Globelics

Global Systems of Innovation: Water Supply and Sanitation in Developing Countries

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Innovation is a process of problem solving. In its broadest sense, innovation means doing things in new ways. When conditions change and routines no longer work, humans experiment and learn. In a narrower sense, innovation means developing new ideas into new products or processes. Whether the process happens in the public domain or in the market, the sign of successful innovation is something new being used widely to solve a problem.

Many problems that face humanity today take on global dimensions, and their solutions are likely to involve cooperation as well as competition across national boundaries. Global climate change is the clearest example: human activity has set changes into motion that affect people in various parts of the world in ways that they did not choose but have to work together to address. Disease is another example, in which growing networks of transportation are spreading pathogens faster and wider than ever. No one country can protect its health without joint information gathering and international public health efforts.

To address global challenges, humanity needs to be able to solve problems at global scale. In our research, we aim to deepen understanding of one form of global problem-solving, namely, global systems of innovation. A global system of innovation (GSI) is a learning space (Arocena and Sutz 2000) in which a multi-level network of diverse actors interacts to address a world-level challenge, accumulating knowledge across national borders and developing, testing, and adopting new approaches.

This paper helps to develop the GSI concept using information on responses to global challenges in the household water supply and sanitation sector (WSS).[3] In this research, we use a broad concept of innovation that encompasses both new technologies and new approaches, such as community-demand driven systems and privatization.[4] The

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[4] In this, we follow roughly the distinction made in the review of the state of the art done for the Gates Foundation in X year. See http://www.aguaconsult.co.uk/pdf/Main_Report_FINAL_Apr2007.pdf; http://www.aguaconsult.co.uk/pdf/Approaches_Landscape_Apr_2007.pdf;

paper reports preliminary observations based on interviews with nearly100 people who work in organizations in the sector, at global, national, and local levels, including intensive interviews in Costa Rica, Mozambique, and South Africa. In addition, we have analyzed the published literature in this area and consulted an extensive set of documentary sources.

The first section of the paper introduces the concept of a global system of innovation. The second section describes how preliminary data from the WSS sector match or modify the GSI concept. The final section raises further research questions and points to possible policy implications.

1 Varieties of Innovation Systems

1.1 Systems of Innovation: National, Regional, Sectoral

The concept of national innovation systems is attributed to (Freeman 1987), (Nelson 1993), and (Lundvall 1992). All three scholars work in the tradition of evolutionary economics (Nelson and Winter 1982), where technological change is seen as a process in which entrepreneurs and inventors generate a variety of new technologies but only some of those variants survive the selective pressures of market and non-market conditions. The process is strongly path-dependent – success of a technological variant at one point in time sets the conditions for the survival of later variants. The idea of national innovation systems helps to systematize this perspective by providing tools to describe the complex organizational ecology in which technological change happens.

The three basic elements of a national innovation system are firms, research organizations, and rules of the game. Innovating ***firms*** are at the center of the picture. They have a stake in introducing new technologies to gain competitive advantage in the market and are therefore the driving force in the system. Firms maintain competitive advantage through ***learning and capacity building***, processes that are much broader than the traditional notions of invention or R&D (research and development). ***Research organizations*** (primarily universities or government laboratories) can help in this process of learning and capacity building, so they play a support role in an NSI. "Absorptive capacity" (Cohen and Levinthal 1990) or the ability of the system to use new information generated elsewhere, can benefit significantly from the efforts of research institutions. Finally, ***"institutions" or rules of the game***, in North's sense of the term (North 1990), are also important in the environment. They can make it easy or hard for entrepreneurs to start new firms and for new technological variants to be introduced, tested, and adopted. ***Interaction*** among three sets of actors – firms, research organizations, and government – is the fundamental process that helps firms generate new ideas and new technological variants and thus enables the system as a whole to build capacity and learn.

These concepts have provided a framework for a wide range of comparative studies of national systems of innovation (for example see chapters in (Freeman and Lundvall 1988); (Nelson 1993); (Muchie, Gammeltoft et al. 2003); (Cassiolato, Lastres et al. 2003); (Lundvall, Intarakumnerd et al. 2006). In addition, they are being taken up

http://www.aguaconsult.co.uk/pdf/Technologies_Landscape_FINAL_Apr2007.pdf; accessed August 3, 2008.

broadly in the practical world of science and technology policy, where the phrase system of innovation is developing its own set of diverse variants. For example, in developing countries, where firms are often less active in driving innovation, policymakers may use the term to refer primarily to interaction among government agencies, universities, and public laboratories. Some of the innovation systems literature has been specifically directed to the problem of so-called "catching up" – using new technological opportunities to create economic growth in less affluent countries (Fagerberg and Verspagen 2007), including spreading the benefits of growth widely (Sutz 2003).

Two other levels of the innovation system concept, both sub-national, have taken their place beside national systems in the literature. Philip Cooke has applied the concept to regional (sub-national) development (Cooke, Uranga et al. 1997). A regional system of innovation (RSI), like the national variant, has firms at the center and includes research organizations and government. The defining characteristic of a regional system is its geographic concentration, allowing more face-to-face interaction than in the frequently more disperse national system. Since much technological knowledge is believed to be communicated tacitly, face-to-face interaction can be an advantage, and the agglomeration of firms that need each other's skills in a particular place is posited to improve the chances of innovation happening there. Regional authorities can create both incentives for interaction and rules of the game that are favorable to firm success, and thus attract industry into the region, providing jobs and creating demand for services. Much research has examined this process (for example, (Fritsch and Franke 2004), (Asheim and Coenen 2005), (Holbrook and Clayman 2006)).

