Facilitating Community Water Supply Treatment

From transferring filtration technology to multi-stakeholder learning

Jan Teun Visscher

Promotor

Prof. Dr. Ir. Niels G. Röling

Promotie commissie

Prof. Linden F. Vincent
Wageningen Universiteit

Prof. Dr. Huub J. Gijzen
UNESCO-IHE, Institute of Water Education, Delft

Dr. Ir. Paul Engel
European Centre for Development Policy and Management, Maastricht

Dr. Grazia Borrini-Feyerabend
Switzerland

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Jan Teun Visscher
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Preface

This publication is about what it takes to ensure that when people open their tap they can safely drink the water. In smaller communities in the developing world this is a very complex issue. The quality of surface water sources may show considerable variations; trained staff is not always available; advisory support is usually lacking; chemical supplies are not reliable. In fact, the odds against success are even greater because people interfere with the systems and they may well not see water quality as a priority.

Three decades ago, this situation prompted researchers from different developing countries, together with IRC, to initiate a research and demonstration project on Slow Sand Filtration (SSF). They were convinced about the usefulness of this technology and wanted to test it and share it with communities in need of improved water supplies. They put in a lot of effort and had some success in the process, but found that SSF alone was not sufficient. Maintenance of the filters was a problem and was aggravated by high turbidity peaks in some tropical rivers. This led to the development of Multi-Stage Filtration (MSF), an enhanced technology with potential for much wider application, which was the basis for the subsequent TRANSCOL project.

This publication tells you about these technologies, how they were developed and shared and what was learned in the process. It discusses technology transfer and learning in the light of different theories. It reflects a great deal of experience that was developed with communities and agencies, with universities and with interdisciplinary teams.

The experience shows that water supply is much more complex than many people think or are willing to accept. It is not a straightforward engineering problem that needs to be solved. It is in the first place about people and not about technology. I found how true this is when I took over the management of the SSF project. Immediately, I was working with people from six different countries, each with their own culture, views and ideas. It was like six cultural shocks in a time-span of 4 months. We did not even share the engineering language, as some project partners came from other disciplines. I must say that these shocks in a way made it easy for me as an engineer to accept at some point in time that water supply is primarily about “soft-system thinking”. It is about perceptions, different realities, different world views and working with different disciplines. And that makes it a challenge.

Before long, an exciting thing happened in that the idea of “learning projects” arose when conceptualizing the introduction of MSF technology with the CINARA team in Colombia. Learning projects flow from a very rich process of inter-cultural collaboration, of different views and mindsets, of out-of-the-box thinking. They generated dialogue in which views could be exchanged in a very productive manner but also created heated discussions and debate. The process involved shared efforts of different disciplines, a meeting of community experience and scientific knowledge (or perhaps community knowledge and scientific experience). Along with my colleagues from CINARA, we started to write papers and give presentations not just about the technology but also about the learning process. We were really excited about it, as were the agency staff and communities that participated. I have used the opportunity of writing this publication to take this comprehensive methodology a step further. I have chosen the acronym FLAIR: Facilitating of Learning, Application, Implementation and Reflection to try to capture the philosophy underpinning the learning projects.

It was fortunate that I had built up a considerable period of sabbatical leave and that IRC was prepared to provide additional support to allow me to review this experience and to try to make sense of it. This review process included meeting members of the TRANSCOL team and going back to some project sites ten years after the project ended. It was wonderful to hear that many of the colleagues that had been involved in the TRANSCOL project considered it one of the most important projects of their life, where they felt that they truly learned what participation and multi-disciplinary teamwork was all about. I am convinced that the learning concept embedded in this project has a lot to do with this experience.

It was very much about how we worked in the project, how we tried to be open to ideas. I remember that I became involved with a CINARA team in a participatory evaluation in Ecuador. We asked the implementers to be part of the evaluation process and they indicated at the start that they were already applying participatory techniques and gender-sensitive approaches with the communities. After three weeks in the field with the CINARA team, one of them said: “this is different from what we have done before, now I know what participation is all about, we have to learn to listen”.

This publication gives you the opportunity to listen to the ideas and voices of many people who have worked hard on their dreams: people in communities fighting for a better life; agency staff dedicated to help these communities, sometimes struggling to do away with their former paternalistic style; university staff, some coming from very small communities, who have worked their way into university and want to devote their knowledge and experience – their lives – to development, to helping to create better conditions for those who are less fortunate. This is the rich knowledge base that I was allowed to work with and to capture, because they all felt that this experience needs to be shared.

I am grateful to all the people who have contributed to this process that took more than 25 years. It could not have happened without the continuous support of the Directorate-General for Development Cooperation of the Netherlands government, who can be proud of these projects. Also the role of IRC has been very important with its strong orientation to work with partners in the developing world. Colombia gave the learning the special touch; the dynamic CINARA team of friends brought a lot of creativity and a lot of experience through very nice people such as Antonio Castillo and Hector Perez; it became my second home.

There are so many people that have supported this work. I will just name a few, but I am equally grateful to all the others who have contributed. The three leaders of the SSF project, who I met in 1983 and learned to appreciate, Sunanta Buasemuang from Thailand, Mario Santacruz from Colombia and Paramasivam from India. They accompanied me throughout the SSF project. Then the Colombian chapter started with my dear friend Gerardo Galvis (who doesn't take no for an answer!). Together we had many discussions and have written many papers. Equally important was Mariela Garcia, another close friend, who brought in a social and philosophical dimension, challenging the technical team of CINARA (and me), at the start of TRANSCOL, to do things differently. She did not stop challenging and I am grateful to her that she accompanied me in the thinking, always willing to give comments and suggestions. I also thank Niels Röling who enrolled me in the challenge to write this publication and accompanied me with a listening ear, great advice and a lot of enthusiasm.

I also owe my thanks to Sascha de Graaf for guiding the publication process, to Betty Westerhof, Cor Dietvorst and Ingeborg Krukkert for providing information support and to Brian Appleton who has scrutinized the text. It is more than 20 years since he edited my first publication and he has not lost his touch, always posing critical questions where they are in order.

Although the development of this publication has come to an end, there is a lot more to learn. The recent work of my IRC colleagues about Learning Alliances, the new experience of CINARA with community learning centres, all point to facilitation and learning as essential ingredients for sector improvement. That is why I believe that we really need to take up the challenge to go forward with FLAIR-based approaches.

Delft, 15 March, 2006

Jan Teun Visscher

1. Introduction

> *"The number of water taps per 1,000 population will be an infinitely more meaningful health indicator than the number of hospital beds." H. Mahler, Director-General of the World Health Organization, 1980*

This publication describes research and development work in search of better interventions in community water supply based on biological water treatment. It is about people, technology and the relationships between them. It reports on a 25-year struggle to learn about technology sharing in so called "developing countries"[1] or "countries in the South", countries with limitations in their physical and organizational infrastructure. It draws on the fascinating experience of two research and development projects that included slow sand filtration (SSF) as a water treatment technology. This is a biological process invented at the end of the 18th century and provides very good results if properly designed and managed.

I will demonstrate that the approach used in these projects changed from technology transfer to a multi-stakeholder learning approach that we called "Joint Learning". This change has parallels in similar developments in other sectors, e.g. natural resource management and water resources management. I intend to show that this experience goes much further than the introduction of biological water treatment and is very relevant for wider development. I am confident that it can contribute to meeting the crucial challenges the water sector is facing. More than 1.1 billion people still lack access to improved water supply, and many more lack access to water that is safe to drink. The essence of this important participatory learning experience was nicely captured by Mr. Campo Elias, a farmer from Cerinza in Colombia, one of the project participants, when he said:

> *"In this Programme everybody is the teacher of everybody and everyone is learning from everyone"*

Exploring this experience is very salient in view of the Millennium Development Goals (MDGs) that were agreed in 2002. These goals are the world's targets for dramatically reducing extreme poverty in its many dimensions by 2015 – income poverty, hunger, disease, exclusion, lack of infrastructure and shelter – while promoting gender equality, education, health, and environmental sustainability (UNDP 2005). Target number 10 (in Goal number 7) specifically addresses halving by 2015 the proportion of the population that lacked sustainable access to safe drinking water supply and basic sanitation in 1990. The Project Task Force on Water and Sanitation has stressed that achieving the water and

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[1] The term developing countries is misleading if I take into account the very interesting and vere e people I have become friends with in these countries. Often I found them much more "developed" in terms of the human dimension and less consumption-oriented than my own countrymen in the Netherlands. So if I use this therm it reflects more the limitations these countries have in terms of physical and organizational infrastructure.

sanitation target and investing in water infrastructure and management are crucial to the achievement of all MDGs (Lenton et al., 2005). The experience is also salient in view of the new Decade Water for Life that has been established by the UN agencies for the period 2005-2015.

Starting with the SSF project

The first project that I review is the slow sand filtration (SSF) project initiated in 1975 by the International Reference Centre for Community Water Supply and Sanitation (IRC) in The Hague. The purpose of this project was to test and promote the application of SSF in developing countries to help solve the problem of drinking water quality in small and medium-sized communities. It was implemented by different organizations in Colombia, India, Jamaica, Kenya, Sudan and Thailand, as will be described in the first case study. This project was very important for the participating institutions in the countries but also for IRC and its staff, as it offered many opportunities to learn and develop new thinking. A senior staff member of IRC described a visit in 1980 to Alto de los Idolos, one of the communities involved in the project, as “one of the first of many personal experiences of how a combination of local and external expertise can effectively diagnose and solve problems in a way which either party probably would not have achieved on its own” (Wijk, 2001 p.1). It also benefited the organization as a whole. “It was through the SSF project that a good part of the Community Education and Participation work of IRC developed. This must be counted as one of the major contributions of the project, more important perhaps than any specific achievement in this field in the participating countries under the project” (White, 1984, p 1).

I became involved in this very interesting project in 1983 when I joined IRC after having worked with UNICEF and UNDP in a rural water supply and sanitation project in Guinea Bissau. I started as a consultant preparing a manual for the operation and maintenance of SSF plants and a related trainers’ guide. After a few months I took over the management of the SSF project, which was then in its third and intended final phase, aiming at disseminating the experience. I inherited a huge volume of project documents, many of them produced by staff from the partner institutions telling the story of a very interesting struggle to help improve the sector by trying to introduce water treatment by SSF in community water supply systems. I did not know it then, but this was not to be the final phase of a project but just the start of a learning process, as will be shown in this publication.

1.1 The origin and sequence of the projects

In April 1973 a number of directors from institutions in four different developing countries that worked together with IRC came together in Bilthoven to assess key problems in the water sector in their countries and to discuss potential solutions. An important conclusion from this meeting was that suitable water treatment able to achieve the required water quality was often not available. They identified SSF as a potential solution and assigned the highest priority to further research on this technology under different climatic conditions. SSF is a fascinating natural water treatment process in which water passes through a submerged sand bed. During the passage the water quality improves as a result of very effective biological, physical and bio-chemical processes. To obtain good treatment results, it is crucial that the design and the operation of an SSF respect the biological nature of the process. Once the system is in place, it is the operator who holds the key to its continued good performance, but it often also requires good interaction with the users and some back-up support. Management goes beyond the SSF system itself and may include addressing efficient water use, and dealing with conflicts that may, for example, arise from competing water uses.

In one of the project documents it is claimed that "SSF is the oldest effective method for purifying contaminated surface water. Particularly its ability to remove pathogenic bacteria makes this process appropriate" (Soleman, 1976 p. 27). SSF indeed is very effective but it is not the oldest treatment process. According to Baker (1981), people have always been preoccupied with water quality. He mentions that in the year 98, Sextus Julius Frontinus published two documents concerning the water supply of Rome that, for the first time, presented a public water supply that included treatment in the form of sedimentation basins. Whether this remains the earliest reference to water treatment may depend on the deciphering of the script of the early civilizations in the Indus Valley. It appears that they may have used the same type of treatment. They had at least built large storage tanks 2500 years earlier. Interestingly, the Romans also used a kind of disinfection without having the scientific background. They stored water in containers made of silver without knowing that these were quite effective in the inactivation of bacteria (germ theory only developed in the second half of the 19th century). The same principle is still used today in certain types of household water filters that have a silver coating on the inside.

The recommendation of the Bilthoven meeting triggered the preparation of the research and development project on SSF. This project was formulated by IRC with the help of an advisory group and implemented in close collaboration with institutes in developing countries. The SSF project, the first 'field project' of IRC, was funded by the government of the Netherlands and was initiated in 1975. It started with research on technical scale SSF units in research institutions in the participating countries, followed by the development of full-scale demonstration plants in different communities in four countries and was supposed to end with a dissemination stage using seminars and publications. At that time, this represented a rather common approach to technology transfer, with the exception that a number of the key actors in the project were institutions from developing countries.

Promising new developments

An additional phase was approved when project results showed that maintenance was a problem and that existing SSF systems had difficulties in coping with higher levels of turbidity – a common characteristic of many tropical rivers, which is actually a growing problem because of increasing erosion in catchment areas. This phase however, was restricted to only the two countries where results were best: Colombia and India. Different types of pre-treatment techniques were tested at a pilot scale and a new operators' manual was developed.

Results were promising and two new projects were developed, both concentrating on Colombia because of the matching interests of the Colombian and Netherlands governments. One project focused on further development of the most promising pre-treatment methods. It resulted in establishment of a new water treatment technology: Multi-Stage Filtration (MSF), a combination of gravel filtration and SSF. The other project, TRANSCOL[2], was developed to introduce the technology in eight regions in Colombia. The projects were mutually reinforcing, as will be explained in chapter 7. The TRANSCOL project triggered a substantial change in the project approach, moving towards a multi-stakeholder learning process, based on learning projects. It also helped the national counterpart, CINARA (Centro Regional de Abastecimiento y Remocion de Agua)[3] of the University of Valle, to change from a working group led by Gerardo Galvis into a foundation (while remaining part of the university) and to become an important support centre for the water sector in Colombia and Latin America.

