tool for interdisciplinary teams deployed in integrated water and sanitation development programs and a valuable didactic tool for training activities.

1. Introduction

Lack of adequate sanitation threatens the life of billions of people in the poor regions of the world. Together with access to a safe water supply, a hygienic means of excreta disposal counts amongst the most basic human needs. Failure to meet this need not only weakens a population's health, it also impacts the economy and the natural environment, jeopardising all attempts of a society to climb up the ladder of development (UNDP 2006). The last 50 years saw a great deal of evolution in the policies guiding water supply and sanitation (watsan) development. Initially, these matters were mainly tackled by 'traditional engineers' and economic experts and were viewed as the mere provision of infrastructures and services to the population by the public authorities (Black 1998). In the early 80s, the repeated failure of this top-down, supply-driven, 'technologist' model in the rural sector encouraged the development of alternative models based on demand-driven, participatory approaches putting people at the centre of the development process (EAWAG 2005, Schouten and Moriarty 2003, Black 1998). In urban contexts, a comparable yet more recent awareness is also tangible. The framework Sanitation 21, developed by the International Water Association, advocate a shift from a Victorian era perspective of sanitation to a more complex approach more concerned with the users' interests and stakeholders capacities (IWA 2010). Indeed, according to this leading actor in the sector, 'the conventional approaches to sanitation planning and design seem to fail with depressing regularity' (IWA 2006). In the bottom-up approaches to rural watsan development, techno-economic aspects become parts of a multidimensional issue comprising social and cultural factors (Liebler 1994). The popularity of such approaches has grown considerably during the last decades (Schouten 2003, Lockwood 2004) and they are now increasingly advocated by national and international donor organisations. Community Led Total Sanitation (CLTS) approach, for instance, was launched in the late 1990s and achieved 100% sanitation coverage in over 400 Bangladeshi villages (Kar 2003). It has proven to be an effective and sustainable solution in many African countries where it is now

1 actively promoted by large NGOs such as Plan International, WaterAid, and Islamic Relief, as well as the

2 multilateral donors UNICEF and the World Bank (Saha and Negussieb 2009). Household-Centred

3 Environmental Sanitation (HCES), promoted by the Swiss Federal Institute of Aquatic Science and

4 Technology and the Water Supply and Sanitation Collaborative Council is another recent example of

5 people-focused, multidimensional approach to sanitation (EAWAG 2005).

6 Generally speaking, this transition in the approaches advocated in the watsan sector involves much

7 concern for integrative thinking, as noted by Robbins (2007) who described the emergence of 'reflexive'

8 watsan engineers, with their characteristically more integrated and holistic view of socio-technical

9 systems (Robbins 2007). Integrative thinking is on the agenda of most donor agencies, who recurrently

10 warn of the shortcomings of fragmented approaches (BMZ 2009; DFID 2008, UNDP 2006). Part of this

11 fragmentation originates in the segmentation of the knowledge on sanitation into independent disciplines.

12 Despite the rise of cross-disciplinary specialities, such as environmental engineering or sanitary

13 engineering, an important disconnect remains among certain disciplines (eg. public-health,

14 social/behavioural, economic/political), which are essential to comprehend a complex issue such as

15 sanitation development (Batterman et al. 2009). This disciplinary segmentation of knowledge is projected

16 to a large extent on the institutional plane too, contributing to the splitting-up of the responsibility for

17 sanitation among a multitude of institutions, which Jenkins and Sugden (2006) have generically

18 described: The Ministry of Water, historically in charge of water supply and sewer networks, has little

19 expertise in on-site sanitation and much less in hygiene education. This is the ground of the Ministry of

20 Health, ideally placed to address hygiene, water borne diseases and behavior change, but which

21 nonetheless lacks technical expertise in sanitation and budget for implementation. In decentralized states,

22 sanitation services can fall under the duty of the Ministry of Local Government. Local governments are

23 well situated to assess the needs of their people but tend to lack skills for sanitation, and may not have

24 much political interest in the issue. The Ministry of Rural Development is generally involved in the

25 development of infrastructure at household and community level and the Ministry of Environment is

26 increasingly concerned by the impact of lack of sanitation on surface and groundwater resources. In this

27 context, effective co-ordination is practically impossible and the further decentralization of

28 responsibilities at regional, district, and city levels leads to a net result of 'tangled web of overlapping,

29 uncoordinated, unworkable policies, low budget allocations, low prioritization and lack of accountability'

30 (Jenkins and Sugden 2006). Fragmentation in the approach to sanitation development is thus increasingly

regarded as a key obstacle by the international community, which increasingly advocates holistic

approaches as a remedy, as the following quotes demonstrate:

'Interventions should be based on a holistic and systems-based approach […]' (SIDA, 2004).

'UNESCO's International Hydrological Programme addresses the issue of sanitation in the broader

context of sustainable urban water management, by adopting a holistic approach [...]' (UNESCO 2007).

'We thus advocate a holistic total sanitation approach […]' (SDC 2007).

This paper describes the development of such a holistic approach chiefly designed to highlight the interconnectedness of all the factors (technical, economic, social, cultural, political etc.) influencing sanitation development and thus to counterbalance the habit of fragmenting and tackling this issue through independent disciplines. This case-study research, undertaken in Mexico, focused on three rural and peri-urban communities. First, the methodology, which relies on qualitative methods of investigation and incorporates conceptual mapping as a visual means of representation, is described. The results are then presented: the maps are generically described as well as common patterns detected amongst the case-studies. The overall approach is then critically evaluated. Its strengths and limitations, as well as its practical usefulness are examined.

2. Methodology

The research design and the data collection process was pilot tested in Mexico and applied in situ in three case studies. Data analysis and the graphic presentation of the results as conceptual maps were carried out in the UK.