The second major offshoot is the sectoral system of innovation (SSI). Pavitt (Pavitt 1984) laid the groundwork for the concept, and Malerba and his co-authors have more recently developed it using a later generation of system of innovation concepts (Malerba 2002, 2004). A sectoral system of innovation brings together the three organizational elements in relation to a product or product group. The concept differs from the traditional one of an industry sector in the theoretical development of the concepts of interaction and learning. Although the concept is relatively recent, scholars have used it to examine a number of sectors from high-tech to traditional (for example, (Lau 2002), (Wengel and Shapira 2004), (Mu and Lee 2005), (Sumberg 2005), (Sundbo, Orfila-Sintes et al. 2007). Malerba is currently leading an effort at cross-national comparative studies in five sectors: agricultural supply and processing, automobile production, pharmaceuticals, telecommunications, software, microelectronics.[5]

1.2 Global Systems of Innovation in Theory

Our research is developing an additional SI level: global systems of innovations (GSI). A global system of innovation is a learning space (Arocena and Sutz 2000) in which a multi-level network of diverse actors interacts to address a world-level challenge, accumulating knowledge across national borders and developing, testing, and adopting new approaches.

The concept grows from our research on the global challenge of providing clean water and basic sanitation to all the world's households, reflected in the Millennium

[5] http://www.merit.unu.edu/research/projects_view.php?id=182.

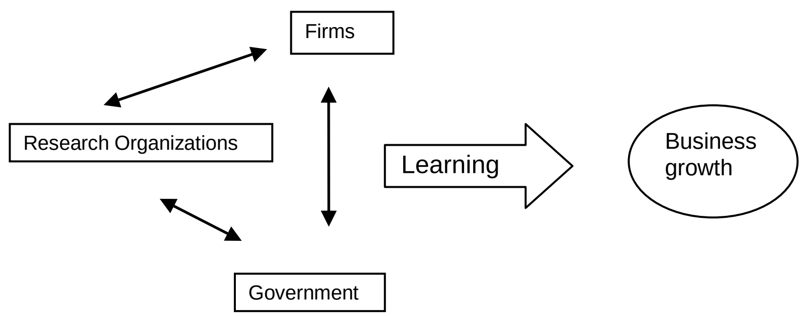
Development goals.[6] Our research was originally designed to explore whether the international research effort in this area served as a global redistributive mechanism, helping both to solve the immediate practical problem of household water and sanitation and to build local capacity for further problem solving. Because water supply and sanitation are generally referred to as a sector (the WSS or Watsan sector), we tried to use the sectoral system of innovation concept to understand the dynamics of this area (Cozzens and Catalán 2007), but found several mismatches between that concept and the network of action we were observing. For example, the public sector not the private sector was in the lead; the effort was organized around a public health goal rather than economic growth or business success; and there were a number of important actors that seldom appeared in innovation system accounts, most prominently non-governmental organizations (NGOs). We began to use the phrase "public sector innovation system" to expand the system of innovation concept to non-commercial goals and actors. Indeed, we want to carry this more inclusive concept along into our definition of a GSI.

Equally importantly, however, the learning process we observed in WSS was clearly taking place across national boundaries, in an interactive network that did not derive from national action but had its own dynamic. Neither national governments nor multinational firms were the dominant actors, although they were present. Rather, a coalition of organizations with global missions was central to the process of problem definition, experimentation, learning, and problem solving. They were the major carriers of information up and down the levels of the sector, from local to global and back, and sometimes even across locations within countries. In short, we realized that while we were certainly observing an innovation system in WSS, it was not a set of NSIs, RSIs, or SSIs stapled together at international level. It was a different kind of SI entirely. We named it a global innovation system (GSI).

Before turning back to the realities of the GSI in WSS, let us pause to articulate the two extensions of the SI concept involved and thus establish the theoretical model that we can further modify, elaborate, or expand based on the details of cases like WSS. As we have seen, the core sets of actors in a system of innovation are firms, research organizations, and government agencies. Interaction among them creates a network, and the SI tradition posits that interaction in that network leads to learning in the form of generating, testing, and adopting new products or processes. A simple diagram might depict these relationships as follows.

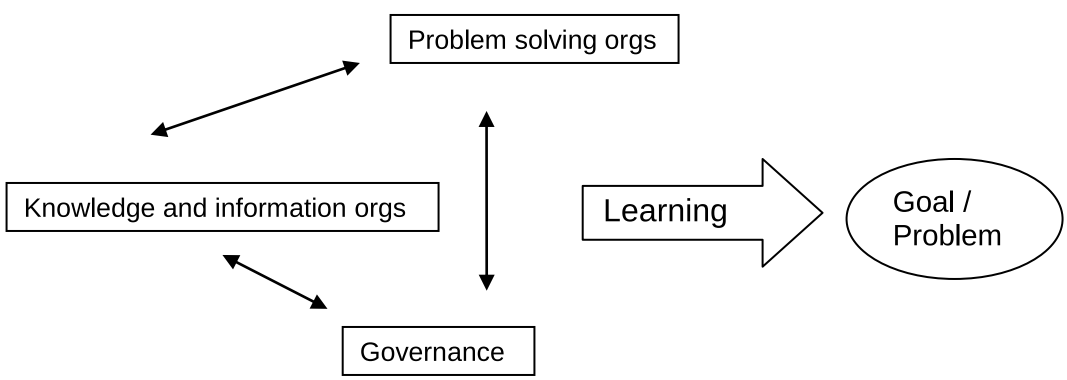
[6] http://www.unmillenniumproject.org/goals/gti.htm#goal7. See Target 10.