The development of *Joint Learning Projects* did not stop at the end of the TRANSCOL project in 1996. It continued in different interventions in which CINARA was involved, often together with IRC, including further work in two of the project communities of TRANSCOL. In 2004 an opportunity arose to revisit a number of the project communities and to meet again with different actors that had been involved in the TRANSCOL project. Returning ten years after the project ended proved to be a revealing but also frustrating experience. It was very good to find that most MSF systems were still working. Many though needed improvements in operating procedures and some repairs, several of which could be easily achieved with some additional support to the operators. The other frustration was that staff remembered the project as a great learning experience, but often lacked the institutional support to apply what they had learned, particularly the non-technical part. Even the CINARA staff was often constrained by the strong implementation bias in the sector. I will show in chapter 7 how re-visiting project communities and participants after such a long period was extremely helpful in enabling me to reflect on the implications of the project, which in turn strengthened my desire to write this publication. The visits showed the need for changes in the approach used. In chapter 8 I address the insights that were brought about by this study bringing in different theoretical concepts. Those new insights helped me to reflect on an emerging approach for introducing water supply systems, based on the concept of learning projects, as I discuss in chapter 9. I am using the acronym **FLAIR** to label this comprehensive approach designed to make interventions sustainable. FLAIR stands for

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[2] Transferencia organizada de tecnología simplificada para el tratamiento de agua en sistemas de abastecimiento en Colombia

[3] The current name of CINARA is: Cinara, Instituto de Investigación y Desarrollo en Abastecimiento de Agua, Saneamiento Ambiental y Conservación del Recurso Hidrico, Universidad del Valle

Facilitating of Learning, Application, Implementation and Reflection and in my view has potential also beyond water supply interventions.

Although I have been part of the development process as a manager of the two projects, I feel able to view it from a reflective distance because the approach was implemented by staff from the organizations in the countries. I have participated in some of the seminars and workshops and in testing the fieldwork. This was a great learning experience and perhaps what I have learned most is that posing the right questions is far more important than providing answers. Reflective distance is also supported by my use in this study of different external evaluations and by going back to several of the project partners and project communities ten years after the project ended. The latter made it possible to see the long-term results and limitations and discuss my views and new ideas with others. As will be explained in the methodology (chapter 2.), I have taken extra care to make sure that my advantage of insider knowledge and experience is not devalued by self-serving bias.

1.2 The IRC

The IRC was established in 1968 as a reference centre for community water supply and sanitation, based on an agreement between the Netherlands government and the World Health Organization (WHO). This was a result of new thinking in the WHO, which adopted the concept of Collaborating Institutions as a means of coordinating research and development. WHO designated two networks of collaborating institutions – one for community water supply and one for waste disposal. IRC became the hub in the community water supply network of some 32 National WHO Collaborating Institutions in both developed and developing countries.

IRC started as a small unit in the Netherlands National Institute for Drinking Water Supply and has grown into an internationally known organization with some 40 staff. An external evaluation team concluded in 2001 that "IRC has evolved from an information and reference centre on primarily technical aspects of water supply, to a resource centre and a main player amongst the knowledge organizations in the water supply and sanitation sector offering a range of services in collaboration with resource centres in a number of developing countries" (Woersem and Manuel, 2001). In an early stage of its existence IRC broadened its mandate as reference centre, by giving greater emphasis to information sharing and capacity building with partners. On the occasion of its 25th anniversary it was claimed that it functions as a bridge between those possessing valuable knowledge and those seeking that knowledge and experience in the water and sanitation sector (Appleton, 1994).

IRC became an independent foundation in 1981, a move that was thought to make it easier for bilateral agencies from other developed countries to support IRC projects. It gradually grew in size and over its 35 years of existence has been working in more than 50 developing countries. An important vehicle to reach sector staff is its newsletter SOURCE-Weekly, published in English, French and Spanish. From the time it became a foundation, IRC has sustained a dialogue with leading water supply and sanitation professionals from UNDP, UNICEF, the World Bank and the World Health Organization among others, by including them in an advisory capacity on its Governing Board.

From its earliest days, IRC's programmes have been directed towards information sharing and the development of solutions that can be demonstrated and applied in the field. Both projects I review in my two case studies are good examples of this and the SSF project was the first multi-country project developed and implemented by IRC. IRC was responsible for management of the projects, which were funded separately by the Netherlands' government in addition to its core subsidy to IRC.

During the first five years of its existence, IRC had a staff of four involved in research and development issues for both industrialized and developing countries. Its first publication: 'Plastic Pipe in Drinking Water Distribution Practice' addressed an issue of concern primarily in the industrialized countries, but seen as increasingly relevant in the developing world. The rapid pace of sector activities brought with it a growing need for research and information exchange. Against this background, IRC's focus shifted from networking between WHO collaborating institutions to a wider networking function among those active in water and sanitation activities in developing countries. In this period IRC quickly learned that "the apparent attractions of networking are only realized in practice when the networking institutions have clear common interests. Networks build up when there are practical results to be shared; they are not in themselves a means of generating those results" (Appleton, 1994 p. 14).

The proclamation of the 1980s as the International Drinking Water Supply and Sanitation Decade, with the slogan "Safe water and sanitation for all by 1990", stimulated the further growth of IRC. With a staff of 30, strong support from the Netherlands government and having learned from its experience, IRC was able to develop activities that responded to the demand for hand pump and public stand post programmes, community participation and for the exchange of information. Towards the end of the Decade it broadened its scope by starting activities on rainwater harvesting, hygiene education, school sanitation, gender and community management. This period also saw a further intensification of the relationship with a number of key partner institutions in developing countries that were participating in IRC's research and development projects and in its training activities.

The first external evaluation of IRC, that took place in 1996, indicated that IRC's activities had kept pace with changes in the sector. IRC had been successful in promoting integration of socio-economic aspects with technical aspects. It had influenced donor and developing country policies through its action research and dissemination activities. The evaluation found "the most striking aspect of IRC's work in recent years to be the capacity building of partner institutions in developing countries. The key to IRC's success is a highly committed staff with field experience and long-term partnerships with institutions in developing countries. The broadening of joint activities enhances the potential impact of IRC's work" (Schulzberg et al., 1996).

A new external evaluation in 2001 confirmed IRC's role as an information broker having long-standing relationships with partners in developing countries who consider it a reliable partner (Woersem and Manuel, 2001). The evaluation indicated that IRC's publications are known and appreciated although sometimes considered too abstract and not focused enough on emerging fields. The recommendations of this evaluation indicated that IRC should receive greater support from the Netherlands government to enable it to adjust its course of action placing stronger emphasis on collecting and sharing sector information, building strategic alliances also with partners from the industrialized countries, and intensifying capacity building of resource centres in developing countries.

In response to the evaluation and the new business plan of IRC, the core subsidy increased from an average of Euro 1.1 million per year for the period 1997 – 2001 to Euro 2.9 million per year for the period 2002 – 2006. This amount however also includes some Euro 850,000 per year for partner organizations and consultants, which in the past were funded through specific projects such as the SSF project and TRANSCOL. For example, the financial support from the Netherlands government for the SSF project (1975-1986) amounted on average to Euro 200,000 per year including a financial contribution to partners of Euro 120,000 per year. In TRANSCOL (1989 – 1996) the average annual contribution amounted to Euro 300,000 per year including a contribution to partners of Euro 230,000 per year.

I joined IRC in 1982 and have worked in different capacities in the organization including management of the last phase of the SSF project and of the TRANSCOL project. In 1997, a year after the first evaluation of IRC, I became director of the organization, a position which I held for a period of six years.

1.3 Community water supply an important problem

There are few issues that have greater impact on our lives and the life of the planet than the management of water, our most important natural resource. Water is a basic requirement for human life; we need water to stay alive and maintain basic health and sanitation. We need it to grow our food, to maintain our industry and economy and to sustain our environment. In this section I will explore the importance of water supply in some more detail, assess the challenges the sector faces and indicate the different strategies that have been used to improve community water supply coverage and the role of water supply treatment. This coverage may include simple piped water systems or a range of point sources, such as boreholes with hand pumps, dug wells and protected springs (WHO 2004).

History clearly shows the relationship between water and civilization. The Indus Valley civilization flourished around 2,500 B.C., far before Roman times, in the western part of South Asia, in what today is Pakistan and western India. The remains of this civilization were only discovered in the 1920s and many basic questions about the people who created this highly complex culture are unanswered. Archaeological evidence shows that the Indus civilization was primarily an economic empire composed of confederations of local tribes, but united on a larger scale as a grouping of cities with a shared culture. The people of this civilization used the wheel for transportation as well as to turn pottery. They developed ceramic plumbing systems (water supply, irrigation, and sewage disposal) that were more advanced than the technology that was being concurrently used in Egypt and Mesopotamia (NSAB, 2000 p.3). The latest theory is that the civilization was destroyed by climate change that made the rivers dry up.

Water supply essential for development and poverty alleviation

"Clean water for domestic purposes is essential for human health and survival; indeed the combination of safe drinking water, adequate sanitation and such hygienic practices as hand washing is recognised as a precondition for reductions in morbidity and mortality rates, especially in children" (Lenton et al., 2005 p. 4). This actually is not new as water and waste were already recognised as key health issues in 1959, when WHO pushed for research to find ways of improving coverage for the rural poor, among others, through its Community Water Supply programme. Potable water supply and basic sanitation are essential for the improvement of public health and socio-economic development, particularly in countries with a high incidence of water-related diseases, which affect particularly children. "The incidence of diarrhoeal disease is thought to have remained stable since 1990 but mortality from diarrhoeal diseases has fallen from 2.5 million deaths in 1990 to about 1.6 million deaths in 2002, now accounting for 13% of all child deaths under age 15" (Mathers et al., 2003 p. 47). The fact that the incidence of diarrhoeal diseases has not reduced seems to relate directly to the fact that community access to water supply (water coverage) has not increased very much over that period. The reduction of the mortality rate should therefore be interpreted as a result of improved treatment of children with diarrhoea by for example Oral Rehydration Therapy.

The UN Millennium project Task Force on Water and Sanitation argues that water supply and sanitation services are catalytic entry points for efforts to help developing countries fight poverty and hunger, safeguard human health, reduce child mortality, promote gender equity, and manage and protect natural resources. At the same time, they state that although far more people suffer the ill effects of poor water supply and sanitation services than are affected by headline-grabbing topics such as wars and terrorism, those are the issues that capture the imagination – and the public resources – in a way that water and sanitation issues do not. Hutton and Haller (2004) show how investments in the water sector can both generate economic benefits that considerably outweigh costs and contribute to human development. Economic benefits ranging from US$ 3 to 34 per dollar invested would be gained in the health, agricultural and industrial sectors if the MDGs related to water and sanitation were achieved. The benefits would include an average global reduction of 10 percent in diarrhoeal episodes and some US$ 7.3 billion in health-related cost would be avoided. Not only do the economic benefits far outweigh the costs, but the investment in improved water and sanitation infrastructure also accelerates economic growth.

Water supply also is an important ethical issue. Lord Selborne (2000) suggests that debates on water resources management, the broader concept in which water supply is embedded, mirror broader debates on social ethics and relate to what many consider universal ethical principles. The UN Universal Declaration of Human Rights of 1948 and the proclamation of the 1977 UN Water Conference claimed that 'all peoples … have the right to have access to drinking water in quantities and of a quality equal to their basic needs.' Lord Selborne relates this basic right to six universal ethical principles. The three that have most bearing on drinking water supply are:

- The principle of human dignity, for there is no life without water and those to whom it is denied are denied life;
- The principle of participation, for all individuals, especially the poor must be involved in water planning and management, and gender and poverty issues must be recognized in fostering this process;
- The principle of solidarity, for water continually confronts humans with their upstream and downstream interdependency.

He makes an appeal to international solidarity because "the cost of building and operating water infrastructure is so high that many developing countries cannot make adequate provision for much of the population. Increasingly, capital will have to come from the private as well as the traditional public sector, raising serious ethical issues such as transparency and openness of information to the public and compatibility with basic values and beliefs concerning resource ownership and rights" (Lord Selborne, 2000, p. 8).

Funding indeed raises the important ethical issue of sharing of benefits. Over the last decades international and national funding has mainly been used for heavily subsidised urban projects developed and managed by governments and external support agencies. For example, between 1980 and 1990 only three percent of the water-sector lending of the World Bank was for rural water supply. Between 1990 and 2000 this increased to 11 percent (Ringskog, 2002). Politically, it is the urban folks who have the clout. With the seat of power and the political/economic elites typically in the urban areas, it is to be expected that available funds are spent there. As well as their own comfort, urban planners and decision makers have other pressures to improve urban water services, as the threat of epidemic due to waterborne diseases grows when population density increases (Missen, 1990). Also, for the donor community, the urban bias is an advantage, as it involves larger projects with more opportunities for using imported hardware and advisory support from consultants.

Yet the coverage figures do not support the suggested bias towards urban areas. Whereas during the Water Decade only some 20 percent of the funding went to rural areas, this was sufficient to provide improved water supply to some 771 million rural people against some 579 million people that received improved services in urban areas (Table 1). So, the investment in urban area is much higher, not because it concerns more people, but because of the higher cost involved in the higher service level that often is being provided in urban water supply. After the Water Decade, progress in coverage continued at a lower speed and turned more in favour of the urban population, with another 493 million people being served, against 323 million in rural areas – less than half of the population reached during the Water Decade.

The challenge for the water sector

The water sector is facing important challenges in providing universal access to potable water, which is considered one of the basic human rights. Although we have entered the 21st century and despite having had an International Water Supply and Sanitation Decade, at least 1.1 billion people lack access to some form of improved water supply, with the worst coverage in rural areas (Table 1).

Table 1. Global water supply coverage

	1980[1]			**1990[2]**			**2000[2]**		
Area	Total	Access	Cov. (%)	Total	Access	Cov. (%)	Total	Access	Cov.(%)
Urban	1,737	1,600	**92**	2,292	2,179	**95**	2,845	2,672	**94**
Rural	2,698	1,190	**44**	2,974	1,961	**66**	3,210	2,284	**71**
Total	4,435	2,790	**63**	5,266	4,140	**79**	6,055	4,956	**82**

The 1980 coverage figures are the least reliable. They are extrapolated from data from some 87 developing countries with a total population of 1,870 million. Coverage in the more developed regions comprising 749 million people is assumed to be 100 percent.