2.1. Research design

2.1.1. Case study research

A systems approach was followed to comprehensively assess sanitation development in the school. The components of the system were defined as all the factors influencing sanitation development. The methodology had to allow for the identification components of diverse nature (e.g. technical, social, cultural, institutional, economic...) and emphasise their interactions. Qualitative methods of investigations

1 were found most suitable to encompass these various dimensions. A standard case-study research

2 approach was used in the three communities over a period of 14 months.

3 *2.1.2. Sanitation in Mexico: situating the research in the macro context*

4 Mexico provides a rich and multifaceted context for this research. The country is deeply involved in a

5 modernization process, which has economically benefited northern and central parts of the country

6 essentially, leaving the South in a comparatively severe level of poverty. The high rates of urbanisation

7 and demographic growth, respectively +26% and +21% during the period 1990-2005(CONAGUA 2008)

8 have contributed to intensify groundwater overexploitation and contamination of all water resources, to

9 such an extent, that water was recently established as a national security issue (Presidencia de la

10 Republica 2010). Regarding sanitation, the National Water Commission (CONAGUA), placed under the

11 authority of the Ministry of Environment (SEMARNAT), indicates a steady progress in the provision of

12 services. In 2008, 86.4% of the population was connected to the sewer system and around 40% of the

13 collected wastewater (36% of the total effluent produced) was treated. A closer look to the data reveals

14 severe problems in some regions: while the State of Nuevo Leon (Northern Mexico) processes 100% of

15 its wastewater, only 12.9% of the effluent produced in Mexico City's district ever reaches a treatment

16 plant. Most of it ($53m^3/s$) is pumped northbound to a neighboring State for agricultural reuse. The

17 southern states of Yucatan and Campeche only treat 2.1% and 3.8% of their wastewater. And as expected,

18 populations living in rural areas, of particular interest in this research, have a less access to the sewer

19 system (62%) than in urban areas (94%) (CONAGUA 2009). These official data, however, do not capture

20 the tough sanitary reality of an increasing portion of the population, which amasses in informal

21 settlements of the peri-urban zones of large cities, and who often do not have statistical existence. Nor do

22 they detail the sanitation alternatives used by the 38% of the rural population unserved by the sewer

23 system.

24 Mexico presents other relevant features for this research on a holistic approach to sanitation development.

25 CONAGUA, the leading institution in the water sector, has traditionally addressed sanitation from a

26 typically Victorian, technologist perspective (CONAGUA 2009). The institution, which was originally

27 founded to develop irrigation infrastructures in the country, introduces itself as the 'heir of a great

28 tradition in hydraulics' (CONAGUA 2010). In spite of the decentralization, CONAGUA's maintains a

29 significant influence on the sector. In her research on capacity building in the Mexican water sector,

30 Tortajada (2001) reports that the World Bank repeatedly pointed out that aside its considerable technical

expertise, the Mexican water sector needed a stronger interdisciplinary expertise with better planning and management skills. According to her, holistic efforts involving the development of human resource in domains that are not purely engineering and the integration of these skills in multi-disciplinary and multi-sectoral approaches are urgent. Multilateral institutions such as that of the Inter-American Development Bank (IDB) and the World Bank strongly foster such efforts by imposing certain conditionality to their loans. For instance, the project 'Potable Water and Sanitation in Rural Areas II' approved in 2005 counted community participation and institutional strengthening as key components aside infrastructures (IDB 2010).

2.1.3. System boundaries

The research focused on sanitation development in small communities of less than 4000 inhabitants. First of all, the identification of the external influences on systems of such scale is a much simpler and less time-consuming task than in a city. In addition, as described in the previous section, much of Mexico's efforts in sanitation development now have to address the important gap between the sewered cities and the non-sewered, dispersed rural localities and informal peri-urban zones. The research was designed on the basis of three case studies (preceded by a pilot case study) to test the validity and robustness of the approach against varying circumstances. The communities were selected on the basis of four criteria: *population size; sanitation infrastructures; economic and socio-cultural environments; institutional and political background* (see Table 1). Figure 1 shows the location of each case study. Ultimately, the case studies were chosen following the advice of respected informants (e.g. NGO members, researchers). One of the case studies significantly differed from the others in that a primary school was chosen to form the boundary of the system. The objective was to test the approach on a smaller scale and to evaluate its relevance in a context that has become much of a concern for the international community (UNESCO, UNICEF, WHO, The World Bank 2005).

Table 1. Case studies characteristics

Case study	El Copal - *pilot case study* -	Tepezalá	El Mirador primary school	San Luis Beltran
State	Guanajuato	Aguascalientes	Oaxaca	Oaxaca
Municipality	Irapuato	Tepezalá	Santa Cruz Xoxocotlán	Oaxaca de Juárez
Population (inhab.)	1100	3500	200 pupils (1000 inhab.)	1200
Setting	Rural zone	Rural zone	Fast growing, peri-urban slum	Rural village aside the urban zone

Sanitation infrastructures	On-site sanitation and frozen off-site project (sewer + Imhoff tank + constructed wetland)	On-site sanitation and off-site sewer + pond with agricultural effluent reuse	Two pit latrines and five useless flushing-toilets	Ecological toilets and unfinished, deficient sewer system
Political Background	Community leader, low community participation	Municipal government	Division in rival factions, weak leaderships, low community participation	Community council, pre-Hispanic political customs
Economic and socio-cultural environment	Various sources of employment; high cultural homogeneity	Very low economic activity; part of the community marginalised	High poverty, cultural heterogeneity, loose social fabric, mistrust	Abandonment of farming activities; shift in cultural values
Period of investigation	June 1999 to October 1999	November 1999 To April 2000	May 2000 to September 2000	October 2000 to January 2001

1

2 Figure 1. Location of the case-studies (Adapted from map of Mexico (CIA 2010))

3

4 The first five months of fieldwork preceding the first case study were spent testing the research design in

5 El Copal, state of Guanajuato. Notably, data collection tools were evaluated and selected on the basis of

6 the relevance and quantity of information they permitted to gather from various stakeholders. This pilot

7 phase was particularly useful to become more familiar with the people and institutions with a stake in

8 community sanitation and with cultural features of Mexico.