Figure One: A Standard System of Innovation



Although the goal of a standard innovation system is implicitly economic growth or business success, in creating a more general SI version, we want to include the possibility of non-commercial goals. We also, then, want to allow for other organizations to be in the lead in creating movement towards that goal. We will use the phrase problem-solving organizations (PSOs) to indicate this more general category, which will point to firms in some systems, but in other instances might point to utilities, health services, etc. Following this generalizing logic, the GSI concept refers more generically to knowledge and information organizations (KIOs), rather than research organizations, to include different kinds of knowledge accumulation, for example in networks of practitioners. It also incorporates governance rather than government to include a broader range of deliberative processes including voluntary consensus formation among non-governmental groups. As in the standard model, the various organizations interact to achieve the goal, and their interaction produces learning.

Figure Two. A more generalized innovation system



We will call such a system global if the actors share, to some degree, a world-level goal. One kind of global innovation system might be a scaled-up version of the sectoral innovation systems that have already been studied; in this case, the goal would be commercial, namely, the global expansion of the business.[7] However, we have now

[7] Jennifer Spencer has used the term global system of innovation in this sense. See Spencer 2000, 2003.

made the model general enough that we can also analyze networks of interaction with non-commercial goals at regional, national, or global levels – for example, in the water supply and sanitation case, the Millennium Development goals.

The diagram is simple, but it provides a tool for gathering information to characterize differences among systems of interaction. We can expect variation in each box, among types of organizations and with regard to their levels of operations, from local to global. There should be variation on each double arrow, from low to high interaction; and the levels of interaction may also be different at local, national, or global level, and the interactions can be competitive or cooperative. There is variation in the oval, for example, with regard to level of consensus and clarity among the actors on goals. Any of these factors might be used to account for variations in learning, that is, the pace at which variants (new approaches) are generated and tested and the breadth and speed at which successful approaches are adopted.

Using the expected variation, we can formulate some initial hypotheses to begin the analysis. All other things being equal:

H1: The more interaction, the greater the learning. (This is the central hypothesis of innovation systems theory.)

H2: More heterogeneous sets of problem-solving organizations (PSOs) will produce more variants for testing.

H3: Intersecting but not identical goals will produce more variants than unified goals unless the interaction patterns become segmented by goal.

H4: More new approaches will be generated and tested when global-level interaction is high than when it is medium, low, or absent.

H6: The higher the level of global interaction, the more quickly and widely PSOs will adopt successful new approaches.

The hypothesized relationships among global problems, global solutions, and global innovation systems should now be visible. Global systems of innovation can, in theory, facilitate the process of generating and testing possible solutions to global problems and help spread and apply information about successful ones.

2 Water Supply and Sanitation

In this section, we present descriptive information on the elements of the model for water and sanitation, introducing new hypotheses as we go based on the experience of this sector and, in the last section, modifying the model itself.

2.1 Problem Solving Organizations (PSOs)

Standard innovation systems models have it easy: they can focus on firms as the center of the model. GSIs have a harder time, because the organizations that tackle global problems outside the market are often more diverse. This is the case in WSS. But the firms of a standard system and the PSOs of a global system have one thing in common: they are the organizations that try out new options in technologies or approaches. As with a standard system, they are at the center of the innovation process.

Responsibility for water supply and sanitation is almost universally shouldered by local governments. These units have different names in different countries (e.g., municipal, district, county) but share a position two levels down the political hierarchy from the national government, just below states or provinces. The locality may deliver just water or water and sanitation service. They may do those things themselves, through a water and sewer department, or through one or more outside contractors. Installation of the system is often, but not always, contracted out.

If the locality is urban, it will probably arrange for centralized services through a network of water pipes and/or sewers, along with treatment of water going into the system and sometimes treatment of what comes out of it as well. In most developing countries, there is a good chance that part of the population of the urban area will live in informal settlements (variously labeled "peri-urban areas," bairros, favelas, etc.) that are not served by the centralized system and that therefore pose significant health and political problems. These settlements are on the locality's plate to worry about. If the locality is rural, it may be primarily concerned with helping villages set up and operate their own water systems based on pumped groundwater and with urging households to build latrines and use them safely; or it may be concerned with other options for ensuring safe water and adequate sanitation in the countryside.

Let us illustrate the variety of ways that these functions can be organized with some of the PSOs we have talked with in our research.

- CEDAE – a large, urban quasi-public company providing water for Rio de Janeiro. CEDAE barely survived privatization a few years ago and sells water to some of the private operators in the Rio metropolitan area.
- Instituto Costarricense de Acuaductos y Alcantarillados (AyA) – the national water agency of Costa Rica, with policy responsibility for the whole country, regulatory responsibility for rural systems, and operating responsibility for some municipal systems, including the capital
- Aguas de Mocambique (AdM) – the private contractor that operates the water system in Maputo, Mozambique; owned primarily by Aguas de Portugal. AdM is operator only; the infrastructure for the Maputo system is owned by a quasi-public company (FIPAG) and both are regulated by an independent regulator (CRA).
- City of Tshwane, South Africa – a municipal operator, with all functions carried out by the city government but which gets its water from several sources, including both local springs and Rand Water, a huge quasi-governmental ("parastatal") bulk water provision company
- Sekhuhune Municipality, South Africa – a rural municipality, with responsibility for installing latrines and delivering safe water to all rural settlements – except where there are competing jurisdictional claims from local chiefs

The services arranged by municipalities are sometimes supplemented with private provision, purchased directly by households. This is especially common in peri-urban areas, where population density allows for a good ratio of revenues to costs for small-scale entrepreneurs, who benefit from the fact that the locality is not serving the area. So for example in the Hulene B neighborhood in Maputo, Mozambique, we visited a private water service. The owner had paid to have a borehole drilled and a pump and water taks installed. He then installed piping to neighborhood houses that were willing to pay for a connection. The water was also available for sale to families who brought water containers to a common tap and carried their water home; the owner employed someone to mind the tap and collect that money. The water was more expensive than city water would be – but city water was not available there. Interestingly, this installation was illegal because of the contract between Maputo and AdM, which gives AdM a monopoly on providing water. However, the concerned parties in Maputo were looking for a way to legalize the operation, since it was clearly of public benefit in an area where AdM's network had not reached. Other peri-urban water services may include small tankers that sell water around the neighborhoods or services that empty latrines or septic tanks.