1) Based on United Nations 2003, Najlis 1996, WHO 1984

2) WHO 2000 and WHO/UNICEF JMP 2004

The figures clearly indicate that over 18 percent of the world's population still have to solve their own water problems (to some extent). They do this in different ways, including: collecting rainwater; digging wells; transporting water over considerable distances; or purchasing it from local vendors. And they may pay a very high price in terms of money, effort to collect water, or poor health. In Santa Marta, Colombia, for example, poor people pay 25 times more for one litre of water than those connected to the piped water system (El Tiempo, 14 November 2004). In the world as a whole, approximately 10.8 billion cases of diarrhoea each year cause 1.7 million deaths, mostly among children under the age of five (Mathers et al., 2003; WHO, 2005). A considerable number of these cases can be attributed to poor sanitary conditions. Intestinal worms which infect about 10% of the population of the developing world are also a problem. These can be controlled through better sanitation, hygiene and water supply (Chan, 1997). Intestinal parasitic infections can lead to malnutrition, anaemia and retarded growth, depending upon the severity of the infection.

The lack of services referred to in international statistics relates particularly to developing countries. In these countries, the main concern is provision of better access to water supply and sanitation facilities and abatement of the acute risk of waterborne diseases, requiring water source protection and basic water treatment. The industrialized world, the developed countries in terms of infrastructure and industry, faces different problems. Here water supply services are in place and the acute risk of waterborne disease has largely been overcome by water treatment. The emphasis has shifted to reducing chemical and chronic risks including the potentially carcinogenic health risk from the long-term consumption of water disinfected with chlorine (Craun et al., 1994).

It is also good to mention that a new worldwide concern is emerging as it is becoming apparent that global warming may have serious impact on drinking water supply. It leads to changing patterns of rainfall, which has consequences for water availability, run-off patterns and water quality. “Effects on runoff are potentially serious as evidenced, for example, by a 50% drop in water supply to the reservoirs supplying Perth since the 1970s and near-record low water levels in storages in much of south-eastern Australia in 2002–03 due to low rainfall and high temperatures in the south-east since 1996” (Pittock, 2003). The changing rain patterns may also lead to higher run-off over a shorter period of time, which may cause flooding. This may have an important effect on water quality but also on water supply systems, making risk mitigation measures more important to ensure that water supply is available quickly after a flood occurs.

The figure of 1.1 billion people who lack access to “safe” water supply is presented in the latest report of the Task Force on Water and Sanitation, (UNDP 2005), quoting the report of the Joint Monitoring Programme (JMP) (WHO/UNICEF JMP 2000). The Task Force, however, makes an important mistake by talking about “safe” water supply, whereas the JMP, the programme that has been reporting on the progress of the water and sanitation sector since 1990, has made a significant change in its terminology by shifting from “access to **safe** water supply” to “access to some form of **improved** water supply”. This shift is the result of the JMP finding that “there is a lack of information on the safety of the water served to the population. Population-based surveys do not provide specific information on the quality of the drinking-water. Therefore, it has changed its approach for the 2000 Assessment assuming that certain types of technology are safer or more adequate than others (Table 2) and that some of them cannot be considered as coverage”.

The methodology used for the 2000 Assessment is a significant improvement, but an important limitation remains that the technology indicators shown in Table 2 are unreliable when it comes to water quality. All point water sources include water storage at the home and carrying the water from the source to the point of storage. This implies a considerable risk of contamination during transport and storage that depends on the “water culture” of the users. A household connection has a much lower risk of recontamination, but the water may be obtained from polluted sources and may not be properly treated. In many countries, service providers do not meet their legal obligation to supply safe water to the consumers. Many water supply systems both in urban and rural areas are operating intermittently and do not include water treatment. If they do, often the treatment shows very poor performance or is not used at all. In most systems maintenance problems are significant and revenue collection is low (Lloyd and Helmer, 1991; Visscher et al., 1996a and 1996b; Quiroga et al., 1997).

What emerges is a disturbing picture that is obscured by the statistics. On the one hand, it is clear that the challenge is much greater when we talk about safe water supply being the provision of enough water that is of an acceptable bacteriological and chemical quality. To ensure safe drinking water, water treatment will often be needed, which is the leading theme in this publication and still a major problem in many developing countries. On the other hand, everyone living in a specific place has access to some form of water supply. Although some of these supplies may be unacceptable to outsiders, they may be well appreciated by the local user. People create their own 'world view' and have their own perception of their situation, which is the basis for their actions. "My real world is different from your real world and this must always be so" (Russell, 1991 p.1050).

Table 2. Qualification of water technologies for Assessment 2000[1]

Technologies considered "improved"	Technologies considered not "improved"
Household connection	Unprotected spring
Public standpipe	Unprotected spring
Borehole	Vendor-provided water
Protected dug well	Bottled water[2]
Protected spring	Tanker truck provision of water
Rainwater collection	

1. Source WHO/UNICEF JMP 2000 p. 5
2. Not considered "improved" because of limitations concerning the potential quantity of supplied water, not the quality

1.4 Coping strategies falling short

To understand how people can be assisted to obtain a sustainable water supply with adequate treatment it is useful to review the approaches that have been used in the sector. Accepting that there are country-specific variations, the changes in the water sector show certain common patterns and trends. This section summarizes the main approaches to rural water supply in the sector over the last 50 years (Table 3).

Technology-driven agency projects

In the 1950s and 1960s, water supply provision increasingly gained attention from national governments and international organizations. In India, for example, the provision of drinking water supply in rural areas was primarily the responsibility of the different states, but it was observed during the mid sixties that water supply schemes were implemented only in easily accessible villages, neglecting hardcore rural areas. In response to this, the national government of India in 1972 introduced the Accelerated Rural Water Supply Programme to assist the state governments with 100 percent grant-in-aid to accelerate the coverage of problem villages (Government of India, 1996).

Table 3. Coping strategies for rural water supply in developing countries

Period	Strategy	Comment
Prior to 1970	Technology-driven agency projects	Strategic interventions in water supply became an issue for many governments, copying strategies and importing equipment.
1970-1980	Technology adjustment in agency/NGO-driven projects	In response to largely failing projects, "new" low-cost technologies were developed and used.
1980–1990	Water for all; The Water Decade; Scaling-up with community involvement	Overly ambitious goals were set and community involvement was seen as a key issue for sustainable water supply. Users should contribute at least the maintenance cost.
1990–2000	Organizational change and decentralization	Government's role was criticized and changed from provider to facilitator. A clear call for community management and private sector involvement but progress was slower than in the preceding decade.
2000 onwards	Setting new goals (MDGs) and scaling-up community management	More realistic goals were set and the need for adequate support for community management was stressed.

Latin America spear-headed developments in 1961, when governments of the Americas came together in Uruguay and agreed to join forces to speed up the socio-economic development of the region. They indicated that one of the key objectives was to provide potable water to at least 70 percent of the urban and 50 percent of the rural population in the next ten years (Salazar, 1980). They gave a number of key recommendations indicating that:

- Drinking water is not a free commodity and water tariffs need to cover the running cost as well as the construction cost.
- Good construction and competent staff are pre-requisites for water supply systems.
- Community participation is a necessary support for every water supply programme.
- Research and development to use local materials, equipment and methods help to reduce cost and support economic development.

In other parts of the world the focus on full cost recovery was not so much an issue. Rural water supply was seen as a 'social commitment' of the government, for which payment could not be sought from users. The issue of community participation was also less prominent. An important reason for this may be that Latin America has many gravity water supply systems, which offer more potential cost savings through the provision of free labour from communities than for example machine-drilled wells. Glennie (1979) seems to confirm this. He states that in Malawi organizing and training the rural communities to maintain and manage their own systems was only a leading issue in gravity piped water supply projects.

With technologies available in the industrialized countries to overcome the risk of waterborne diseases, it is understandable that when water supply appeared on the international agenda in the 1950s, the development model clearly focused on technology transfer from industrialized to developing countries. At this stage, technology was seen as the key to progress. Yet it was also recognised that the high-technology options being implemented in industrialized countries were not appropriate for rural water supplies in the developing world (Appleton, 1994). As a result of this thinking, less complicated technological options in the form of family type hand pumps and treatment technologies such as SSF were introduced in developing countries, but without considering their suitability to local conditions. The result was that many of these systems failed. For example family type hand pumps showed 75 percent failure rates in community use in India (UNICEF 2000) and slow sand filters failed completely in Peru (Lloyd et al., 1987) and Brazil (Hespanhol, 1969).

Another common element of the approach in this period was that interventions were supply driven, e.g., “external agencies controlled all or most of the financing and decision making. It is typical for such projects that they are conceived, initiated and planned by governments and external agencies with no influence from the users” (Wijk, 2001 p.17). Underlying this approach and the technology bias is the assumption that water supply is a problem in need of a technical solution to be brought about by ‘caring” (government) institutions. Engineers with good intentions, convinced of the need to bring water to the people, could access financial resources from their governments to take their concern forward. They were trained to solve technical problems and were holding the purse strings. Their solutions were also attractive for local political leaders often interested in quick results, but less pre-occupied with longer-term performance.

Agency-driven technology adjustment

In response to the failures observed in the sector, interest arose to develop new technologies better suited to the task at hand in rural water supply. The most salient experience was the UNICEF-supported development of the India Mark II hand pump (Wijk, 2001). This pump was developed especially for community use and its mass production started in 1977-1978 with 600 units a month. Annual production by the 36 Indian manufacturers licensed to produce the pump grew steadily, reaching 100,000 in 1984 and 200,000 in 1987. The pump has been widely used in India and has spread to other countries in Asia and Africa. In 1981 it was, for example, introduced in Guinea Bissau through a UNDP/UNICEF-supported project in which I worked.

Together with the pump, an innovative three-tier maintenance system was developed in India, leading (initially) to a substantial reduction in downtime. The community (first tier) was expected to do preventive maintenance but not repairs, while local mechanics (the second tier) carried out repairs. The government provided a third tier of mobile teams, each responsible for 500 hand pumps, for complex below-ground tasks (Colin, 1999).

The success of this type of appropriate technology did not go unnoticed. The OECD stressed that “Appropriate technologies, whenever they are available and technically feasible, should be used so as to minimise costs and allow programmes to reach a greater share of the public” (OECD, 1985 p.12). Unfortunately, as the number of hand pumps grew in India the system became overloaded and downtime, the time between breakdown and repair, increased to an average of 45 days due to the lack of third-tier support (Colin, 1999).

The drive towards appropriate technology was very important and made it possible to reach more people, but it was not shared by all sector professionals. Even today this unfortunately is the case. As a result we still see that high-technology options, such as package plants using chemical water treatment, are being installed in rural communities in countries such as Nicaragua and Colombia. This is done despite the fact that this type of treatment is not low-cost in terms of operation and maintenance and has a very bad performance record in rural water supply systems in the developing world.

Community involvement

In parallel with the focus on appropriate technology, community involvement became an issue on the international agenda, spearheaded by countries in Latin America that had been experimenting with it since the early 1960s. In 1977, the Mar del Plata Conference recommended that “countries should adopt policies for the mobilisation of users and local labour in the construction, operation and maintenance of projects for the supply of drinking water and the disposal of waste water” (United Nations, 1977 p.25). This was the consensus at that time, but already groups of sector professionals took the idea further, stating that the situation could only be improved by establishing a partnership between communities and the government (IRC, 1977).

Community involvement was adopted by different actors in different ways as can be seen from the 1985 report of the Development Assistance Committee, stating that: “there is no blue-print for involving the community in the planning and decision making process, but it is essential to build on the existing structures or organizations in the communities and to avoid creating new ones. A common approach to community participation has not been established. Donor-supported programmes follow different approaches even in the same country” (OECD, 1985 p. 11). This diversity was actually an issue of ‘parallel developments in splendid isolation’ with high ‘opportunity cost’ for the recipient countries who were encouraged (forced) to follow the ideas of the international support organizations. In essence, communities were primarily involved in the construction of the systems but hardly took part in decision making. Furthermore the emphasis remained on construction and to a much lesser extent on the operation and maintenance of completed systems and effective use of water.

In this context it is also good to realize that many agency projects that were called ‘participatory’ were in practice supply-driven blueprint projects, because people’s participation was limited to providing physical contributions to strictly planned top-down government interventions (Wijk, 2001).

Scaling-up: the Water Decade

An important stimulus for the sector came from the targets that were set for the Water Decade. These were new in terms of their worldwide application, but already had a track record in Latin America, where progress in the sector was ahead of other areas. The Water Decade also stimulated a review of experiences, and findings were mixed, to say the least. A review of different evaluations as reported by Wijk (2001) shows that:

- Many projects were engineering-led and involved no or few social scientists;
- Target-driven construction programmes had high outputs but poor results in maintenance and use;
- Strategies to involve communities were limited, with users (women) hardly having a role;
- Maintenance of facilities was a crucial bottleneck. When projects were in place, maintenance was often carried out by project teams with reasonable performance of the facilities (hand-pump wells), but one year after completion of projects, performance was dramatically lower, with breakdown rates in some countries being 50 to 60 percent.
- Existing systems are falling apart or must continuously be renovated.

Where results were not positive, pressure grew to do things differently and a strong call was made to involve NGOs and the private sector. "Yet despite this growing pressure most infrastructure improvements are still undertaken through government projects and programmes" (Wijk, 2001). This is also reflected in the funding situation. During the first five years of the Water Decade, national governments invested some US$ 12 billion per year in the sector, representing approximately seven times the investment of the donors. In the second half of the decade, national investments dropped to some US$ 6.4 billion per year, whereas donor contributions increased to some US$ 2.9 billion (Ling, 1993). National investments started to decline in 1983, just at the moment that the net flow of financial resources reversed. The developing countries changed from net receivers into net suppliers of financial resources. In 1988 the developing countries paid US$ 30 billion to the industrialized countries, some three times the level of the annual investment in drinking water supply and sanitation (Global consultation secretariat, 1990).

An important development during the decade was the concept of Village Level Operation and Maintenance (VLOM) in response to the important operation and maintenance problems that were experienced in all hand-pump programmes.

As early as 1975, the term 'village technology' had been introduced by Macpherson and Jackson, to indicate a technology in which both construction and repair could be undertaken by villagers. This could be achieved by, as far as possible, substituting wood for metal, and by using materials known to and used by villagers (UNDP, 1977). UNICEF supported further work on this issue, including a meeting on "Simple Technology for the Rural Family" in 1976. It noted that the term 'village technology' does not just represent a collection of labour-saving devices. Its development and implementation require an attitude of mind which says, in effect: How can we use our own approach to this problem by using our own ingenuity, our own skills, and the resources which are available to us? No idea is too 'old fashioned' or too 'far-fetched' so long as it provides a pragmatic answer to a local need in a manner which is appropriate to local ways of life and local resources (UNICEF News, issue 90). This resulted in bottom-up projects that focused on the development of appropriate technology, building on locally available materials, sometimes completely neglecting potentially positive inputs from outside. This approach has similarities with the bottom-up approach that Röling (1988) describes in relation to the agriculture sector, which sometimes also overemphasizes participation, local knowledge and local problem-solving capacity.