9 **2.2. Data collection tools**

10 The pool of data collection tools actually used in each case study is presented in Table 2. Qualitative

11 interviewing in its various forms represented the core instrument of the data collection process. Literature

1 review, which largely contributed to the baseline study of each site, also served during the analytical

2 phase to assess the relevance of generalizing observations from patterns common to several case studies.

3 Table 2. Data collection tools and their applications

Tools	Information sought
Literature review	Biophysical, social, cultural, historical information of the community in its regional context.
	Macro economic, cultural and political information
Qualitative interviews	
Informal conversations	Narratives on one or two topics (e.g. school sanitary conditions in El Mirador)
Semi-structured interviews	In-depth information on a given event or process (e.g. the detailed story of ecological toilet project in San Luis Beltran)
Cultural interviews	Shared values, worldview of a group of people (e.g. significant cultural changes in San Luis Beltran during the last decades as the community integrates the rural-urban fringe)
Social surveys	Quantitative data on specific issues (e.g. prevalence of open air defecation in Tepezalá)
Accounts of events	Data on individual and group behavior (e.g. level of community participation, teacher attitude towards hygiene in Morelos primary school, El Mirador)
Photography	Local pictures illustrating key factors influencing sanitation development
Measuring methods	More occasional. Quantitative data to validate or refute an hypothesis (e.g. sufficient availability of water supply for the operation of a conventional sewer in San Luis Beltran)

4

5 The following dialogue is an example of the rich and vivid kind of information that semi-directed (or

6 topical) interviews produced. In this case, A, an ex-leader of San Luis Beltran, a village in the rural-urban

7 fringe of Oaxaca City, explains the main reason why his community had always been opposed to the idea

8 of a sewer project. The sewer system was viewed as the doorway to urbanisation, with its gain and losses.

9 J (interviewer): They were offering water in exchange for the right to carry the water across the

10 village to San Felipe and to Donaji, right [in exchange of sharing your spring]?

11 A (interviewee): Exactly, and for all the communities down the hill. And we said no, because they

12 wanted to contaminate our water [mix it with other water sources and chlorinate it], which comes

13 from the hill and is clean. Thank God we have it. So they said: 'we connect the water to the tank we're

14 going to make for you, and we'll give you water.' They were going to put in flow-meters; they were

15 going to incorporate us...

16 J: Do you mean that they were going to make you dependent on...the city.

A. Yes, on the city. So we refused...

J: They were offering both things: water and the sewer system.

A: Exactly. So I was one of the pioneers to see that. [..] We don't want the [their] water, we've got water to survive, we don't need the sewer, we've got latrines. We're happy like that. [...] The other thing is that they said that if they put in the sewer here, they would pave the road over the sewer. I tell you that the government does things its way, but they don't tell the people about the benefits and the drawbacks. But we're guilty, the people who govern and the population, for not realizing what the projects involves. Because I repeat: during the two terms of office previous to mine, they had offered the sewer system. And when they offered it to me, we refused for the same old reasons.

J. Why is there such a strong willingness from the government to implement it?

A. It is to enclose us within the city. As municipal agencies and as villages, we've always opposed ourselves. But the government doesn't want us to remain a village, but a district…

J. …which can be managed...

A: Exactly! This is what happened with Dolores: it used to be a municipal agency, and it is not anymore: it has become a district now. It lost its independence. It lost it!

SI2- A, community leader in 1990-1992

Pictures were very useful to increase the validity and credibility of key concepts gathered through interviewing. The following picture shows the unfinished and abandoned construction of five cistern-toilets in the primary school Morelos. It portrays both the motivation of the parents to improve their children's sanitary conditions at school, the lack of technical expertise of the parents' committee (indeed, to operate, cistern toilets need a reliable source of piped water, which the school cannot provide). And in particular, it clearly describes the devastating influence of corruption in this group, as confirmed by extracts of several interviews quoted here together with the picture:

X [interviewee] explained how they had been required to financially contribute (50 pesos) to build up new toilets at school and how 'the president [of the parents' committee] who was supposed to build the toilets stole the money' MI20 - X (pupil 's parent)

'In the committee last year, the president was a mason and the treasurer was contractor, and they seized money. Furthermore, they asked every father two contributions of 50 pesos. [The treasurer

then] set up his own shop in the residential zone. He took his daughter out of the school and put her in
Mineria [Mineria school] 'M127 - Y (teacher)

Figure 2. The 'new' toilets of Morelos primary school.

2.3. Data analysis process

2.3.1. Data Coding

The collected data were coded with the computer software QSR *Nvivo* (QSR International 1999). A two-level classification was used, with the primary criteria based on scale (*Community level*, *Neighbourhood-Regional level*, and *Country level*) and the secondary criteria based on disciplinary-like dimensions (e.g. economic, political, technical, socio-cultural, institutional). For each scale, a summaries grouped short statements describing direct or indirect influences on sanitation development. These propositions were intentionally structured as causal relationships between several concepts, as required by the next phase of the analysis, involving conceptual mapping. For example:

'Social cohesion *hinders* corruption, and *promotes* the participation of people in community development.'

'People first accepted the ecological toilets *because* they believed that they would never get access to a sewer system, *because* it was too expensive and the community leaders disapproved the use of this technology.'

1   'Paternalism *leads* people to accept everything the authorities offer them, without knowing the

2   use they'll make of it. *As a consequence*, the ecological toilets were widely accepted, but some

3   people use them as a storehouse or as a hen-house, and some just used the material to build

4   something else.'

5 For each case study, the coding phase thus yields a collection of propositions featuring concepts

6 linked by causal relationships. In distilled form, this information presents the complexity and

7 diversity of the factors affecting sanitation development and implies a web of relationships amongst

8 these factors.