Localities get help from a number of other organizations in fulfilling their WSS responsibilities. As noted, they often hire contractors for construction and sometimes operation of systems. For example, AyA will have a contractor doing the extension of its sewer system. When the national government undertakes a special program to extend coverage, national program staff work with localities. For example, the ASNANI project in Mozambique, which is working in one or two provinces with local governments to install new water points, is building local capacity at the same time.

When there are special efforts like this underway that go beyond routine operation and maintenance, the locality may also use local NGOs to carry out the necessary organizing and training. This is happening, for example, in the rural water program in Kerala, India, where the NGO is developing training materials and running workshops for village water committees. Small scale systems are often managed entirely by CBOs, community-based organizations. In Kerala, for example, a national program is providing 90-95% subsidies for drilling and installing a village pump with pipes to each house. Then the village is expected to maintain it. Unfortunately, it is quite common for villages not to manage the maintenance, and there is a general sense in the sector that many such village systems are no longer operating within three years or so of installation. The ASADAs in Costa Rica, which have been successfully running rural water systems since the 1970s, provide a counter-example.

Another set of PSOs that appear in some countries, including Mozambique among our cases, are the international NGOs, such as WaterAid, CARE, and UNICEF. We include these organizations as PSOs if they are actively engaged in programs to establish WSS systems at the grass roots level. For example, in Mozambique, WaterAid has funding from the EU Water Facility to work with local partners in establishing working water and sanitation processes in several of Maputo's bairros. Judging from our interviews, these organizations are interested in more than just getting systems working; their larger goals are to spread new ideas and try them out and to change local environments in ways that help the poor. Precisely because they are international and because they want to play these roles, it appears that they are an important source of global learning in our sense of the word. WaterAid, for example, operates in 17 countries, shares experience of staff actively across those places, and participates fully in the global networks concerned with solving WSS problems. Its staff members are a rich source of outside ideas to be tried at local level. Interestingly, the more centralized systems do not encourage such free-wheeling action by international NGOs. South Africa decided after its democratic transition that all international aid would come through government, so direct NGO programs would not be possible there. The international NGOs are also not evident in Costa Rica.

In summary, the PSOs in WSS appear at all levels, from global (NGOs) to national (sometimes), to distict/municipal (most common), to local NGOs and CBOs. At the forefront of trying to deliver safe water and adequate sanitation to a specific set of households, these organizations share a common question and concern: What works? We return to the question of how they are motivated to make things work in our discussion of the rules of the game.

Our initial hypothesis linking PSOs to learning was that more heterogeneous sets of PSOs would provide more variants for testing. We are still analyzing the data, but it appears that the most heterogeneous area in the PSO network is the mix of public and private in the urban settlements. Indeed, a variety of new ideas are emerging there. However, new ideas in Northern water systems are not necessarily coming from the PSOs themselves but rather from their interaction with research organizations. We now turn to that topic.

2.2 Knowledge and Information Organizations (KIOs)

The KIO category is already expanded from our original version of the GSI model and is thus two steps away from the standard model. In the first step, we went from "research institutions" to "knowledge producing institutions," to try to leave room for kinds of knowledge that did not need to be produced in a laboratory. In the second step, we added "information," as we encountered important organizations in WSS that were devoted to managing and distributing knowledge rather than producing it. For example, the IRC in the Netherlands (full name, International Water and Sanitation Centre) is a dedicated knowledge management and networking organization devoted to gathering the report literature on low cost rural systems and making it available worldwide.

Our study was designed from the beginning to compare national contexts that had medium levels of "science and technology capability" measured by standard indices and those that did not. We have now visited one in the first category (South Africa) and two in the second (Mozambique and Costa Rica, although Costa Rica clearly has a stronger higher education sector than Mozambique and more PhD researchers devoted to water issues). We find that there are indeed significant differences. Our preliminary observations suggest that research institutions are not essential to make knowledge about technological options available, but professional knowledge is essential for technology adaptation and use. In terms of organizational innovations, the research base appears to be too thin to apply the same concepts.

We began our project by building a data set of publications on WSS over the period 1990-2006, to tell us what institutions were publishing new science-based knowledge and what they were focusing on. Sizable numbers of publications appear both in the engineering literature, centered on civil engineering, and in the public health literature; there is also a smaller set in the social sciences. Topics and institutions from affluent countries dominate the publication lists. WSS is by no means a technologically stagnant area when viewed from the North. For example, membrane technologies have been introduced over the period we studied and modeling and control systems have moved forward significantly. These are expensive technologies that are relevant to sophisticated urban systems, but are not usually feasible to help meet the challenges of peri-urban and rural coverage with basic water and sanitation in developing countries. These topics and the institutions that study them appear to form their own network. If we were studying the sectoral innovation system in WSS in affluent countries, this literature would apparently play the predictable role of spawning and exploring new technological options.