The VLOM concept was different, as it did not have the connotation of the use of local materials and local expertise for its development. To satisfy its definition, a VLOM technology would have to be:

- Easily maintained by a village caretaker, needing minimal skills and few tools;
- Manufactured in-country, primarily to ensure the availability of spare parts;
- Robust and reliable under field conditions; and
- Cost effective (Arlosoroff, 1987).

With this concept in mind, the UNDP/World Bank Hand pump Programme initiated the development of a new pump, the AFRIDEV, which was tested in Kenya in 1985.

The AFRIDEV uses the revolutionary concept of an open-top cylinder. The rising main has the same diameter as the cylinder and this allows removal of both the foot-valve and the plunger through the rising main. This common maintenance task now no longer requires a technical team, but can be easily done by a local male or female caretaker. The same concept was also adopted in India and led to the development of the India Mark III model, produced according to the Indian Standard of 1991. The Mark III has many common components with the Mark II except for the rising main and the open top cylinder, which make it easy to maintain.

"The introduction of VLOM should have heralded a new era of sustainability in rural water supply schemes. Sadly, this did not happen and by the early 1990s pumps had fallen into disrepair throughout the developing world. It was clear that hand pumps, including some VLOM designs, despite their many advantages were not living up to earlier expectations" (Colin, 1999 p.6). Colin presents different reasons for the problems, which can be condensed to three important considerations:

- The VLOM technology has an important potential but it was introduced before it was "ripe". Problems with the PVC rising mains, pump-rods and the removal of plunger seals, became apparent when research funds had more or less dried up;

- A general problem with ground water supply, is the high cost of wells particularly in Africa and the sometimes poor quality of wells, leading to sand intrusion and siltation
- The lack of understanding that VLOM is not a technical concept.

The last point in particular is an important obstacle, which very much has to do with the technology-transfer approach that was being followed. Often it is assumed that communities are willing and able to take up maintenance tasks. But this does not come automatically. The more successful VLOM projects took a period of several years of training and support of the community. They also guaranteed back-up support when needed. Evaluations of more successful VLOM projects such as the Karonga project in Malawi and the Imhambane project in Mozambique show that over 95 percent of the pumps are working. Communities mainly repaired their own hand pumps, but did require occasional outside support for more comprehensive repairs. Even in these projects, difficulties did exist. Preventive maintenance was lacking; and in some communities tools had been lost. Also some of the trained pump attendants were no longer in the communities (Kleemeijer, 1997 and Obiols and Bauman, 1998 cited in Colin 1999).

This clearly shows that VLOM technology also needs an enabling environment that often has to be created by the government. Availability of spare parts and back-up support for more complex repairs needs to be guaranteed and training opportunities are required for new pump attendants. Also government agencies have to accept their new role, including the fact that their staff no longer will do the repairs. This is threatening because it implies that they have to lay off staff, which in many countries implies less opportunities for 'fringe benefits' such as hiring relatives and friends.

So, whereas progress was made in terms of technology development, the clear message is that a technical approach is not sufficient. Furthermore it should be remembered that "neither the top-down nor the bottom-up approach alone seems able to lead to sustainable solutions. The bottom-up approach leads to a client service which may be effective but does not introduce change; the top-down approach may lead to change introduced to no effect" (Röling, 1988). A much more comprehensive approach was needed that combined the good elements of both top-down and bottom-up approaches to technology development and utilization.

Organizational change and decentralization

It has become increasingly evident that the approaches taken so far and the level of funding provided do not come close to the level required to achieve full coverage at any time in the near future. Ultimately the solution will depend on people's ability to pay for services and the ability of water 'companies' whether public or private, to provide services in an efficient and environmentally sustainable manner (Najlis, 1996).

"The principal challenges of the next decade will not be technological questions – the 'hardware' of water supply and sanitation – but the 'software' issues. How are water and sanitation programmes to be organized and financed? How can people be trained, organized, and motivated to install, use, and maintain the facilities? How can institutions develop the sector further and make improvements more sustainable? These were the questions for the 1990s. We do not have complete answers, but we have learned important lessons be it often by small groups. There is a need to make this experience widely available so that others do not have to gain it the hard way" (Cairncross, 1992 p. 1).

Donor agencies started to follow a new strategy, exemplified by the Swedish International Development Cooperation Agency, which stated that its strategic role is geared towards comprehensive tasks such as the analysis of project conditions, preparatory planning and guidance, follow-up and evaluation and feed-back. Implementation was considered the task of the recipient (local) governments (Wilkens, 1990).

The 1990s were marked by a proliferation of international meetings to discuss the water supply sector, but mostly in the context of the broader water resources issue. This contributed to an advance in the rhetoric and in the development of new alliances at the international level with a stronger role for the private sector. At the same time, the number of additional people provided with access to improved water supply dropped from 1,350 million during the Water Decade of the 1980s to 813 million in the subsequent decade.

It is not so easy to establish the main cause for this lower rate of achievement. For many countries, the financial situation deteriorated, which led to reduced spending on water supply. New systems became more costly because they had to be built in more difficult areas. An important change took place in the actors who were involved in the sector, with the government gradually changing its role from implementer to facilitator. The call for decentralization placed the responsibility for public service delivery, including water supply and sanitation, in the hands of municipalities and communities. Often this responsibility is assigned without strengthening the local level in technical, financial and administrative terms (Galvis et al., 1997).

In practice, the situation was even more worrying. Government agencies involved in water supply planning and implementation were dismantled and staff that earlier was available to support community water supply systems was put on other tasks or laid off. For example, health promoters in Colombia, who earlier were involved in project construction, and who were the backbone of the support system for the committees in charge of water systems, were given a new role. They were to start monitoring water quality, with very little financial support and no technical back-up. Their earlier tasks were handed over to municipalities that unfortunately did not have the technical and organizational capacity to take them up. Private-sector involvement did not really increase as this sector is weak in many countries and less interested in operating in rural areas and small communities. In countries such as Ecuador, Bolivia and Peru, NGOs started to compete in tenders, for example for World Bank-supported rural water supply programmes. So they partly became the ‘new’ private sector for rural water supply, monitored by inexperienced government staff.

Scaling-up community management

Towards the turn of the century, community management was beginning to be seen as an alternative to the failure of supply-driven approaches to providing rural water supply services, which often did not meet the real needs of users and resulted in systems which broke down far earlier than the end of the design period. There is now a growing body of evidence to suggest that better quality participatory planning and management leads to better performing community water supplies (Narayan, 1995; Gross et al., 2001; Wijk, 2001).

However, community management is by no means problem-free. Despite strong investment in capacity building in many projects, a significant number of systems still run into problems. Widespread evidence suggests that after a number of years of operation, many rural systems will face a variety of problems and obstacles if they are to maintain services, even under the community-management approach. The challenge is huge, particularly taking into account that, so far, community-management projects have been mainly small in scale but comprehensive in approach, including elements of mobilization, participation, needs assessment, willingness-to-pay surveys, capacity building and, eventually, project implementation (Schouten et al., 2003).

Community management was increasingly being adopted in national policy and legislation frameworks as the favoured approach to operate and maintain rural water supply systems. To date, however, there has been little sign of community management being successful, either in reducing the unacceptably high numbers of people unserved, or in improving the sustainable performance of systems (ibid). The emerging picture is that sector practitioners do not yet sufficiently master the skills needed to embrace community management and do not receive the necessary support. For many practitioners, and especially government officials and staff, it remains a major and difficult change in mentality to truly team up with the community and to change from a project approach to a service approach with a longer (indefinite) time frame. They claim that this process is more time-consuming and therefore they prefer to stick to traditional supply-driven approaches, despite the numerous examples that end in failure.

Meeting the Millennium Development Goals

Meeting the MDGs (see Page 1) is a huge challenge. If we accept the statistics (Table 1 in section 1.4), it will be necessary to reverse the downward trend in people acquiring access. This requires doing considerably better than during the Water Decade. Promising developments are being reported from countries such as South Africa and Uganda but in other countries progress is less positive. Overall coverage in Uganda increased from 52 percent to 58 percent between June 2002 and 2003 (Quarterly newsletter European delegation in Uganda, March 2004). This level of progress suggests that Uganda could exceed the MDG target, provided it can sustain the existing and newly constructed systems. According to Sinclair (2004), Uganda's recognition for this achievement is well deserved, particularly in reference to the creation of an enabling institutional environment. The sector-reform programme of the late 1990s transformed the way rural water services were delivered. With strong central leadership and new roles for district-level organizations, the reforms enabled the government to marshal considerable increases in financing for the sector, from both domestic and international sources. The decentralized approach used the private sector as the main implementing agent. With the number of water supply installations across the country climbing steadily, there was optimism that the ambitious targets set by government, aiming for full coverage by 2015, would be achieved.

However Sinclair (2004) states that reaching full, sustainable coverage in the rural water sector will take much longer than expected because:

- The simple coverage rate overestimates the number of people with a sustainable and reliable supply.
- The number of systems has grown dramatically but issues which affect long-term sustainability have been neglected. Significant improvements are needed in the quality of service delivery, in accountability (to reduce corruption), in community involvement and in back-up support provided by local government.
- It will be increasingly difficult to maintain the rate of progress because of high population growth, higher-cost technologies, general overhead cost increases and a growing scarcity of donor and government funding for the sector.

Water quality a serious problem

The MDGs call for halving the number of people that do not have access to **safe** water supply by 2015, but in fact deal with access to some form of **improved** water supply. The word safe implies that water treatment both in existing and new rural water supply systems becomes a key issue for those countries that rely heavily on surface water, such as Colombia, Bolivia, Peru and many others, but also for countries with ground water quality problems such as Bangladesh and India.

Safe drinking water is of great importance for the health and well-being of people and for their economic development. The number of people that do not have access to safe water supply is considerably higher than the official figure of 1.1 billion, because the people that are considered to have an improved water supply often receive water that is not safe for human consumption.

In Colombia, for example, 80 percent of the water supply systems depend on surface water (Foster et al., 1987), which is often subject to bacteriological and sometimes to chemical contamination. To avoid the risk of disease transmission, this water needs to be treated. This can be done by the users, for example, by boiling the water before they use it, or by including water treatment in the water supply system. At present only few of the water supply systems in rural areas and small towns include adequate water treatment.

To continue with the example of Colombia, only some 16 percent of the small urban centres below 10,000 were considered to have adequate treatment in 1997. In rural areas the situation is even more critical. According to a 2002 survey, only seven percent of rural water supply received some form of treatment (El Tiempo, 04-11-2004) and only in part of these could the treatment be considered effective. In Bolivia, the situation appears even more critical. Only one percent of the systems in rural areas and rural centres include treatment, and even that is often not reliable, with the result that few people living in these areas have a 'safe' water supply (Sanchez and Quiroga, 1996).

Designing appropriate water treatment for communities with less than about 15,000 population in developing countries is very complex, as the treatment has to function in a very constrained environment. The treatment process therefore has to be robust, reliable and relatively simple to operate and maintain. Water treatment by SSF meets these criteria and by MSF even more so, as it is a combination of SSF and gravel filtration. As will be further explained in chapter 3, this type of water treatment involves a combination of biological, physical and chemical processes. The biological process is strongest in the 'Schmutzdecke', the 'dirt layer' that is formed on top of the sand bed in the SSF, due to straining and absorption of material from the water, biological growth, etc. Operation and maintenance can be carried out by local operators, but, because of the biological nature of the process, it requires good care, particularly in controlling the filtration rate and in the different cleaning processes involved. It follows that the operator and the community need to understand the treatment process; they must learn to manage the water-ecosystem that SSF represents. A close involvement of the community is essential, as this may help to protect the water catchment area, reduce possible conflicts over multiple water use and encourage efficient water use, so putting less pressure on the SSF water treatment process.

As will be shown in this document, community water supply treatment requires a paradigm shift. It needs more than a 'technical intervention'. It requires collaboration between communities and external agencies (private sector, NGOs and government). But foremost it needs a change in perception and attitude of the agency staff as well as of the communities. This can only happen if we are willing to learn together and to bring new perspectives in sector programmes and in training and education. Otherwise history could repeat itself as was suggested in a project meeting in Colombia in 2004 when staff of an implementing agency still talked about such issues as:

> *"I need the people to participate in the project"*
> *"When I present "my project" to the community"*
> *"I start to organise the people from the start"*
> (Field notes Visscher, April 2004)

This is quite similar to the attitude voiced in 1989:

> *"I tried to get women's participation, but they wouldn't come to my meetings (Melchior, 1989).*

So sector practices do not change that easily, despite the general agreement at the international level and the wealth of literature stating that the role of the government needs to change from implementer to facilitator, and that communities have the right to decide their own future. Putting "new ideas" into practice clearly needs more than training in which agency staff and external advisors maintain a 'paternalistic approach'. Interestingly, they often are reinforced in that role by communities, who themselves do not seem to know how to work differently with agencies, perhaps because they have never had the opportunity to do so or are afraid that they will "get less out of it". So, the crucial question remains how institutions and communities can learn to share decision-making powers better, to take care of the problems at hand, and to benefit more from the innovations that are developing in the sector.

1.5 The purpose of this study

Two important projects, the SSF and the TRANSCOL project have been implemented to promote wider application of respectively SSF and MSF water treatment technology in developing countries. The experience of these two projects is very important, particularly when taking into account that without *good water treatment*, the MDGs will remain a dream. So what can be learned from these projects about the technology and the methodology that has been used? What can be learned from the 'learning projects' that I mentioned in section 1.1? Are they a practical way to enhance information sharing and to develop sustainable solutions? Can this experience generate new approaches? The overview of the strategies that have been used in the sector over the last 40 years clearly shows that new venues have to be found to build capacity of sector staff, enhance collaboration and ensure the sustainable functioning of water supply and sanitation[4] systems.