9 *2.3.2. Conceptual mapping*

10 A means to make this complexity and interconnectedness tangible, easily accessible and of practical use

11 for field practitioners and decision makers was sought in the field of information visualization. Research

12 in psychology and communications has shown that visual representation encourages synthesis by the

13 receiver, while language typically requires analytical decomposition (Unnava & Burnkrant, 1991). They

14 are also particularly advantageous when the task involves - as in this research - illustrating relations,

15 identifying patterns, presenting an overview and details, improve understanding and problem solving and

16 communicate different types of knowledge (Burkhard and Meier 2004). Conceptual mapping, also called

17 concept mapping or causal loop diagram in the systems community, was the method chosen to bring out a

18 holistic visual representation of each case study system. It is particularly effective in capturing and

19 sharing experts' knowledge (Cañas *et al.* 2005) as well as fostering processes of knowledge acquisition

20 (Tergan 2003) and memorizing (Burgess et al. 1992). In the watsan sector, this versatile technique has

21 already been used to picture complex issues, such as the relationships between health, productivity,

22 education and culture (Burkey 1993) or the linkages between road construction and the rise of diarrheal

23 diseases in Ecuador (Batterman et al. 2009). Of much relevance for this research too, Schouten and

24 Moriarty (2003) developed a map presenting the requirements for sustainable community management of

25 rural watsan services. As in this research, the factors cover various dimensions of the problem (economic,

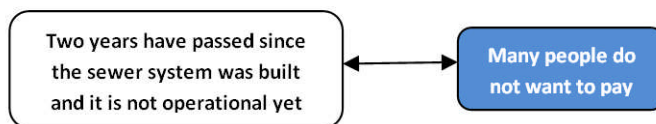26 technical, legal, social) at different scales (country, region, community).

27 A conceptual map generically consists of a collection of concepts interrelated by links (usually causal). In

28 this research, a map was created for each case study, made of concept-boxes related by positive or

29 negative causal relationships. The concepts, which describe the factors deemed most significant in

sanitation development, emerged from the review of the node summaries. For instance, in San Luis Beltran case study, the node summary at community level includes the statement:

'Two years have passed since the sewer system was built and it is not operational yet. *As a result,* many community members do not want to pay until the sewer is operational. Unwillingness to pay *hinders* the sewer system defects from being fixed.'

On the map, it translates into two concept-boxes and, in this case, a bi-directional causal link (positive feedback loop) (see Figure 3).

Figure 3. Two concept-boxes connected in a positive feedback loop.

The selection of the concepts was constrained by two imperatives:

• Revealing the complexity and the multidimensional nature of the issue without overloading the map, a typical tradeoff in the development of conceptual maps (Batterman et al. 2009; Burgess *et al.* 1992);

• Highlighting the uniqueness of each case study without neglecting macro factors (influences at national and regional scale).

Certain features were used to aid understanding and recall of map content: macro factors were placed on the edges of the maps when possible, and key concept-boxes (called 'nodal-factors') at the centre. To facilitate reading, criss-crossing between concept-links was minimized using the software *Decision Explorer* (Banxia 2000). Also, a colour code differentiates concept-boxes (factors) according to the disciplines typically used to address them (i.e. grey for political factors, yellow for social factors, blue for economic factors, red for cultural factors, white for nodal-factors...).

2.4. Research validity and reflexivity

2.4.1. Validity criteria

The question of the validity of qualitative research has given rise to many different interpretations and generated much debate. The researcher is considered as part of the experiment and his influence on the outcome of the work cannot be eliminated (Neuman 1997). The quest for absolute objectivity is thus futile. Yet, qualitative research still needs to demonstrate a scientific validity, which can be done by complying with some of the key validity criteria synthesised by Whittemore et al. (2001):

• Primary criteria: *integrity, authenticity, credibility* and *criticality*

• Secondary criteria: *explicitness, thoroughness, creativity, vividness, congruence*

Credibility refers to the conscious effort to establish confidence in an accurate interpretation of the meaning of the data (Whittemore et al. 2001). In this respect, transparency was sought throughout the research process, making available all the gathered data, the raw interview transcripts, as well as the details of coding. *Authenticity* relates to the capacity of a research to reflect the meanings and experiences that are lived and perceived by participants. Triangulation and the pursuit of interviews on a given topic until the 'point of theoretical saturation' (Glaser and Strauss 1967) were means to meet this criterion. The log sections of every interview transcript, which compile information on the context of the interview (date & time, setting, general feeling, personal comments, awareness of and suspension of personal assumptions) and specify the bit(s) of the interview deliberately left out, contribute to satisfy the *integrity* criterion. *Criticality* was addressed through a reflexive assessment of the work, which is examined in the following section. The research design, process and methodological decisions were made very *explicit*, conferring auditability to the work and much *vividness* was provided by detailed and faithful descriptions. *Congruence* between the study aim, the approach and the results was also established.

2.4.1. A reflexive approach

According to Marshall (1990), reflexivity and critical analysis of all aspects of the investigation add to the validity of qualitative research. Willig (2001) makes a distinction between personal and epistemological reflexivity. Personal reflexivity questions how 'our own values, experiences, interests, beliefs, political commitments, wider aims in life and social identities have shaped the research [...] [and] how the research may have affected and possibly changed us, as people and as researchers' (Willig 2001). 'Epistemological reflexivity' is about examining the implications of the research question and the methods used on the outcome of the research. The research transformed the understanding of sanitation development of the main author, which quickly shifted from a 'traditional' towards a 'reflexive' engineer's perspective,

whereby social and cultural issues became as important as the technical and economic concerns, ultimately providing an insight into the social construction of reality. The research project originally focused on technological, environmental and economic dimensions mainly. Social and cultural dimensions had been barely considered. The confrontation with the field reality quickly led to correct this oversight. Shadow socio-cultural, institutional or political factors, which generally receive too little attention from engineers, appeared to play a significant role in the rather frequent failures of sanitation systems in Mexico. The urge to know more about *all* the factors which influence sanitation development and how they interact is what motivated this research.