Within our sets of publications, however, is a much smaller number of articles that do focus on the issues of developing countries. Here, institutions from the global South predominate (from China, India, Brazil, etc.), with just a few from the North participating (e.g., the Water Engineering and Development Center at Loughborough and the London School of Tropical Hygiene and Medicine, both in the U.K.). There is some overlap in the topics these sub-sets take up, but significant differences in emphasis. The gap between the two indicates to us that we should not conceive of the problem of knowledge in the WSS GSI in the terms we started with, namely, the flow of knowledge from the international research community to practitioners in the global South. Instead, we need to examine the dynamics of knowledge demand and supply from the viewpoint of PSOs in the South.

So far in our fieldwork we have visited two countries that contributed very few articles to our datasets, Costa Rica and Mozambique, and one that was in the top twenty, South Africa. In Mozambique, the university is contributing to professional knowledge in WSS by training people who serve in the sector; we met several in our interviews. This is a really important role, since the shortage of trained people is severe. University faculty members are also serving as consultants on various national and international projects. Overall, however, Mozambique's WSS sector was still at a stage of absorbing knowledge from outside; for example, the main national water quality laboratory was gearing up to attempt ISO9000 certification – an elementary level compared with the laboratories in the other countries. We found Mozambique to be a very innovative country in WSS, but in the area of approaches, not technologies.

Costa Rica's universities were also contributing to the WSS sector primarily through training – again quite important given the skills shortage. There was very important research work being done at the university, however, on groundwater quality and water resource management issues, research that was helping to shape the policy context for decisions within the sector. Again, the technical base did not appear to be present for Costa Rica to innovate rather than imitate technologically and we found that even the diffusion process appeared to be a bit slow. If old technologies were working, Costa Rica stayed with them and devoted its resources to solving other problems. One sign of the modest pace of diffusion into Costa Rica is the fact that San Jose still depends largely on an old set of septic tanks installed when the city was growing, and is just taking on the task of connecting and extending sewage pipes and treating what is collected.

Indeed, we found more instances of technological innovation in our first day in South Africa than we had encountered in two weeks in the other countries. The innovations were all incremental, but clearly showed the capability of making a step forward that could not only meet local requirements but also diffuse to other places. All the examples we saw that afternoon, which ranged from redesign in the water treatment process to new monitoring software, were at Rand Water, the largest water utility in the Southern hemisphere and the home of a significant concentration of world class expertise. Other institutions in South Africa also demonstrated how well connected that country is to new knowledge in WSS. For example,

- WISA, the Water Institute of South Africa, a professional organization brings together municipal water specialists with the top experts in the country, and links them to equivalent international organizations; it had just completed its biennial meeting with over a thousand in attendance.
- The Water Research Commission, with a levy-based budget, is targeted to expanding knowledge relevant to South Africa's water needs and gives many stakeholders including municipalities the opportunity to shape the research agenda.
- Researchers from CSIR, the main government laboratory, were working with water authorities to develop new technologies and evaluate the effectiveness of past efforts.
- A top water researcher from the University of Pretoria is serving on the board of the International Water Association, which is working to share knowledge between developed and developing country urban systems.

What was striking in South Africa, however, was the vast distance between these technological capabilities and the worst parts of the WSS challenge there -- the ramshackle latrines and the shacks without latrine access at all; the too-widely spread public standpipes with water only part of the day. The predominant view among WSS professionals in international organizations is that the core of the problem lies in governance or "approaches," not technology. If this is true, then South Africa's powerful technological resources may not account for very much of its movement towards its own ambitious goals of free basic water and sanitation.

2.3 Governance and Rules of the Game (ROGs)

What do these WSS experts mean when they point to "governance" as the heart of the WSS problem? Let's start from the bottom up. One of the innovations in approach that the international experts cited in our interviews with them was "total sanitation," which is a variant on the "community demand driven" (CDD) approach. The basic idea is that communities need to define their own needs, set their own priorities, choose their own technologies, and make the key decisions about design of systems they are going to use. If they do not, the systems will fail. For example, women cannot be left out of decision processes. Since women bear most of the burden of the problem (literally, on their heads, carrying water home from distant water sources), if a "solution" does not meet the needs of women, it will not "solve" anything. So for instance, water points next to public roadways are convenient for the installation crews but useless to women who must have privacy when they bathe. The principles of good program design in WSS thus include CDD. Many programs incorporate this approach.

Beyond the choices already mentioned, however, it is remarkable how few of the rules of the game in WSS are set at the local level. Municipalities and districts, which we have identified as the main PSOs, have to play by rules set by national authorities in all the countries we have studied so far. The national authorities, in turn, set their own rules, but often in the context and constrained by rules set outside the country.

Each of the countries we have visited so far has legislation that sets the ground rules for the WSS sector – sometimes more than one Act. In Costa Rica, AyA was established by a law passed several decades ago under which it still operates. In Mozambique, the national water agency, DNA, was also established by law. In South Africa, several acts provide the legal framework, including the Constitution (which insures the right to clean water), the Water Act, which insures free basic water and sets the rules for establishing and running local water authorities; and the state and local government act.

Obviously, along with these acts come the key government agencies that provide the lead in the sector: AyA, DNA, and in South Africa, DWAF, the Department of Water Affairs and Forestry. DNA and DWAF have been divesting themselves of operational responsibilities for water systems over the last decade or so, in accordance with current public administration theories which call for division of responsibilities. Both are evolving into strategy and policy-setting bodies instead. AyA has been criticized by an international agency report for keeping both policy and operational responsibilities, but Costa Rica is not contemplating major changes, perhaps a sign of its relative independence from external influence as compared with the other two countries.