With so many millions of people still deprived of safe drinking water supply, it is essential to build on both positive and negative lessons from the past. With this in mind, I have taken up the challenge in this study to systematize the experience gained in the SSF and the TRANSCOL projects. I also review the development of CINARA, the partner organization in TRANSCOL in Colombia, which has played an important role as process facilitator. Its staff learned the task on the job and CINARA continued to play its role in the sector after the project ended.

The purposes of my enquiry

The **first purpose** of my enquiry is to understand better the introduction of rural water supply treatment by SSF in the SSF project and the TRANSCOL project. This enquiry spans a period of 30 years as is shown in Table 4.
Under this exploratory first part of the research, I will address the following research questions:

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[4] I mention sanitation here although this study particularly concerns water supply, just to stress that the evidence is very convincing that the provision of water supply alone is not enough for improved health and economic development. It needs to be combined with improved sanitation and hygiene behaviour.

- Was the introduction of water treatment by SSF in the participating communities and countries successful?
- Has an effective facilitation approach emerged for the introduction of this water treatment technology?
- Have the conditions been created to sustain the technology?

By answering these questions I hope to clarify whether participants in the SSF project and TRANSCOL project have really shared their experience, have appropriated the technologies and methodologies concerned, and have continued to use and introduce them. I assess the level of success on the basis of three important dependent variables:

1. The performance of the systems judged on the basis of a physical inspection of the treatment plant and a review of performance data
2. The way operators carry out their maintenance tasks
3. The replication of the SSF technology and project methodology in other communities.

I will include a focus on knowledge sharing and on different platforms of decision making related to these projects, as well as on their interactions. The main stakeholders comprise: policy makers at the national and international level who set the boundaries for sector interventions; the project team facilitators; agency staff often with an engineering background; community representatives; water operators; and community members – the end users.

The **second purpose** of enquiry concerns the challenge of contributing to the development of an effective approach to introduce water treatment in community water supply and to assess whether this also has potential for solving other community water supply and sanitation problems. Under this line of enquiry I will:

- Review the key components of the 'joint learning project' approach that contributed to the introduction of water supply treatment in Colombia;
- Explore what further changes are needed to develop it into a comprehensive

Table 4. Time-line reflected in this study

Period	Activity
1975–1977	Testing the technology: Technical scale research of SSF in six countries (The first phase of the SSF project)
1977–1981	Research and Development in full scale community plants
1982–1983	Dissemination of results
1983–1986	Revisiting some research issues and publication of results
1987	First Intermezzo: Rethinking the Approach
1989–1996	Development and transfer of Multi-Stage Filtration Technology in Colombia, the TRANSCOL project
1996–2004	Other interventions by staff involved in the earlier projects
2004	Second Intermezzo: Revisiting the TRANSCOL project
2005	Formulation of an emerging strategy with the acronym FLAIR

methodology to Facilitate Learning, Application, Implementation and Reflection in the water sector.

The field of analysis

The experience that is reviewed in this study arose in different settings. *Contextualization* is taken into account in the case studies and it will be shown that the context has an important effect on the potential success of the introduction of water treatment technology. Water quality is a complex issue, connected to the 'frames', interests and ideas of the different actors involved. Some may be aware of the risk of bacteriological contamination and be concerned for themselves or for their children; others may think we have been drinking this water all our lives so why does it need treatment. Some may see it as a way to make money; others to gain votes, etc. For all these reasons, it was necessary to widen the field of analysis beyond technical and organizational aspects, and to get a better feel for the human dimension and people's interest in water quality.

Initially, I was particularly interested in the potential adoption of SSF technology and whether the actors involved continued implementation after the project ended and adapted it in the course of time. Reflecting on this when the SSF project came to a close influenced the design of TRANSCOL and led to the development of the learning project approach. Therefore, I felt that it would be worthwhile to explore both, the adoption of SSF and the development of the 'learning project approach'. The SSF and TRANSCOL projects comprise a very rich experience and an important learning ground for me as well as for colleagues from the project countries and from IRC. Critically documenting and reviewing this experience very much helps to structure the ideas behind it. It also creates a tool for discussion with others and confronting their views; and it contributes to the learning needed to improve the situation in the developing world.

I feel comfortable with the suggestion by Maxwell (1984:7 quoted in Lammerink, 1993) that "the basic (humanitarian) aim of inquiry is to help to promote human welfare, help people realize what is of value to them in life. (...) But in order to realize what is of value to them, the primary problems they need to solve are problems of action - personal and social problems of action as encountered in life". In this I also sympathize with the statement of Bohm, (1993), quoted in Röling, (1995), that: "it is not the task of science to enlarge the quantity of knowledge, but to formulate new perspectives".

Structure of this document

The structure of this document largely follows the timeline presented in Table 4. In chapter 2, the approach to the enquiry process is presented. In chapter 3, a number of key issues related to sustainable community water supply and water treatment are discussed, including important performance indicators to characterize the level of service that is being provided. The chapter also describes the importance of the human factor in community water supply and ends with a detailed description of water treatment, SSF and MSF. In chapter 4, the conceptual framework is presented that guided the development and implementation of the SSF project. Chapter 5 presents the first case study: SSF multi-country research and demonstration project. The reflection in chapter 6 revisits the conceptual framework and brings in several new elements that were crucial for the development of the TRANSCOL project aimed at the introduction of MSF water treatment (SSF combined with pre-treatment) in Colombia. The TRANSCOL project itself is the second case study, and is described in chapter 7. This is followed by a new Intermezzo in chapter 8, to reflect on the emergent theory about water project interventions that involve treatment with the required institutional framework, including facilitation and the role of CINARA. The final chapter 9 is used to draw conclusions about the development of thinking about water project interventions and to present the design of FLAIR, Facilitating of Learning, Application, Implementation and Reflection, an emerging approach to facilitate interventions in community water supply and in 'learning projects'.

2. Approach to the enquiry process

> *"He who exactly knows where he is heading for, is precisely the person who never will discover anything as he is only obsessed with the point of departure and the point to reach." Manfred Max-Neef*

This chapter presents the exploratory research that has been used to understand how the approach of IRC and its partners to the introduction of drinking water treatment using SSF in rural water supply has changed since its inception in the 1970s. This study partly reflects on my own practice, as I have been involved in these activities since 1982 and played a major role as project manager in the period 1983 to 1997. A number of choices are described with regard to the focus and structure of the research: its organization, the type of research approaches and the theoretical underpinning. Two main methods are used, grounded theory and the case-study approach. Reflecting on my own experience makes it essential to be very critical. To ensure that the study is credible I have made ample use of external and internal evaluation reports and have sought feedback from actors involved in the process.

The conceptual starting point of the study is the conventional approach to technology transfer that formed the basis for the SSF project in the period 1975 – 1983. SSF had a long track record in Europe where it has proven to be a reliable and robust technology, but few new plants were being built, as the focus had shifted to Rapid Sand Filtration (RSF), a technology based on dosing with chemicals to destabilize the suspended solids and encourage the formation of flocs that can be removed by filtration. RSF makes it possible to apply higher filtration rates, thus requiring smaller treatment plants. However, the plants are more difficult to operate and require continuous dosing with chemicals, making them hardly appropriate for use in rural areas of developing countries.

The set-up for the SSF project was designed by Europe-based experts in consultation with leaders from research institutions from a number of developing countries. I follow the flow of the project as reflected in project documents and internal and external evaluations in general, and in more detail in two of the project countries, India and Colombia, where project activities have continued after the initial SSF project ended in 1983.

In the period between 1984 and 1988, activities continued along the lines of the original project, but the project partners acquired a bigger say in development and new elements were introduced, particularly in Colombia where there was a closer involvement of communities and much greater emphasis on pre-treatment. This period allowed for the necessary reflection and resulted in the conceptual starting point moving from technology transfer through demonstration to 'joint learning'. Bringing in the issue of learning was a crucial paradigm shift that proved to be difficult but very rewarding, as will be discussed in chapter 6 in the description of the first intermezzo. The new paradigm formed the basis for the TRANSCOL project, which was initially established for a period of three years to achieve a similar objective to the earlier SSF project, i.e. the introduction of SSF-based water treatment in community water supply, but this time confined to eight regions in Colombia. However, the project was extended to a period of almost seven years, which allowed an adaptive approach to implementation. During this period the 'joint learning project' developed and its application continued after the project, albeit in a less systematic way because of funding constraints. Facilitation is the key to these projects and to sustainable interventions in the sector – hence FLAIR, Facilitating of Learning, Application, Implementation and Reflection,

A reflexive perspective

In looking back and trying to understand and learn from past experiences in a reflexive fashion, this study deals with what Kronenburg (1986) calls "research after action". This type of research recognizes that valuable knowledge gained through personal involvement in change processes can be lost if not recorded in a disciplined way. It also deals with action as part of research, continuously adjusting strategies and approaches on the basis of experience obtained.

In fact, the empirical development of the learning projects has been a continuous process of reflection and adjustment and is the result of many interactions with friends and colleagues from different parts of the world. I mention particularly Mariela Garcia, Gerardo Galvis, and Edgar Quiroga from CINARA in Colombia. This activity represents experiential learning on a large scale that needs to be captured. Bringing this experience together and returning to several of the project staff and project communities ten years after the TRANSCOL project ended makes it possible to further consolidate the experience and to present FLAIR as the methodology that is emerging from the enquiry.

2.1 Methodological viewpoint

The study of the introduction of SSF in the project countries is complex. On the one hand, it comprises elements that can be treated as an external reality, as objective facts that adhere to a positivist research design. Examples are the performance of the system and the number of new systems being built. These provide 'quantitative measures of success' that are objectively verifiable.

On the other hand, many elements of the projects concern issues that can only be studied in qualitative terms. These include: innovation and adoption of the technology and the facilitation and learning processes involved. For these I believe that several models and constructions exist for the different actors involved. This matches the constructivist view that reality is not objective, but constructed and given meaning by the individual – so multiple realities exist (Guba and Lincon, 1998). So, from a methodological viewpoint I will rely on the use of multiple analytical and evaluative methods to try to understand the different perspectives and to give meaning to the phenomena studied.

Taking into account that the introduction of SSF took place in different communities and different countries, a case-study approach seemed the most appropriate to capture the experience. An added complexity is that the approach to the introduction of the technology changed over time and my intention is to study this process, which emerged from interaction among different stakeholders. I have therefore established an initial theoretical framework based on the assumptions that were underlying the initial development of the project in the 1970s. I then use grounded theory to adjust and improve upon this framework so that the case-study reviews related to the TRANSCOL project reflect the theoretical change that developed over time.

2.2 Grounded theory

My study uses grounded theory as a methodology to develop theory from the data that I have gathered and analyzed. The sources of qualitative and quantitative data I use are not different from data used for other qualitative research, such as interviews, observations and documents of all kinds.

The developers of the methodology, Glaser and Straus (1967), took the position that "The adequacy of a theory for sociology today cannot be divorced from the process from which it is generated". Theory consists of plausible relationships proposed among concepts and sets of concepts. Theory evolves during actual research, and it does this through the continuous interplay between analysis and data collection (Straus and Corbin, 1994 p. 278)." This fits very well the process that was followed in the projects I am reviewing. Straus and Corbin (1994) further indicate that theories developed in grounded theory are always traceable to the data that gave rise to them – within the interactive context of data collection and data analyzing, in which the analyst is also a crucially significant interactant. Grounded theory is very fluid as it embraces the interaction of multiple actors and because it emphasizes temporality and process. All interpretations are always provisional; they are never established forever and are limited in time as conditions change.

"Theory may be generated initially from the data, or, if existing, (grounded) theories that seem appropriate in the area of investigation, these then can be elaborated and modified as incoming data are meticulously played against them" (ibid p. 273). Grounded theory has two key analytical features: the constant comparative method and theoretical sampling. The comparative method begins as soon as researchers start forming provisional categories from data. While coding an incident in a category, it is compared with previous incidents in the same category and in my case with the initial theories that were formulated. As a consequence, theoretical properties of categories are generated. As coding continues, new incidents are compared with the properties of the emerging categories. This comparison also guides the selection of additional data, the so-called theoretical sampling (Glaser and Straus, 1967; Straus and Corbin 1994). Locke (1996 p. 240) emphasizes that "the grounded theory approach requires not only that data and theory be constantly compared and contrasted during data collection and analysis but also that the materialising theory drives ongoing data collection”. In my case, this resulted for example in the formulation of new perspectives in the course of the TRANSCOL project and in the collection of data from other systems developed after this project. In my study I follow the views of Strauss and Corbin summarized by Locke (1996) that a researcher should be actively involved in the research process, essentially interrogating the collected data to arrive at conceptual categories. Their stand also allows me to bring *a priori* knowledge to the research project and to use existing theory, non-academic publications and professional experience to gain insight into the data (ibid). Like Guba and Lincoln (1989 p. 99), I indeed experienced that research outcomes are partially shaped during the course of inquiry by the interaction between the actors and me, even though I was keeping a low profile.

I am interested in conceptualizing the patterns of action and interaction between and among various types of social units (actors). I seek interpretations for understanding the actions of the individual and collective actors. I follow the position of Straus and Corbin (1994 p. 274) that “Those who use grounded theory accept responsibility for their interpretative roles. They do not believe it sufficient merely to report or give voice to the viewpoints of the people, groups, or organizations studied. They assume the further responsibility of interpreting what is observed, heard, or read”.

This is a clear constructivist or relativist stand, as different researchers will bring different experiences (realities) to the table. Constructivism claims that there exist multiple, socially constructed realities ungoverned by any natural laws (Guba and Lincoln, 1989).

On the other hand, I also base myself on positivistic grounds, as part of my research deals with facts and figures, concrete structures, specification of materials, water quality indicators, etc. The fate, or perhaps better, the challenge of a ‘social engineer’ is to try to make the best out of the mix of constructivism and positivism, to make, as Wijk (2001) called it, the best of both worlds.

By exploring the views of different actors that were involved at different levels, I systematically seek multiple perspectives, which I then critically review to bring their perspectives and interpretations into my own interpretation (conceptualization). I subsequently share the emerging substantive theory with a key group of actors to enlarge the theoretical sensitivity and credibility of the research. The latter is also achieved by comparing my findings with views developed in other fields that deal with natural resource management, which has parallels with the complex management of SSF and MSF water treatment systems.

2.3 Case study approach

Introducing SSF in community water supply involves actions and interpretations of people which in part I tried to study in depth, using case studies. Yin (1989 p. 23) suggests that a case study is an empirical inquiry that:

- Investigates a contemporary phenomenon within its real-life context; when
- The boundaries between phenomenon and context are not clearly evident; and in which
- Multiple sources of evidence are used.