This early shift in the framing of the problem shaped the methodology. The social and cultural dimensions being recognised as part of the problem, qualitative methods of research became most relevant. Literature review in the fields of qualitative research, contemporary sociology and cultural studies had an interpretive influence on the research. Epistemological reflexivity went as far as examining basic assumptions behind this research, such as the meaning attached to sanitation development. Opinions vary. Foucauldians and neo-Marxist perspectives challenging the conventional view were examined. In this research sanitation was regarded as a decisive factor of progress, representing one of the fundamental steps of the ladder of development. Arguably, open-air defecation does not necessarily represent a hindrance in societies that form small communities scattered in a natural setting. However it increasingly poses health, security and environmental issues as data clearly suggest in the case of Mexico.

3. Results

3.1. Case study conceptual maps

For each case study, the graphical outputs are: an *overall map,* several *sub-maps* and *connection-groups.* The *overall map* (see Figure 4, Figure 5 and Figure 6) is a large and dense graphical representation counting up to 70 concept-boxes, which reveals the complexity of the sanitation issue and the interconnectedness of the factors affecting it. Sub-maps and connection-groups are provided to facilitate the exploration of the different regions of the map. The *sub-maps* are sectors of the overall map comprising around 15 concepts (Figure 7). Their slight overlap ensures no information is lost in this close-up process. *Connection-groups* are small sets of 2 to 5 concepts (see Figure 8). Thorough explanations, substantiated by vivid field data (interview quotes, literature review, pictures etc.)

1 accompany them. In this paper the authors present critical findings drawn from the analysis of the overall

2 maps. These results, which consist in general patterns, are described and illustrated with examples from

3 case-studies.

4 Figure 4: Overall map - El Mirador's Primary School case study

5 Figure 5: Overall map – San Luis Beltran case study

6 Figure 6: Overall map – Tepezalá case study

7 Figure 7: Sub-map 1- El Mirador's primary school

8 Figure 8: Connection groups

9 **3.2. General patterns**

10 The overall maps depict the uniqueness of each case-study, reflecting the diversity of the local conditions

11 met across case studies. However, common patterns were also found, which were examined and

12 compared with the existing literature to establish whether generalizations could be drawn. For practical

13 reasons, these patterns were arranged in four themes: cultural, political, demographic and economical

14 patterns.

15 *3.2.1. 'Cultural' patterns: corruption, duplicity, resignation...*

16 Bribery, corruption, and machismo were identified as significant influences on the development of

17 sanitation in each and every case study. Whether occurring in the higher spheres of government or at local

18 level, fraud was found to affect the sustainable development of sanitary conditions. As The Water

19 Integrity Network (WIN) demonstrated, corruption is widespread in the watsan sector. It affects all

20 countries, both private and public services, and concerns policy design, budget allocation, contract

21 awarding, billing systems, water connection fees (WIN 2010). Massive corruption is often cited as a

22 major cause of Mexico´s catastrophic wastewater treatment experience (Dasso 2008). Although its

23 intensity may be far greater on large-scale project involving centralised sanitation infrastructure, the

24 research also revealed the presence of corruption in projects involving decentralised systems. In San Luis

25 Beltran case study, the reputation of the state sanitation program supporting the construction of ecological

26 toilets in rural areas was stained by massive government frauds. The bribery that granted exclusivity of

27 the ecological toilet seats contract to a single firm of Mexico City ruined the community workshop.

28 Small-scale community projects are not immune to corruption either. Despite its lesser intensity in these

contexts, its effects are nonetheless economically and emotionally equally devastating for the population. In El Mirador, for instance, recurrent frauds in the parents' committee largely contributed to bring sanitation development to a standstill. Additionally, at community level, the groundwater supply project was jeopardised by the fraud involving one member of the community council and the borehole drilling company.

Duplicitous attitudes of officials from local, municipal and state governments were also a major hurdle to the development of sanitation projects. Likewise, the understandable passivity and resignation of people witnessing dishonest deeds or enduring harsh conditions of life, as well as a general atmosphere of mistrust in the three communities investigated affected sanitation development. Research on these cultural features revealed them as characteristic of Mexico (Paz 1985; Schneider and Silverman 1997; Oppenheimer 1996). It also indicated that they can hardly be examined as separate aspects because they stem from a common set of symbolic representations, a cultural heritage deeply ingrained in the minds of the Mexican people. These factors are likely to be present and affecting sanitation development, to varying degrees, in most parts of the country.

3.2.2. Economic patterns

The general state of poverty of people in Tepezalá, El Mirador, and San Luis Beltran certainly impedes to some degree their capacity to improve their sanitary conditions. It partly explains why many dwellers use inadequate pit-latrines or defecate in the open-air. However, excessive generalisations of the economic features common to the case studies would be misleading. Economic activity and poverty are heterogeneous throughout Mexico. The three case studies are in no way representative of the country situation: El Mirador and San Luis Beltran are located in the state of Oaxaca, one of the poorest regions of Mexico, where development is highly dependent on federal funds. In 2008, a long awaited wastewater treatment plant was inaugurated in Oaxaca. It has a capacity to treat all the effluent of Oaxaca City and the 12 surrounding municipalities, which comprise the small communities of El Mirador and San Luis Beltran. Lack of state and municipal financial resources was clearly one of the main reasons delaying the construction of this much-needed treatment plant. The increased economic support of the federal government made it possible. Notably, as part of the National Fund of Wastewater Treatment, the government actually subsidies the operation of the wastewater plant at up to 0.50$MN per cubic meter, which in the case of Oaxaca represents 83% of the operation cost (Presidencia de la Republica 2008). As for Tepezalá, its decrepitude and low capacity for investment (cf. section 3.2.4) starkly contrasts with the

relative wealth of Aguascalientes State. It remains that the impact of NAFTA (North American Free Trade Agreements) on the agricultural sector and the low fiscal capacity of the municipalities are features that can be observed consistently in rural and peri-urban zones countrywide, and which can affect sanitation development to some degree.