Mozambique has moved a step further than South Africa towards division of responsibilities for how the rules of the game are set and enforced. In 1998, it spun off from DNA an independent regulatory body (CRA) and an independent asset holding company (FIPAG), under a principle it calls “delegated management.” It then put management of the Maputo water system out for bid, with FIPAG and CRA as key players in the negotiation. The winner was AdM, described in our section on PSOs. (Costa Rica also has an independent regulatory body for the parts of its system that AyA operates.)

These illustrations point to two external influences on the rules of the game that national authorities set. The first is international best practices and standards. The Costa Rican regulatory agency, for example, was very active in regional networks of regulators, and was clearly trying to follow common standards. Even more explicitly, national authorities were aware of international environmental standards such as those embodied in the ISO certification processes we already mentioned and international health standards set by the World Health Organization (WHO). None of these standards is binding on national authorities, but they were taken very seriously nonetheless in the countries we have visited as benchmarks for performance and frameworks for local legislation.

The other strong influence on national WSS authorities is much more binding, and that is the conditions for external funding, either as loans or as grants. It does not appear accidental that the country in our study that is most dependent on external sources of funding has also moved the farthest towards a market based approach in WSS governance, a favorite approach of the lender and donor community. The year before we visited, Mozambique had qualified under the market and political criteria of the U.S. government for funding from the Millennium Challenge Account, and a big grant had been approved for the water sector. The World Bank has made major loans over the years, and the African Development Bank funded the huge ASNANI Project. In addition to setting pre-conditions for funding, these sources expect demonstrated performance on specific, pre-set indicators, creating palpable pressure on FIPAG and DNA to demonstrate progress towards their (the funding body's) goals. We return to the specific form those goals are taking in the next section. Suffice it to say here that the institutional and performance expectations of lenders and donors appear to us to be by far the strongest rules of the game in the global WSS network.

Thus, while global governance technically does not exist in the sector since there are no international bodies with the authority to make decisions that are binding on national authorities, there is a de facto global governance process that takes the shape of donor and lender conditions. A nation's ability to set its own rules depends crucially on its independence from those international money flows.

This complex network of rules of the game, from national to international regulations and performance expectations, creates the incentives for learning among a variety of actors we talked to. But the rules of the game are not just abstract: they are in fact the conditions for provision of crucial resources, including the salaries of the people who work in the PSOs. What we begin to see, then, is that the arrow between PSOs and ROGs in the diagram represents the process of public funding – the politically articulated demand for water and sanitation.

2.4 Goals and Targets

We defined a global system of innovation as a learning space in which a multi-level network of diverse actors interacts to address a world-level challenge. The global nature of the goal is thus the defining characteristic. We hypothesized initially that the learning process in a GSI may vary with the extent of consensus or clarity on the global goal.

Global goals in WSS are a long-standing phenomenon. 1981-1990 was the first International Drinking Water Supply and Sanitation Decade, and it adopted a goal of clean drinking water and basic sanitation for all. Performance fell far short of expectation, but progress was made. As a result of the Decade, an international monitoring program was established specifically for this sector, the Joint Monitoring Program, housed at the World Health Organization. The current goals in the area are ensconced in the environmental section of the Millennium Development Goals, along with specific indicators:

> Target 7c: Reduce by half the number of people without access to safe drinking water.
>
> > 7.8. Proportion of population using an improved drinking source.

7.9. Proportion of population using an improved sanitation facility. [8]

In addition, the United Nations has designated 2005-2015 as the Internal Decade for Action "Water for Life." The water part of the water-and-sanitation challenge is much easier to talk about in most cultures and more politically appealing, so the international coalition that recognizes the public health importance of "the other issue" has stimulated the United Nations to declare 2008 the "International Year of Sanitation."[9]

In our interviews, we have deliberately not introduced the MDGs, but those we interviewed at international and national levels often brought them up themselves as a context for their work. This was a bit less true in Costa Rica, which we have already observed is less shaped by donor expectations. They came up quite often in our second set of interviews in Mozambique, which had just adopted the MDGs in the previous year, after the first set. They came up in South Africa, but were somewhat overshadowed there by a similarly strong and specific set of national performance objectives, the requirement for localities to provide basic water and sanitation.

It appears that attention to the MDGs weakens as one moves down the levels of the GSI. We are still doing the analysis, but it is our impression that the MDGs came up most often in our interviews with international organizations, fairly often in national-level interviews, and less often in local interviews. And there would of course be no reason to expect households to be motivated by them. In fact, the fundamental challenge of rural and peri-urban WSS projects is getting households to put priority on WSS goals, which are not necessarily the most pressing day to day issues for very poor families. Vertical alignment of goals thus appears to be quite and important activity in the learning system. The community-driven approach was widely thought to be the most effective way to do that alignment at the lowest level of the system.

But it appears that the MDGs are having the unintended effect of distracting effort away from community-driven approaches. There was a strong view among many of those who discussed the goals that they were having unintended negative consequences; and in South Africa, that the national goals were having similar effects. The problem described is one that is well-known in the literature on performance indicators. The singular emphasis in the goals on quantity was leading to neglect of quality and sustainability, according to those observers.

For example, rural water supply can be established in many places by drilling bore holes and installing pumps. All this takes is money and a contractor: service can be extended to hundreds of thousands of people in such a borehole campaign. Likewise, latrines can be installed in top-down programs. However, just installing the pump does not assure that the water meets quality standards, and without maintenance, most of those installations will be out of service in three years. Latrines may stand empty, used only by guests. Professionals in the field therefore recommend CDD programs with plenty of training along with investment and commitment from the local community to maintenance. But many of those we interviewed pointed out that it is quicker, easier, and cheaper to meet the MDGs with the less sustainable approach. In Mozambique and South Africa, some people we interviewed thought that the less sustainable approach was being

[8] http://www.undp.org/mdg/goal7.shtml, accessed August 9, 2008.
[9] http://esa.un.org/iys/, accessed August 9, 2008.

used by other actors in the system. A recent study in South Africa had shown that the rush to quantity had sacrificed quality: none of the sampled installations met the standards set by the national authority. The qualities of the performance targets that are considered so essential – specific, measurable, time-bound – were leading to rushed, top-down activities, according to some observers in the field.