According to Stake (1995), a case study is the study of the particularity and complexity of a case, coming to understand its activity within important circumstances. He suggests that: "Qualitative case study is highly personal research. Researchers are encouraged to include their own personal perspectives in the interpretation. The way the case and the researcher interact is presumed unique and not necessarily reproducible for other cases and researchers. The quality and utility of the research is not based on its reproducibility but on whether or not the meanings generated by the researcher or the reader are valued. Thus a personal valuing of the work is expected" (Stake, 1995 p.135). He also warns against including too much information in the case studies. This indeed was a major issue when looking at the very rich experience of the projects under review. The experience can involve telling many stories, which may have commonalities in their technical data in terms of number of SSF systems and their performance, but differences in other aspects and in the interpretation of findings. Yin (1994) indicates that a case study is a good approach to seek answers to 'how' and 'why' questions, the type of question I pose in this research. He presents four principles to obtain the highest quality that I will take into account:

- Show that the analysis relied on all the relevant evidence
- Include all major rival interpretations in the analysis
- Address the most significant aspect of the case study
- Use the researcher's prior, expert knowledge to further the analysis

I carry out what Stake (1995) calls collective case study and Yin (1994) case study research based on multiple cases, where the subsequent study of different cases are instrumental to gain understanding about the introduction of SSF technology and the learning involved. In fact I adopt a case study within a case study approach, selecting a number of cases within the case of the SSF project and within the case of the TRANSCOL project for a more in-depth review.

The unit of analysis

What is the 'case' in this study? Stake (1995 p.4) stresses that it is important to select cases that are likely to lead us to understandings, to assertions, perhaps even to modifications of generalizations. The cases I select come from two projects that focus on the introduction of SSF, one in six countries and the other in eight regions in one country. This implies that it is very different from the classic case study where the case is the individual. As the study concerns projects in different settings, this implies that even the domain of study can be different. As Engel (1995 p.8.) puts it: "we ourselves create our 'object of study' by applying our distinctions to events and ideas we perceive." So I adopt a similar metaphor as he does and call my domain of interest "community water supply projects as theatres of change in the water sector in developing countries". I like this metaphor, because as Engel puts it "a student of theatre may take up a position in the back row, quietly observing what is going on, or might fully engage in the play as an active member of the public or even as a stage actor". This concept encompasses both elements of struggle and harmony and in that sense it reflects very well the real situation in community water supply.

My first case is the SSF project that was implemented over a period of 12 years from 1975 to 1987, initially in six and later in two countries. I have chosen to review in part the overall project, but to pay special attention to embedded cases in India, Colombia and Thailand, as these were the countries where the development and demonstration systems in the project communities did materialise. I will just briefly reflect upon the other countries where this did not happen, as this also provides some interesting insights. I will present key characteristics of the communities selected for the case studies to enhance the understanding of the reader.

My second case concerns the TRANSCOL project that was implemented over a period of seven years from 1989 to 1996. Also in this case I have chosen to explore the overall project but to include a number of embedded case studies of the experience in a number of the project communities. I have therefore revisited some of the project communities in four of the project regions which were within a days travel from Cali, and left out project regions that were further away. Conditions in the selected systems are not expected to be different from the other regions however, as virtually all communities were very much left to themselves after the TRANSCOL project ended in 1997. I have compared the findings with other communities in the Cauca Valley that have developed water treatment using SSF after the project ended and that receive some continued support from CINARA, the project facilitating institution in Cali, Colombia. Any best possible selection of cases would not give a compelling representation for the country as a whole and certainly not a statistical basis for generalizing the findings. Nevertheless the learning may have considerable relevance for other communities in the mountainous zones in Colombia and in other countries which have rather similar characteristics to the selected cases, as I will show in the second intermezzo.

2.4 Quality check

In case-study work we wonder "Do we have it right?" Not only "Are we generating a comprehensive and accurate description of the case?" but "Are we developing the interpretations we want". In the search for accuracy and alternative explanations, we need discipline; we need protocols which do not depend on mere intuition and good intention to "get it right". In qualitative research those protocols come under the name "triangulation" (Stake, 1995 p. 107), which basically consists of the combination of methodologies to study the same phenomenon that makes it possible to compare and contrast findings. In case study we can basically use observation, interviews and document review. In my case I used data from different sources and different locations and sought feed-back from actors in the process, so that they could enrich my interpretations and findings. I also presented my findings to the team of CINARA and an international workshop in the Netherlands, before finalizing my conclusions.

In the development and interpretation of the quantitative aspects of the case studies, a set of positivistic quality checks are taken into account based on Yin (1994):

- Construct validity: Are correct operational measures selected for the concepts being studied?
- Internal validity: Are the patterns of relationship we see and conclude in the analysis real and not the result of some other factor we did not consider?
- External validity: Are findings generalizable beyond the immediate case?
- Reliability: Demonstrating that the case study can be repeated by another researcher.

I apply these checks with respect to the 'hard' side of the research, i.e. the data on the performance of sand filters, water quality, etc. The rigour of the 'soft' side of the research needs to be judged in a different way, applying a set of constructivist quality checks based on Guba and Lincoln (1994 p. 114):

- Credibility: Can the realities of the actors be matched to those attributed in this study to the actors?
- Fairness: Are the constructions made in this study clarified to and honoured by the actors?
- Authenticity: Are actors empowered to act, and do they learn in the process?

Janesick (1994 p.215) indicates that "Qualitative research depends on the presentation of solid descriptive data, so that the researcher leads the reader to an understanding of the meaning of the experience under study". He suggests that it is probably important not to be overly preoccupied with method as it may distract from the actual understanding of the experience of participants in a research project. This is a reassuring thought and underscores in my view the need to present the interpretations to the actors that have contributed to the process of enquiry.

Information from the actors was obtained through focal group discussions, semi-structured interviews, story telling and use of information collected and reported upon by others. Story telling is an important tradition in developing countries. Interest in story telling is increasing particularly in the area of knowledge sharing in organizations, because "we always know more than we can say, and we always will say more than we can write down" (Snowden, 2001). He indicates that "best practices" often hold fewer lessons than failures. Story telling may help to bring about more lessons from mistakes and it is interesting to remember that "we have to learn from the mistakes of others as we do not have enough time to make them all ourselves". So I have included story telling as part of the interviews, but it did not prove to be an easy technique, because many people, not used to being recorded, seem to shy away from their "mistakes".

Some quantitative data are provided, particularly concerning the performance of the water treatment systems in the TRANSCOL project. Reports from interviews were shared with key participants to examine if they shared the views and conclusions.
Focal group discussions with the managers involved in the SSF project and different participant groups involved in the TRANSCOL project were used to review and reflect

upon the project and its results. Reports were subsequently shared for comments and agreement. This not only consolidates the information, but also stimulates a feeling of ownership. I remember one of the participants in this process stating: “it is so nice to see your own words reflected in the report”.

The experience concerns a rather broad setting of communities and agencies in different regions of Colombia combined with key lessons from the SSF project in India, Thailand and Colombia. This provides a basis to further develop the theoretical constructs and to systematize the approach for wider application, particularly so because several of its components are supported by views and findings in literature.

2.5 The framework of analysis

To avoid the trap of telling too much, I have organised my review of the case studies of different communities that were involved in the TRANSCOL project by adopting a framework of analysis that is based on the ecological knowledge system framework (Röling and Jiggins, 1998 p. 286). This framework was developed from an earlier framework for discussing “integrated extension” presented by Röling and Salomon (1995). It permits the analysis of how facilitation supports learning-based transformation, which matches the learning concept in TRANSCOL. SSF is a complex ecological process so I could rephrase the framework without changing its meaning. For my study the framework comprises the following elements:

- The stakeholders;
- Sound practices for dealing with SSF water supply systems;
- Learning to support SSF water supply provision;
- Facilitation to support the learning;
- Institutional support system;
- Conducive policy context.

Röling and Jiggins (1998, p. 286) indicate that “these dimensions form a mutually dependent and consistent whole in that the nature of the ecologically sound practices (sound practices for dealing with SSF) makes special demands on learning, which, in turn, places special demands on the facilitation, institutional support and a conducive policy context”.

I will use this framework, relating it to the different actors (stakeholders) involved, placing emphasis on two key issues related to actors’ involvement: their reason for participation and their role in decision making.

3. Safe water supply: A complex issue

"Nothing sticks to flowing water."
Proverb from the Pacific Coast in Colombia

Human health depends on providing safe, adequate, accessible and reliable drinking water. Literature suggests that a person needs, on average, a daily intake of water that ranges from 1.8 to more than 10 litres, depending on the conditions. Someone doing hard labour in the sun requires much more water than a person resting in the shade (McJunkin, 1982; Cairncross and Feachem, 1983). This water can cause the person to become ill, as it may contain:

- Microbiological contamination that can lead to diseases such as diarrhoeas and dysenteries caused by bacteria, viruses or protozoa, enteric fevers and worm infestation.
- Chemical contamination causing diseases such as fluorosis and arsenic poisoning, as now reported from several countries, including Bangladesh.

Throughout history, people have equated clean water with health – even before the relationship was fully understood towards the end of the nineteenth century (Lord Selborne, 2000). The term 'clean', however, leaves room for (mis)interpretation. In the Pacific Coast region in Colombia, many people prefer water from the river to rainwater. They use an interesting metaphor stating that: 'nothing sticks to flowing water' meaning that for them the river water is of better quality. Sometimes they feel their 'belief' is confirmed, as visual inspection of stored rain water (which, if handled properly, is much safer in bacteriological quality than the river water) may show the presence of (harmless) mosquito larvae. The presence of these larvae indicates that some organic material is present, as they feed on it, but if the water is captured on a relative clean roof this is not likely to include harmful bacteria.

Conceptual thinking about the relationship between water and disease has gone through various stages. Initially it was the 'wisdom of the ancient' reflected for example in ancient religious codes or in the metaphor used in the Pacific Coast. A more solid epidemiological basis for the relationship stems from the study by Dr. John Snow of an 1845 outbreak of cholera in London, which predated Pasteur's germ theory of disease by one decade and Koch's identification of the causative organism, *Cholera vibrio*, by three decades. Snow's findings led, in the latter half of the 19th century, to a sanitary revolution in Europe and the United States, which resulted in a dramatic reduction in water-related disease (McJunkin 1982).

Discovery of the faecal-oral contamination route, in which harmful micro-organisms present in water or food enter the human body, led to understanding of the need to break this cycle. It should be realized that this concerns not only micro-organisms from human faeces. Many wildlife species and domestic animals can potentially shed organisms pathogenic to humans (Aramini, 2000).

Avoiding faeces entering the water and removing pathogens by water treatment are interventions in the transmission of so-called 'waterborne diseases'. "A study in 1916 shows a fall of 65 percent in typhoid mortality in 20 American cities following introduction of water supply filtration. A similar study some 50 years later in 14 Indian towns showed similar results with a fall of 63.6 percent following the introduction of water purification" (Zaheer, et al., 1962, cited in McJunkin, 1982). "The decline of waterborne disease in the U.S. closely paralleled the establishment of public water supply and sewerage and, it should be noted, economic development. Correlations were particularly strong for cities taking their water supply from unprotected water sheds, with major declines following, first, filtration and then chlorination" (McJunkin 1982 p.4).

McJunkin's study is one of many that support the water supply and health relationship, but it is not feasible to quantify this relationship with any meaningful precision. The latest global burdens of disease (GBD)[5] estimates suggest that around 4.1 percent of GBD world-wide is linked to "basic hygiene" (water, sanitation, food, hygiene behaviours), but in the poorest developing countries the percentage is around 5.8 percent (Mathers et al., 2003).

Traditionally, improvements in water supply and sanitation have been promoted as essential public health measures to improve the population's health status and reduce the burden of disease. If universal piped and regulated water supplies were to be achieved, about 7.6 billion episodes of diarrhoea could be prevented annually, a 70% reduction. These are critical interventions for the health of populations and of children in particular (WHO 2005).

Whereas the risk of microbial disease associated with drinking water is much higher in developing countries it is also still a priority concern in the U.S. "Numerous past outbreaks, together with recent studies suggesting that drinking water may be a substantial contributor to endemic (non-outbreak-related) gastroenteritis, demonstrate the vulnerability of many North American cities to waterborne diseases and have fuelled ongoing debates in Canada and the United States concerning the need for stricter water quality guidelines, changes in watershed management policies, and the need for additional water treatment" (Aramini, 2000).

3.1 The dimension of the problem

From the statistics of the Joint Monitoring Programme and the extensive literature about performance problems, water quality appears as a major challenge in terms of numbers of systems and numbers of users. The bacteriological quality of drinking water is particularly a problem in communities that depend on surface water. This is for example the situation for more than 75 percent of the communities in Ecuador and 80 percent for

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[5] The concept of GBD, the assessment of mortality and disability from disease, injuries, and risk factors in a population which is expresssed in disability-adjusted life-years (DALYs) stems from the GBD study that was supported by WHO and the World Bank (Murray CJ and Loper AD, 1996).

those in Colombia (Foster et al., 1987). The water supply for these communities almost always requires some form of water treatment. In 1992, for example, the piped urban water supply coverage in Colombia was 88 percent, but only 62 percent of the urban population had access to piped water supply with treatment, and only in some 50 percent of these systems was the type of treatment considered to be adequate to process the water. This implies that only 31 percent had access to a “safe” water supply. The situation was worst in smaller towns (<12,500 people) where only 30 percent of the systems had some type of treatment, which was adequate in only 9 percent of the systems (Ministerio de Salud, 1992). A new survey in 1997 in 641 municipalities (out of a total of 1068) showed some improvement, with 16 percent of the small urban centres below 10,000 having adequate treatment. In rural areas with a piped-water-supply coverage of 46 percent, the situation is even more critical, as indicated by a survey in 2002 which showed only 7 percent of the water supply receiving some form of treatment (El Tiempo, 04-11-2004). And this treatment may not be effective in all cases.

Another important dimension of the problem is that in many countries it involves a large number of relatively small communities. Table 5 shows the distribution of the communities in Colombia. This country has 1057 municipalities, 80 percent of which have fewer than 12,500 inhabitants in their ‘urban core’. In addition, municipalities comprise smaller hamlets where a rural population of some 13 million people lives and which often have their own water systems.