3.2.3. Political patterns: lack of continuity, paternalism, decentralisation...

Research on the 'political' patterns common to all case studies showed that short-term planning and lack of political continuity are predominant features in Mexico (Cabrero Mendoza 1998; Carrera-Hernandez 1998). As far as sanitation development is concerned, this generally leads to a lack of coherent long-term strategy. For example, in San Luis Beltran as in the whole state of Oaxaca, the 1990s were marked by the relatively successful introduction of ecological toilets in rural areas, a low-cost approach well adapted to the irregular relief and the dispersion of the population. But at the turn of the Millennium, the newly elected state authorities reverted to promoting the construction of sewer systems. Political imperatives draw their priorities. In Mexico, the periods of office of municipal and state governments respectively last 3 and 6 years. They are not renewable and as a consequence, each new mayor or governor wants to make history and credit his or her party with significant deeds. The completion of large and tangible infrastructures such as roads, sidewalks and sewers provide better opportunities than dispersed ecological toilets for public celebrations of high political benefit. In Tepezalá, until very recently this political logic contributed to the relative disinterest of the municipal government in the much needed maintenance of the sewer collector and the oxidation pond, which are located way out of sight from the public. In San Luis Beltran, short term thinking resulted in the lack of assessment of the impacts of the sewer system on water consumption and ultimately on water availability.

Poor law enforcement also turns out to be a widespread manifestation of the weakness of the Mexican institutions (Schneider and Silverman 1997; Oppenheimer 1996). The no-payment culture is one of its expressions in the watsan sector. Although not a major issue in the three case studies, it represents a significant block to sanitation development at national scale. CONAGUA's director Luege Tamargo indicates that half of Mexico City users do not pay for the water supply service (Business News Americas 2009). While the megalopolis expects the construction of the world biggest wastewater treatment plant (which will treat 60% of the total effluent vs. only 6% currently) it remains uncertain how its operation will be financed. In the current no-payment context, massive subsidies are likely and this band-aid solution would reduce budget allocation for other sanitation projects.

1 Throughout all case studies, state paternalism was found to dampen people's initiative to improve their

2 sanitary conditions. In Tepezalá, for instance, a marginalized part of the community has passively been

3 awaiting the construction of the sewer system. Despite years of waiting, they can hardly conceive of

4 improving their sanitary conditions by themselves and hold on to thinking, as they have been used to, that

5 the government will eventually solve it all. In San Luis Beltran, many people voted for the sewer project

6 because it was supposed to be free of charge, paid by the public authorities. Expecting the government to

7 solve their problems and somewhat lured by this manna, the community members adopted the sewer

8 project, just as they had bought in the ecological toilet program (sometimes diverting the offered

9 construction material for other purposes). In the case of the sewer system, the community failed to

10 examine its possible drawbacks in terms of water availability and future wastewater treatment costs.

11 Although opinions differ on whether it is the product of the PRI (Institutional Revolutionary Party)

12 regime (Adler 2001) or a more deeply rooted cultural trait (Cabrero Mendoza 1998), state paternalism is

13 viewed as a national political feature. Other significant political features affecting sanitation development

14 all over Mexico include the recent decentralisation. It involves transfers of new functions to state and

15 municipal governments, which generally lack the financial, human and technical capacities to handle

16 them, is a process which affects all the country (Nickson 1995; Rodriguez 1997; Carrera-Hernandez

17 1998). Mexican state and municipal governments generally lack the skills required to meet the challenges

18 of the watsan sector they are now in charge of.

19 Finally, a particular institutional issue, the legal fuzziness accompanying the ejido (communal owned

20 land) was found to hamper sanitation development in three case studies. In El Mirador, for instance, an

21 unclear bi-polar jurisdictional status has sustained much division within the community, contributing to a

22 disinterest of the population in Morelos primary school. The complex organisation of the ejido, usually

23 overlapping municipal jurisdictions, often leads to fuzzy legal situations that make the management of

24 water and sanitation issues more complicated.

25 *3.2.4. Demographic patterns: urbanisation stress social and cultural structures*

26 In all three case studies urbanisation was found to influence sanitation development, although each

27 community experienced the phenomenon from a different perspective. In Tepezalá, rural exodus resulted

28 in the decline of the population and local economic activity, which directly impacted the municipal

29 budget as well as the capacity of investment in sanitation. In El Mirador as in the surrounding

30 communities that mushroomed around Oaxaca City during the 1990s, the watsan infrastructure is very

precarious but the municipal and state authorities are powerless to meet the needs of a population that grew at a rate as fast as 12 percent annually. To the people of San Luis Beltran, the expansion of the urban zone means that Oaxaca City is now on their very door step. With increasing population density, per capita water availability diminishes, and open-air defecation becomes less practicable and more troublesome for the neighbourhood, like the nuisances caused by inadequate or ill-operated on-site sanitation system. From a public interest perspective, in this context, the sewer system may be a sensible option. The younger generations, eager to embrace a modern way of life, are favourable to that option. Older people cautiously examine the recurrent invitations of the authorities to offer them the sewer, then the paved road, as they associate a loss of identity and power with this gradual integration in the urban municipality. This phenomenon occurs all over the world: values and behaviours of rural people are challenged as soon as they live in or approach urban areas. Confrontation with the modern world typically reinforces individualism and weakens traditional cultural and social structures.