The problem thus described can be understood as a short-circuited learning process. A top-down process divorced from end users can neither hear local experience about what works and what doesn't, nor see local variations and inventions that might be more widely useful. In addition, it neglects competence and capacity building. All the people we interviewed were convinced that capacity building was crucial to progress in the sector, but worried that resources were being spent in ways that did not contribute much to that goal. The MDGs were therefore often an object of frustration rather than inspiration.

2.5 Learning in WSS

The basic hypothesis of SI theory is that increased interaction among, in the generalized form, PSOs, KIOs, and ROGs should lead to increased learning for the system. But what do we mean by learning? There is a vast literature on this topic, which there is no room to review here. Learning results in capacity or competence that can then be re-invested in new learning.

In our own understanding of learning in WSS we are also working with a broad, bottom-up definition, reflected in a diverse set of qualitative indicators in our national case studies. *Formal education* is included, as is both *formal training* and *on-the-job training*. We include *years of experience*, which represents learning by doing. The core of the concept for our model is *introducing, testing, and spreading information about new approaches or technologies*, so we are looking for approaches or technologies that are new to the organization, new to the country, or new to the world, then paying attention to how they are tested and evaluated and whether the results of that process are shared, through what channels.

Education is clearly a base issue in this broad concept of learning in the countries we visited. WSS issues are flanked on one side by efforts in public health education, including hand washing and safe water practices. These efforts often work through local schools, but do not reach the whole population that way because of low school attendance rates. Mozambique and the second economy in South Africa are critically short on even the basic educational capacities needed to administer effective local government, let alone more specialized skills to run local water treatment plants and distribution systems. The skills shortage sets up severe competition for good people, and public sector organizations in both South Africa and Costa Rica reported that they were losing good people to the private sector. It was very difficult to replace them. All the countries offered some specialized training in civil or environmental engineering in their universities, but mostly masters degrees need to be earned overseas, and certainly doctoral degrees. The international masters and doctoral programs in Delft, started under the Technical University there and now an independent UN-run center.

Training then supplements formal education. Training seemed to be ubiquitous, often offered by national or local NGOs. We also heard about lots of on-the-job training efforts – the core of technology transfer. This was particularly striking in Mozambique, where there were very strong incentives for the private operator in Maputo to train local people to do their jobs well. The people we talked to often represented many years of experience in the sector, a finding one would expect since we were talking by and large to heads of agencies and programs. The more junior people had moved into leadership positions in the field with university degrees, from chemistry and geology through civil engineering. The dominant interaction pattern in training appears to be top-down, requested by a national organization trying to make change or build capacity and provided either by specialized national sources or international consultants.

The communication processes that spread information about new approaches or technologies also appear to follow a similar tree structure. The global-level PSOs and ROGs (that is, NGOs, lenders, and donors) seem to be very well networked among themselves, sharing information and experience through big conferences like Stockholm Water Week and the World Water Forum, regional meetings, and many, many workshops. The global-level organizations also actively share ideas and experience across countries among their own staff, and the World Bank's Water and Sanitation Program also performs this function. National level experts appear to participate in this network; we are still analyzing the data on how widespread their participation is. It certainly appears that contact between national and international organizations is an important source of new ideas for national authorities.

What happens between national and local levels? It is important to grasp the difference in scale of audiences between these two levels. In Costa Rica, there are 1620 rural water committees – somewhat smaller than a district but still the basic building block of the rural water system. In Mozambique there are 126 municipalities; and in South Africa, there are 284. Provinces have not been identified in any of our interviews as particularly strong actors in WSS, so as a practical matter new ideas will spread from national level more or less directly to local level. Understandably, this appears to happen unevenly, with the most intense information exchange happening in the context of national programs focuses on particular areas. We are following through on our national level interviews with another set at local level in two of the countries, and we expect to have better information on this level of interaction after those are complete.

The large number of localities and their closeness to household end users suggests that there would be many variants would be developed at that level. How would the rest of the system find out about them if that happened? We encountered one example of lateral learning between localities, among the ASADAS in Costa Rica (the Administrative Associations of Rural Water and Sanitation Systems), who were beginning to have ASADA-to-ASADA learning events. It is informative, we think, that the ASADAs have been in operation so long. Newer local authorities might not have the energy left over for this sort of thing after tackling their own problems in standard ways. Another route for sharing local experiences is through experts or consultants, who work with one location then pass good ideas to a later client. In South Africa, for example, national-level engineers were working with local ones to adapt a dry latrine design. What they learn there could end up being shared more broadly. Local lessons are also carried into the international network by international NGOs and by the knowledge management organizations we described in the section above on KIOs. But these might not then be shared with nearby localities, unless they happened to be the ones selected under national programs.

It is important to note the difference between peri-urban and rural localities in this regard. The peri-urban areas have several advantages in generating and testing variant approaches and technologies. First, they are in relatively close physical proximity to each other as compared with rural communities. Ideas are more likely to flow laterally between them. Second, they are close to the people who run the urban networks, who are more likely to be connected to international networks. And third, they are the site for the most active entrepreneurial activity. For several reasons, then, we would expect innovative approaches and technologies to emerge and diffuse at a faster rate from informal urban settlements than from rural communities. However, experience may not bear out theory. A second major innovation in the sector, condominial sewers, was in fact invented in a Brazilian favela, but seems to have spread primarily within Brazil. It would be interesting to find out why.