Table 5. Distribution of Colombian municipalities by population range (DANE, 1993)

Ranges based on the number of inhabitants	Number of municipalities in each range	%	Urban population in each range*
< 2,500	419	40	558,110
2,501 – 5,000	226	21	881,672
5,001 – 12,500	215	20	1,865,606
12,501 – 30,000	103	10	2,097,759
30,001 – 100,000	62	6	1,140,888
100,001 – 500,000	27	2	6,728,248
> 500,001	5	1	11,006,250
TOTAL	1,057	100%	24,278,533

* This does not include the ‘rural population’ living in the municipalities outside the centre. In 1993 the total (urban plus rural) population of Colombia was 37,448,000

Many of these are managed by local service providers such as water committees or other community-based organizations (CBOs). According to a study by the National Planning Department, some 2000 service providers exist, but only 40 percent are officially registered. In fact 2000 seems to be a low estimate because, for example, in the Valle region, which has 43 municipalities, some 742 rural settlements exist and in many of these settlements some form of committee (i.e. service provider) deals with the water supply.

The fact that so many small systems exist is an enormous risk, as most of the "small service providers" have neither the capacity to deal with the water system nor the size to attract competent staff. This can be compared for example with the situation in the USA where 46,827 small systems (between 25 and 3,300 users) serving a total of 25 million people, account for an inordinate percentage of violations under the USA Safe Drinking Water Act (Stout and Bik, 1998 cited in Galvis 1999). Yet these systems can count on free advisory support and training provided by a fully subsidized programme that is called the University Based National Drinking Water Clearing House funded by the Government (Saxena, 2001). They can reach this programme through a toll-free phone number and by email.

3.2 Sustainable community water supply

Including water treatment in water supply systems will have a positive health impact, provided the overall system performs well. This cannot be achieved by the treatment process alone, but requires a more comprehensive approach aimed at ensuring that the system is used and is sustainable.

How can we define the sustainability of a water supply service? The main thrust of the concept, as defined by the World Commission for Environment and Development in 1987, is that developments to meet the needs of the present generation should not compromise the resources, or the environmental conditions of future generations. The Development Assistance Committee of the OECD (OECD/DAC), indicated in 1988 that it considers a development programme to be sustainable when it can provide an appropriate level of benefits over an extensive period of time after the financial, administrative or technical support of an external agency has ended (OECD/DAC, 1988, cited by MDF, 1992). This definition has, in my perception, a clear donor perspective, reflecting the approach OECD member countries use in handing over completed projects to the recipient governments or communities. Warner (1990) presents the same concept, orienting it more to the community level by stating that 'the success or sustainability of a project is achieved when it meets its objectives and is maintained by its users over a significant period of time'.

It is important to note that neither definition makes a clear reference to safeguarding the environment, which is becoming more and more the shortcoming of many water supply systems. Many systems already face problems of water shortages and/or flooding because of insufficient environmental care (erosion caused by deforestation, overgrazing, etc.) or because of the more difficult environmental problem of global warming. Systems may also have an impact on the environment, For example, water may be drawn from a source and no longer be available for the local environment or may be polluted by users before it is discharged.

Hence a system may be maintained for many years, producing benefits for the present generation, but its side effects may compromise the people living downstream as well as the environment and so the wellbeing of future generations. This is not sustainable according to the World Commission for Environment and Development, but does meet the criteria of the OECD/DAC. Also it may not be reasonable to expect, as Warner appears to suggest, that the users should be left entirely on their own in keeping their system running. Although governments are changing their role from provider to facilitator (IRC, 1995), several tasks remain that cannot be catered for at community level. Some external inputs will be necessary to sustain the systems, but these should not lead to outsiders taking over the roles of men, women and children in the communities.

Taking into account the experience of CINARA and IRC, the following approximation of sustainable water supply and sanitation systems emerged (Galvis et al., 1997).

A water supply or sanitation system is sustainable when it:
- *continuously provides an efficient and reliable service at a level which is desired;*
- *can be financed or co-financed by the users with limited but feasible external support and technical assistance; and*
- *is used in an efficient way, without negatively affecting the environment.*

This definition encompasses the aspects brought forward by the OECD and by Warner (1990) and is in harmony with the WHO Minimum Evaluation Procedures, which stress functioning and use as the main issues to be reviewed (WHO, 1983).

Although the definition refers to several ‘hard’ characteristics of a water supply system, in an implicit way it also includes the suggestion by Woodhill and Röling (1998) that: “sustainability is an emergent property of a ‘soft system’. It is the outcome of the collective decision-making that arises from interaction with stakeholders”. The formulation of sustainability in this manner implies that the stakeholders have to secure agreement on what people take sustainability to mean for a given environment (Röling and Wagemakers, 1998).

Sustainability as defined with the team from CINARA implies a match between three strategic inter-linking dimensions of the overall political, legal and institutional framework in which the system needs to operate (Figure 1) (Galvis et al., 1997).

The community comprises different people usually with common and conflicting interests and ideas and different socio-economic and cultural backgrounds. The water supply system may be one such common interest, but at the same time can be a major source of conflict. The identity of people in communities is shaped by their history and their socio-economic and environmental conditions. Some of them, often the economically better off, may be better informed, may know more of the world, but on the other hand, may have certain interests in keeping the status quo and therefore may not be willing to solve certain problems. Women may have interests different from those of men and may not have been heard in the past, or their position may make it difficult to achieve changes on their own. The **environment** is the boundary that shapes the community and dictates the risks it faces and the local resources it can draw from to meet its needs. In water supply, these risks often relate to issues such as: available water resources; their pattern over the year; their level of pollution; sanitation practices of the community; and land and water use. These aspects may be affected directly by users of the catchment area as well as by the broader issue of climate change. The environmental dimension also includes the possible effect a water supply system may have on the environment, for example, by producing wastewater and chemical sludge.

The interface between environment and community represents the risk the community has to overcome in relation to, for example, its water supply. The risk-analysis helps to establish and prioritize actions to reduce the risks that will depend on the level of deterioration of the local environment. The action may focus on the reduction of the pollution level by water source protection or by introducing treatment (Galvis et al., 1997).

Technology is the combination of hardware and the knowledge to develop and sustain it. This dimension represents the possibilities and tools actors can use to reduce the environmental risks the community is facing. This risk reduction however, can only be sustainable if the community adopts the solution and gains ownership of it by making it its own.

The interface between environment and technology represents the availability of knowledge and practical options to reduce the risk, either through technical matters or change in behaviour. It deals with the viability, effectiveness and efficiency of solutions and their effect on the environment. The interface between technology and community deals with the type of solutions the community is expecting, is willing and able to manage and sustain, and that are in line with the technical, socio-economic and environmental conditions and capacities of the community.

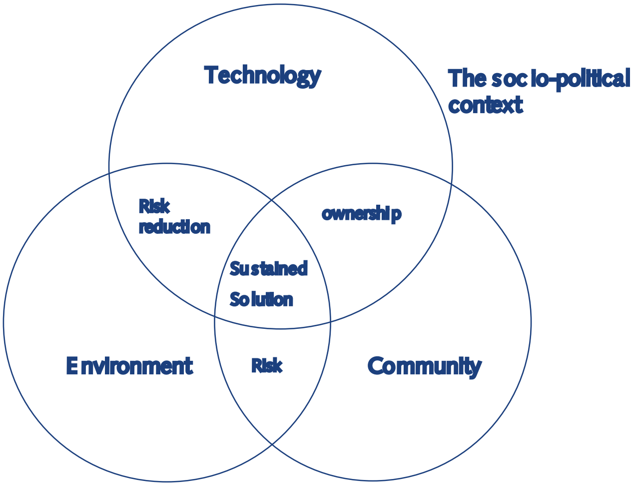

Figure 1. Conceptual framework for sustainability (Galvis, 1993; Galvis et al., 1994)

Solutions that match the three interfaces and the overall political, legal and institutional framework are most promising in terms of sustainability. This requires joint problem solving with the different actors involved and a clear role of the community and the local administrative authorities in decision making.

Some of the answers to the problems may already exist in the communities or local institutions. This calls for good communication between the actors and stimulation of their creativity and initiative. Technologies that are traditionally used in a region often are an important part of the solution, calling for a participatory review of local experience. If ‘new’ technology has to be introduced, testing is needed to allow for the necessary adaptation to the local conditions and to ensure that adequate operation and maintenance can be taken care of, before promoting large-scale application.

3.3 The level of service

This section describes five key elements to characterize the level of service and the performance of a water supply system that includes treatment (Table 6.). It includes the issue of coverage, the main issue considered in monitoring progress of the sector.

Table 6. Requirements of water supply and sanitation service provision

Coverage	Permitting equal distribution of benefits
Quantity	Sufficient to satisfy demand within reason and ensure health benefits.
Continuity	Offering access to service at the required time and location.
Quality	Needed to obtain health benefits and safeguard system performance.
Affordability	Matching users’ willingness to pay, and a rational and efficient use of resources, with special care for the environment.

(Adapted from Lloyd et al., 1987 and Galvis et al., 1997)

Coverage

It is reasonable to assume that coverage refers to the access that people in the community have to the water supply system. But this is not as straightforward as it appears to be, as in fact it is socially constructed. It depends not only on the type of system but also on the socio-economic situation and the ‘qualifications’ that are included in the indicators by the users. The Joint Monitoring Programme in the 1990s talked about coverage as being “access to safe water supply”, clearly bringing in a water quality element. However, in their 2000 report they redefined it as “access to some form of improved water supply”, as measurement of water quality was difficult to secure (WHO/UNICEF JMP 2000).

There is no standard indicator for coverage, even if it is defined as physical access only. For piped water supply, for example, it may be people with a house connection or a yard connection, but it may also include people using public stand posts. For hand pumps it is defined as the number of people within a certain radius of the pump, with the radius differing between countries and within countries over time.

Also, just measuring coverage is not sufficient because a user may be ‘covered’ by having a house connection or access to a pump, but may not receive water for most of the time because the water pressure is low or because of frequent pump breakdowns.

In evaluations carried out in Bolivia and Ecuador, CINARA/IRC defined coverage for piped water systems as the percentage of households in a locality that are connected to the system. Even this can not be interpreted with 100 percent certainty as the coverage figure for these communities as a whole, as it may well be that some households that were not connected had access to other conveniently located protected water sources.

Quantity

This is an important factor for convenience as well as health improvement. The incidence, prevalence, or severity of a number of diseases, including many of the waterborne diseases and skin and eye infections, can be reduced by using water to improve personal and domestic hygiene. These improvements in personal hygiene often depend upon increased availability and use of water. Disease reduction depends primarily on the quantity of water used, rather than its quality (Cairncross and Feachem, 1983). Enough water should be provided for drinking, cooking, food preparation and good personal and household hygiene. Bringing water close to the user reduces the time and effort involved in water collection, a benefit which is particularly important for women and children. It is very common that water supply projects only look at providing water for domestic use and pose restrictions on other uses such as watering cattle and small-scale irrigation. From the design and funding point of view this is a logical idea, as a larger volume of water requires a larger system, which is more costly. The paradox is that users do not think that way and use water that is readily available for the purpose they see fit. In Ecuador, a participatory assessment of water use with children in schools showed that most households used water for small-scale irrigation. In a subsequent survey, adult respondents categorically answered that this was not the case, even when water hoses were visible. The reason was simple: it was prohibited to use water from the system for watering vegetable gardens and cattle at the risk of being disconnected (Visscher et al., 1996a). The unfortunate effect was that people on higher locations had little or no water coming from their taps. So provisions may be needed to cater for the multiple use of water. Certainly it requires a detailed discussion with the community that includes an analysis of the environmental and socio-economic consequences. Making provision for such additional uses, although more expensive, may be very important to gain full acceptance by, and continuous support from the users, who may well be willing to pay the extra costs. Existing standards used for system designs assign global norms to water consumption, but may not be in line with the demands and capacities of the users. Therefore it is essential to discuss the implications with the community and, if needed, to deviate from existing norms, provided the water source permits this. The water service should be equally distributed to the greatest number of users possible. If water availability is a problem, users from high and low-income zones should receive identical quantities. If sufficient water is available, people who want to have more water can obtain this extra service, but perhaps at a higher price.

Continuity

Continuity concerns the continuous supply of the water and, in piped supply, under a reasonable pressure. The pressure is important to avoid risk of recontamination of water in the distribution network. Inadequate continuity can be a problem that affects only part of the community and particularly those living on higher ground. Increasingly it may also cause problems in the dry seasons, because more and more systems are facing reductions in water availability at the source as a result of degradation of the catchment areas (Visscher et al., 1996a; Quiroga et al., 1997). In localities where water cannot be supplied continuously, the risk of recontamination in the distribution network should be investigated very carefully. Also the hours of water supply should be specified in consultation with the users.

Quality

The water supplied should be free of chemical substances and micro-organisms that can result in rejection or disease among users, or in deterioration of the water supply system and domestic utensils. A good quality is also important to protect the adequate functioning of water meters, which are increasingly being used to enhance efficient water use. The contamination of a water source with excreta from people or animals introduces a great variety of bacteria, viruses, protozoa and worms. Insufficient protection of water sources, or inadequate treatment, thus puts the community at risk of contracting infectious diseases. Poor water quality may be particularly harmful for children and old people with defects in their immune systems. For these two groups the infectious dose is significantly lower than for the rest of the population (WHO, 2005). An important problem is that the risk of bacteriological contamination may not be perceived by the community as the pollution is often not visible. Local people may value the water supply and the taste and appearance of the water, but not its bacteriological quality. However, their appreciation of water quality may be influenced for example by information campaigns such as those that were organized in Latin America after the Cholera outbreak in 1991 (Galvis, 1999).

There are few chemical components that produce an acute risk for users, except for situations where accidents occur in industry or through the spraying of pesticides and herbicides. In such cases, the water is often rejected by the consumers. Chemical pollution may, however, bring a chronic health risk associated with long periods of exposure, as can be seen from the incidence of arsenic poisoning in, for example, Bangladesh. Chemical pollution control is therefore important, but of a secondary order in comparison with severe bacteriological contamination (WHO, 2005; Craun et al., 1994). Particularly in countries with a less developed infrastructure, the acute risk associated with bacteriological contamination is more important than the chronic risk related to chemical components that may be present or may develop as a by-product of chlorination. The latter happens for example when chlorine reacts with organic material in the water. The potential health risk of disinfection by-products should not be ignored; however these risks should always be considered in the context of the benefits provided by disinfection, which reduces the much larger threat of waterborne infectious disease (Craun et al., 1994).