4. Evaluation

4.1. New insights into Mexican rural and peri-urban sanitation development

4.1.1. Looking at the 'big picture'

The list of patterns described in the previous section reveals the multiplicity of perspectives used to examine sanitation development in rural and peri-urban Mexico. Each perspective provides an interesting yet fragmented glimpse into the complexity of the problem, and the main benefit of the conceptual maps is certainly to allow one to look at the 'big picture' and to easily relate realities traditionally addressed by separate disciplines. As each overall map reveals the complexity of the problem, the coloured concept-boxes effectively signal its multidimensional nature. Their network arrangement shows the interconnectedness of the factors influencing sanitation development and promotes interdisciplinarity. The labels on concept-boxes are concise, free of expert jargon and other theoretical considerations which often nurture the reluctance to shift perspectives. Taking Morelos primary school overall map for example, its mosaic-like outlook shows much interplay among social, cultural, political, economic and technical factors. Readers will typically focus on the central white concept-boxes first and perceive the key significance of community support, community watsan infrastructure and school facilities on the development of school sanitary conditions. Looking at the mass of yellow concept-boxes on the bottom-

left, they will perceive some of the influence of the social context (community division, teachers' low commitment to hygiene promotion, the eroding motivation of parents...) on the problem. Inevitably, the nearby presence of red, grey, blue and green boxes will also attract attention on the influence of other dimensions of the problem. The reader will gain understanding in the often indirect effects of political and cultural factors (e.g. the cultural heterogeneity of the community, corruption), and in more direct and key technical aspects of the problem (the insufficient capacity of the existing infrastructures, its poor maintenance, the lack of toilet paper, soap and water for hand-washing, the inappropriate design of the new toilets...). Not only do the maps favor an interdisciplinary understanding of the problem. They also offer an insight into the interplay between macro and micro factors, the latter being particularly significant in rural and peri-urban contexts. In the case of Tepezalá (cf. Figure 7), the map stresses the key influence of local factors – biophysical (rocky ground), social (low dwelling density, lack of leadership), cultural (resignation) and economic (municipality poverty) – in the failure to extend the sewer network to the most marginalized part of the village. At the same time, the map indicates how this unique local context is affected by macro political (paternalism, short-term planning, poor law enforcement) and macro cultural factors (duplicity, resignation).

As explained in section 2.1.2., in Mexico, sanitation development tends to be perceived essentially from a technologist point of view and a major challenge of the sector consists in developing skills in domains other than purely engineering and to encourage genuine interdisciplinary approaches. The holistic insight that the conceptual maps provide in rural and peri-urban Mexico is thus particularly useful and timely. It stresses the importance of institutional and community participation issues, which major donor agencies have requested the Mexican sector to consider (IDB 2010), and sheds light on the pervasive influence of the cultural context. This context comprises the traditionally addressed local elements (e.g. the set(s) of values within a community or an ethnic group, its preference for certain sanitation options...) as well as national cultural patterns. To provide a quick and easy insight into the relationships between institutional and social issues, cultural factors, and the concrete techno-economic aspects of sanitation development is most valuable in the context of the 'Victorian' Mexican water sector.
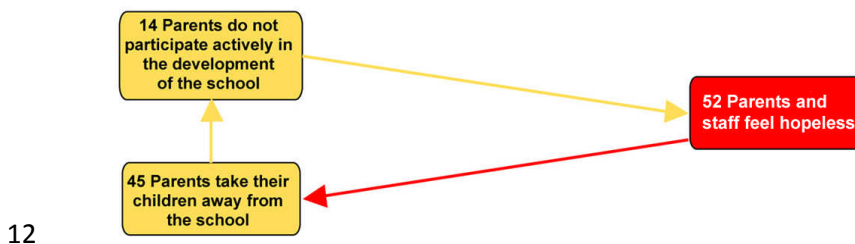
4.1.2. Promoting breadth and depth of understanding

The overall maps provide a holistic view of the system and favour breadth of understanding. Yet, particularly with complex subjects, visualization tools, such as these maps, must be augmented with textual information to help users fully exploit their meaning (Tergan and Keller 2005). In this research,

1 the combined use of (i) the maps, (ii) the pictures and descriptions accompanying all connection groups,

2 and (iii) the analysis on common patterns, provides depth of insight into the components of the system

3 and their interactions. This effort towards describing in such depth and breadth the problem of sanitation

4 development in rural and peri-urban Mexico is an original and meaningful contribution to a more realistic

5 and comprehensive assessment of this critical issue.

6 **4.2. Practical applications**

7 Exploring the maps back and forth from the global to the detail is probably the most strategic way of

8 using them. Effective strategies will target sectors of the map, which offer the most favorable terrain for

9 change. They may choose to boost or disrupt existing dynamics at local level, detectable on the maps as

10 cycles or feed-back loops (see Figure 9).

11 Figure 9: Positive feed-back loop – Morelos Primary School

12

13 In Morelos Primary school, the unsupportive regional socio-economic context (c.f. sections 3.2.2. and

14 3.2.4.) urges to seek a solution where the school addresses its sanitation development in a self-reliant

15 manner. It may be counterproductive to try to solve the political division in the community. It may also be

16 a waste of time to keep soliciting politicians for the sewer system and piped water. Collecting more funds

17 to build appropriate infrastructures will not magically solve the problems of lack of maintenance and of

18 hygiene promotion either. An attentive examination of the sub-maps and the descriptive elements

19 accompanying them may suggest instead the empowerment of the school's actors as a strategic priority

20 and recommend restoring motivation, building a common vision and commitment in the parents and in

21 their committee. Helping them organizing themselves, introducing rules to prevent frauds to recur,

22 providing to the committee and the school staff a basic technical training on sanitation solutions and

23 O&M requirements would represent worthwhile activities. In all cases, effective actions will require an

24 accurate understanding of micro and macro realities. Overall maps are best used as holistic frames of

25 reference, from which micro and macro realities, as well as their relationships, can be explored through

linear, textual and photographical material. They provide a chance to focus on specific aspects of the problem without losing sight of how they fit with the whole.