In brief, the communication patterns in the system seem to be rather centralized, without thick interactions at local level. Users are thus cast in a rather passive role in the process of generating and testing variants. Yet there is ample wisdom in the field that suggests that adaptation to local conditions is a key element of success. If this is true, then the most important people to hear about incremental innovations in rural and peri-urban systems are the people closest by, who are most like the innovators in both physical conditions and culture. Yet these appear to be the people least likely to get that information.

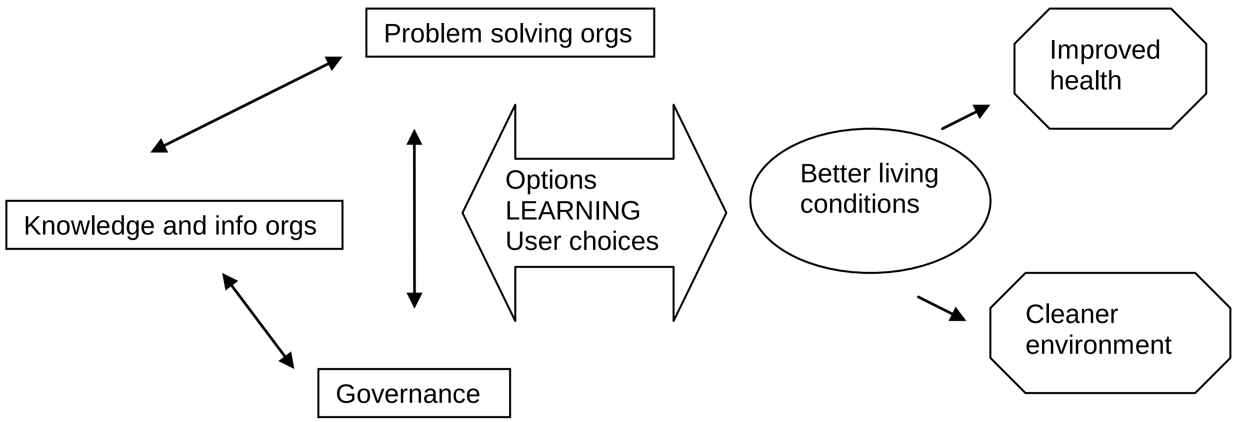
Given this structural situation, is learning happening in WSS and what are the conditions that foster it? Those are the questions that we embodied in the initial hypotheses, presented earlier. But we now have a much broader understanding of context and information flows within which to make summary observations. First, using the education and training elements of the learning concept, there is certainly a great deal of activity going on. But there is no indicators system that captures the activity or its medium and long term results, because there is no high-visibility performance goal associated with it. Likewise, the system is not structured to learn effectively from a set of key users and their local experience, in particular, rural households and communities. 80% of the problem identified in the MDGs on water and sanitation is in rural areas. Perhaps this structural feature of the communication system helps to explains why.

2.6 Modification of the Model

These preliminary observations lead us to make some modifications to our original specification of the GSI model. In particular, we have changed the diagram to feature the role of household users more prominently. If the households are in a place where an urban network exists, they have few choices to make; but the MDG challenge is not located there. But in both peri-urban and rural areas, where the underserved live, households do make key decisions, with limited technological and non-technological options, about where to get their water and leave their wastes. They make choices about latrines versus no latrines, and choose among various latrine designs. They also have a variety of water choices. In rural areas, the choice may be between free surface water that is probably contaminated and a village pumped water system that requires electricity and maintenance. In urban slums, there may be an option of low-cost public water from a local tap or "water point," established by the local water utility. Such water is more often safe but needs to be transported long distances. The other choice may be privately delivered water that is much more expensive per unit.

In short, the technological choices of households are a key process in the learning system. We have incorporated them into the model in the learning arrow, adding an end to the arrow that points back into the middle of the institutional nexus. PSOs, KIOs, and ROGs will need to learn from these household decisions if they want to create sustainable improvements in living conditions in the poor communities of the developing world.

Figure Three. Generic system with users in the learning loop



3 Questions for Further Research

This analysis is still quite preliminary, based now on our impressions and examples that stand out. As we have indicated, we are in the process of doing a full structured qualitative analysis of our interview data in connection with secondary sources. Our conclusions at this time are also therefore preliminary.

1. Conditions in the North are so different from those in the South that new technologies or approaches are unlikely to be developed there and "diffuse." The technologies that are diffusing are not meeting the innovation challenges of developing countries, like the need for simpler, lower cost materials with lower skill requirements. Global innovation programs could be directed to these conditions.
2. Because the places where the challenges exist do not replicate the conditions under which existing "solutions" apply, innovative ideas that actually work in local conditions are most likely to develop bottom-up. These are most likely to diffuse successfully to nearby areas, but communication patterns in the field do not support such lateral processes.
3. Because of the strong influence of local conditions, "training" may not be the right paradigm for bringing communities into contact with new ideas. Instead, support for local selection and choice may be more important.
4. While the goal articulation is global, the solutions are unlikely to be developed at the global level of this network. However, the global level will be helpful in spreading information about innovations that are working – that is, putting the set of choices in front of local communities.

We are undertaking this work because innovation systems theory can offer useful insights to the practical world of water supply and sanitation, pointing to places where network concepts and greater interaction might generate and spread new approaches more quickly. Likewise, the study of global systems of innovation can extend innovation systems theory in useful directions and provide conceptual tools for analyzing movement towards world-level human development goals. We hope to have contributed to both goals with this preliminary analysis.

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