Promising trends in the watsan sector include Community Led Total Sanitation (Kar 2003) and Sanitation Marketing approaches, described by the London School of Hygiene and Tropical Medicine (LSHTM) as 'the ultimate people centred approach [which] replaces the failed supply driven approach with a more sustainable holistic demand driven one [and] provides a framework in which innovation and creativity can thrive' (LSHTM 2009a). These trends share an important characteristic: while they tend to focus on one or several crucial aspect of the problem, such as technology uptake (e.g. improved latrine) or behaviour change (hand-washing) their strategy results from a complex, holistic understanding, which considers a variety of techno-economic parameters, socio-cultural factors and other psychological mechanisms underlying the willingness to acquire a new technology or adopt a new behaviour. LSHTM stresses that the implementation of such models requires a deep knowledge of the system, gained by using an interdisciplinary team of specialists (for large programmes), or by undertaking series of in-depth discussions (for small projects) (LSHTM 2009b). The holistic approach presented in this paper may be a very relevant tool in these contexts.

4.3. Needs for improvements

The conceptual maps developed in this research suffer several limitations, which represent as many opportunities for improvement. First of all, concept-boxes are probably too numerous particularly when considering the lack of significant perceptual patterns structuring the space, such as clusters, vertical or horizontal structures. As a result, firsthand reading is often uneasy and the use of sub-maps only partly settles this problem. Additionally, in the absence of an order of magnitude assigned to each factor, the maps lack relief. Hints are missing for the reader to spot the zones of particular importance. In this respect, the often pervasive influences of macro-factors (e.g. corruption, machismo, lack of political continuity, urbanization, and paternalism) require more consideration than what their limited graphical impact on the maps suggests. Thicker lines could be drawn between important concepts (Radzicki and Taylor 1997). Ranking factors is a complicated and excessively reductionist solution (i.e. grading on the same scale factors addressing different dimensions) subject too much bias. Besides, the magnitude of a factor might not necessarily determine its strategic relevance. Very significant systemic factors such as poverty and corruption may be overly difficult to address in a local sanitation development project. They may not be actually 'killer issues', and strategies summoning local human resources may allow them to

be overcome. At the opposite, seemingly secondary factors, such as gender issues (e.g. machismo) and community leadership, may prove very strategic targets. The map can then serve as a common basis for an interdisciplinary team of practitioners. Its strategic worth is associated with the in-depth study of all its components. It depends on the experience and capacity to interact of its users, who will be able to add relief to the map and identify opportunity areas.

The maps amalgamate factors addressing very distinct realities. For instance, some concept-boxes describe the influence of inter-subjective realities (e.g. 'mistrust prevails in the community'), while others describe tangible physical realities (e.g. 'there is no piped water supply at school'), social structures, people's individual or collective behaviours (e.g. 'the head of the parents' committee did not finish building the cistern toilets', 'Parents have stopped paying for the daily maintenance of the latrines'). A better structuring of these diverse dimensions would certainly improve the comprehensibility of such complex systems. Lack of clear demarcations between spatial scales is another limitation: factors addressing local, regional and national phenomena are all mixed. The preferential arrangement of macro level factors at the periphery of the map is an insufficient hint. In an increasingly global world, more discernment on this spatial dimension is required. Scale is actually regarded as a critical dimension in the HCES (Household Centred Environmental Sanitation) approach, which insists that problem need to be solved as near to the point where they occur as possible. HCES thus establishes a series of zones within an area: the household, the neighborhood, the community, a city ward, the city itself, and ultimately the wider environment, such as a river basin (EWAG 2005). This zoning principle may be integrated in the maps. Another observation can be made regarding the consideration of macro factors: in addition to examining the influence of these macro demographic, economic, political and cultural patterns on local dynamics, as undertaken in this research, there is a need to assess how the community relates to the existing federal, state and municipal programs for sanitation development. Although the research process did not systematically open avenues of inquiry in this direction, understanding the details of Mexican programs, such as PROSANEAR (Federal program for wastewater sanitation) and PROSSAPYS (Program for the construction and rehabilitation of drinking water supply systems and sanitation in rural zones), and particularly the factors governing the eligibility of a municipality and a community, must be part of a strategic assessment.

5. Conclusion

The holistic approach presented in this paper fosters an interdisciplinary understanding of rural and peri-urban sanitation development. Its implementation in Mexico demonstrated its effectiveness in achieving a comprehensive assessment of the problem locally while at the same time establishing the key influence of macro political, economical, cultural, and demographic factors. The conceptual maps successfully highlight the interconnectedness of all micro and macro factors affecting sanitation development. They represent useful frames of reference, which allow the in-depth exploration of the different aspects of the system through more analytical means, without losing sight of how they fit within the big picture. These maps provide to a large audience the opportunity to quickly seize how objective structures (e.g. biophysical, social) and less tangible cultural realities influence sanitation development. These didactic tools are appropriate for training activities promoting integrated watsan development. Notably, considering the current transition in the sector from a fundamentally 'technologist' perspective of the problem to a more complex understanding of it, the approach presented in this paper can be helpful for watsan engineers, who have sometimes been criticised for showing resistance to embracing the concept of a multidisciplinary approach (Schouten and Moriarty 2003, Boss, 2001). It can be productively used by the interdisciplinary teams increasingly deployed in watsan development programs to undertake comprehensive assessments, and particularly in programs built upon integrated strategies such as Community Led Total Sanitation or Sanitation Marketing. Avenues for improvement include situating each community in the context of the federal, state and municipal programs for sanitation development. The means of representation can be improved. Structuring the visual space around two key variables: scale (dwelling, community, district, state, country, global levels) and 'factor dimension' (objective: biophysical, behavioural, social; subjective and inter-subjective/cultural) seems very relevant.

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