Water quality is an issue under debate, as some argue that being too clean entails the risk that humans do not develop resistance to disease. They argue that water quality standards in the industrialized countries may be becoming too strict. Furlow (2005) quotes Frost saying that "microfiltration may move people into a pathogen-free bubble . . . Without protective immunity from mildly contaminated drinking water illness from periodic contamination, or from other sources of infection like infected salads greens, will be more severe". Yet Frost also says that his thought-provoking ideas, which are supported by some others, particularly relate to microfiltration which completely removes exposure to some protozoans such as cryptosporidium. For more serious bacterial and viral pathogens, the aim should still be complete elimination from the water supply (ibid). These ideas show that water quality needs to be seen in the context of local conditions. In an area where there are numerous other potential routes of disease transmission, the impact of less stringent water quality norms may be lower than in very clean environments.

Measuring all the pathogens potentially present in the water on a routine basis would be far too complex. It is therefore normal practice to detect only what are called 'indicator' bacteria, "which are always excreted in large numbers by warm-blooded animals, irrespective whether they are healthy or sick" (Cairncross and Feachem, 1983 p.28). Their presence suggests faecal contamination and thus a potential health risk, as this contamination may contain pathogens. The indicator that is mostly used is "faecal coliforms, mainly comprising *Escherichia coli.* They are a subgroup of the total coliform group and they occur entirely, or almost entirely, in faeces" (ibid, p 28).

The WHO has established extensive water quality guidelines, which form the basis for water quality regulation in many countries (WHO, 2005). Acknowledging the difficulty of assessing and monitoring water quality in rural communities and municipalities with limitations in infrastructure, WHO developed a much less prescriptive approach for these situations (WHO, 1997). The guidelines for such situations propose a combination of the use of a few water quality parameters and the implementation of sanitary inspections. The water quality parameters include:

- *E. coli* counts, or, as an alternative, thermo-tolerant coliform counts, usually referred to as faecal coliform counts (FCCs);
- residual chlorine (if applied);
- pH (if chlorine is applied);
- turbidity.

Even these very few parameters are still difficult to measure on a regular basis. The FCC in particular requires special equipment or the transportation of the sample under controlled conditions to a laboratory. Measurement of the parameters is based on spot samples that may not be representative of the general situation, particularly not if the sampling frequency is low. Combining sampling with a sanitary inspection is therefore very important. This inspection involves a systematic review of the water catchment area, the water source and the water supply system, preferably by experienced sector staff together with community members involved in the management of the system. The inspection aims at identifying all potential factors in the catchment area and the water supply system (intake, transmission main, treatment, storage and distribution), that may lead to contamination of the supply and that put the users at risk (Lloyd and Helmer, 1991; WHO, 1997).

The sanitary inspection and the water quality analysis are complementary activities that are preferably combined. Whereas the sanitary inspection identifies potential risks, the water quality analysis shows if and to what level the water was contaminated at the time of sampling. The inspection is essential for the interpretation of the test results and for prioritizing remedial actions. Against the background of problems with water quality testing, extra emphasis has to be placed on the sanitary inspection. However, further research is needed to establish effective indicators that permit the monitoring of community-managed systems with little external support.

An option may be to rely on the combination of turbidity measurement and residual chlorine. In the Greater Vancouver water basin, the water treatment strategy relies principally on watershed protection and chlorination, which does not eliminate all risk of waterborne disease transmission. Evidence was identified indicating a turbidity-gastroenteritis relationship, supporting the probability that gastrointestinal disease increases with turbidity. The results of this study are consistent with the findings of a number of epidemiological and microbiological studies carried out across North America. The underlying assumption in this study was interesting in that it was assumed that no gastrointestinal events resulted from disinfected water with a turbidity of less than or equal to 1 nephelometric turbidity unit (NTU) (Aramini, 2000). It is important to note that the Greater Vancouver basin is well protected and chlorine dosing may be well controlled. This may not be the case in many other situations, but it provides a direction for a search for the simplest form of water quality testing that can be managed by local operators without fancy equipment, occasionally supported by an external analysis that would include testing for faecal coliforms.

The new water quality guidelines of WHO acknowledge the difficulty of monitoring the large number of dispersed community water supply systems. They suggest that surveillance has to be well designed and geared more towards a supportive role to enhance community management than towards enforcement of compliance. They refer to the limited capacity of the community to undertake process control and verification. They indicate that "frequent visits to every individual supply may be impractical because of the very large numbers of such supplies and the limitations of resources for such visits. However, surveillance of large numbers of community supplies can be achieved through a rolling programme of visits. Commonly, the aim will be to visit each supply periodically (once every 3–5 years at a minimum) using either stratified random sampling or cluster sampling to select specific supplies to be visited. During each visit, sanitary inspection and water quality analysis will normally be done to provide insight into contamination and its causes" (WHO, 2004 p. 89). This recommendation in fact conflicts with WHO's own suggestion to take a supportive approach, which, as will be shown in chapter 7, needs a more intensive interaction with the operator.

In the case of surface water sources, the hydrological cycle may have a considerable influence on quantity and quality. Waste-water discharge may have a strong impact on water quality, particularly in the dry season and also during the first runoff at the beginning of the rainy season, which can create high bacteriological, and sometimes chemical, pollution. In micro-catchments these changes are sometimes of short duration and therefore difficult to detect with occasional water quality testing.

Affordability

High costs of water may force households to use alternative poorer quality sources that represent a greater risk to health. They may also reduce the volumes of water used by households, which in turn may influence hygiene practices and increase risks of disease transmission (WHO, 2004). The costs of water systems are significantly influenced by the water quality risk associated with the source, and by the geomorphologic and geographical conditions. Sometimes a combination of water sources may be feasible to reduce the cost, as was the case on the Pacific Coast of Colombia. A piped supply was provided to the lower part of the community, while the higher part was served with rainwater harvesting systems to avoid costly pumping.

As discussed in section 1.4, Salazar (1980) and many others have recommended that water tariffs need to cover both running cost and construction cost. This poses a dilemma however, as these costs may not be affordable for poor local households, whereas one of their basic human rights is to have access to a reasonable water supply. Hence, cost may have to be shared among different actors to keep tariffs within available means of the users and in line with their willingness to pay. Also in the case of cost sharing, it is vital that users learn about the real investment and running costs of the system, and the contributions of different actors, to help them to better appreciate the 'value of water'.

In my view, it is essential that users pay at least for the operation and maintenance of the system, be it in cash or kind. In the case of gravity water supply or hand pumps, this should be feasible almost everywhere, but for pumped systems it may still be difficult for the poorest households. In such cases, it is better to explore alternative solutions, such as the application of differential tariffs with the better-off paying more, or choice of a lower service level, because long-term subsidy by the government to cover running costs is difficult to sustain.

It is also important to recover all, or at least part, of the investment cost. ‘Co-financing’ by the users, in cash or in kind, will make it possible to reach more users with available government and donor resources. A strong argument in favour of payment via a tariff is that users get a larger say in the type of service they will obtain. Paying for water gives them the right to influence decision making and by interrupting payment they can exert some pressure if the service worsens. If the supply is free of charge, they have to be grateful for every drop they receive.

3.4 The human factor in community water supply

Community water supply in the developing world is a “soft system”, as defined by Checkland (1989), in that it is characterized by a highly complex network of interrelations involving many actors. Water and food are vital for life, but whereas the provision of food is mostly an individual decision, water supply is usually the result of a larger decision-making process, often in the hands of governments, controlled by bureaucratic systems and engineers, and requiring collective action. The providers have a monopoly that brings power, particularly in the urban sector, but also in rural areas (Swijngedouw, 1993). The water sector is quite different from other sectors that have been studied in the context of diffusion of innovations. Many such studies relate to agricultural improvements or the selling of industrial products that have a direct benefit for the persons buying them. The water sector is more complex in that the end users, the ultimate beneficiaries, are not taking the decisions to construct a water supply system. Yet, perhaps unknowingly, they do have influence as they can and do frustrate some of the solutions being established without their participation in decision making. Non-use of new water systems or of imposed sanitary installations like latrines need not stem from technical flaws, but rather from the fact that the intended beneficiaries perceive their benefits as negligible (Vaa, 1990).

An operational and sustainable water supply system results from the interaction of many different actors, who intervene directly or indirectly in its performance. Figure 2 shows a water supply system that receives water from a catchment area and is managed by a water committee with an operator running the system.

The figure indicates the interactions that take place within the community and the support actors outside the community. It incorporates specific information from participatory evaluations of water supply systems in Ecuador and Bolivia. These were two interesting studies carried out with mixed teams from sector agencies, NGOs and universities. Teams were trained at the start of the process, which included the joint definition of criteria and indicators. This proved to be difficult because of the different backgrounds of the participants, several having no experience with this type of activities,

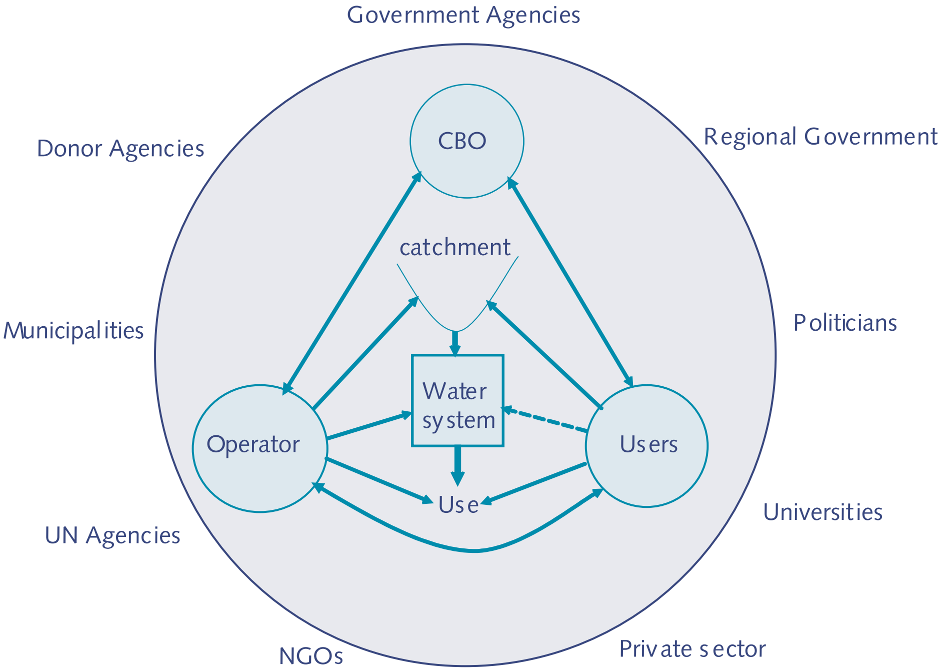

Figure 2. The interaction model for a functioning water supply system

such as the formulation of indicators. A salient aspect of the evaluations was that results were immediately shared with the communities, who later on also received the final report findings about their community.

The users

This is a diverse set of actors – men, women and children – who may, knowingly or unknowingly, strongly interfere with the water system. Their interference can involve a range of activities that are usually not addressed in a comprehensive way. They can, for instance, leave their tap open and so consume more water than the average consumption level that has been used to design the system. Excess water use has been identified in several evaluations, with some consumers using five times more water than others. This is less the case when water is metered, but even then some rich users may consume much more and feel justified since they pay for it. If the system is not designed for this higher consumption, other users in higher parts of the distribution system may experience low water pressure or not receive water at all. Another reason for low pressure may be a poor quality distribution system, perhaps as a result of poor maintenance. Water meters often meet with considerable resistance because people think that it is the first step of a process that will lead to higher water tariffs. Implementing agencies sometimes force people to take water meters, but a much better way is to discuss this first with the community, using, for example, the low pressure in some houses as an entry point for the discussion.

Some users may not pay for the water, and for the poorest of the poor this may be the only option they have. Subsidizing part of the population is feasible, but should be agreed upon in advance to establish the proper tariff. It is not uncommon to find a large number of people with a significant payment backlog. A review in Ecuador showed that, out of 40 communities visited, 21 (53 percent) had users with a backlog in payment ranging from two to 100 percent and averaging 29 percent (Visscher et al., 1996a). Wijk (2001) in a study of 88 communities from 16 countries also finds a considerable backlog in payment. In 25 percent of the systems, the backlog was more than half a year. The result is that water revenue is not sufficient to ensure adequate preventive maintenance of the system. There were even fewer funds available for larger repairs in Ecuador and many of the water committees turned to NGOs working in the area to ask for help. The Wijk study does not explain the reasons for the backlogs in payment, but in the evaluation of 40 community systems, users gave several good reasons, including poor service level. Some people living at higher elevations hardly received any water, so why would they pay for such poor service? Another reason mentioned was the very low incomes of some of the poorest, often female-headed households, which was not compensated by charging a slightly higher contribution from better-off people to ensure sustained performance of their water supply system.

Users sometimes put pressure on the operator to provide more water, for example, to wash their coffee beans, or simply to provide more reliable supplies for those who live in higher areas. The operator may ‘give in’ and provide more water, particularly if the social pressure is high. The result may then be that the water treatment system cannot cope with the larger volume of water and starts to perform inadequately. In extreme cases the operator has been known to by-pass the treatment system and supply untreated water to the community.

Community members may also ask the operator to add new connections, or sometimes they make ‘illegal’ connections themselves. This can interfere with the pressure distribution in the system if it is not done with expert knowledge. For example in El Tambo in the Cauca region in Colombia we found that hardly any water was reaching the treatment plant because of the large number of illegal connections tapping water from the transmission main.

Political cycles often have harmful effects on the sustainability of water systems. Users may exercise control over their water committee, by raising complaints with them and in some cases using the committee electoral process to replace them. Also, when users elect their politicians every couple of years, it can have devastating results. A change in political leadership in a community implies in a fair number of countries that the earlier administration is abandoned in favour of new political appointees. This may result also in replacement of the (paid) operator of the water system by a new (often untrained) one.

Users’ water ‘culture’ includes beliefs formed by history and new influences from modern communications or campaigns. Driven by different cultures, users may in one case be very careful and even reuse the water or, in another case, use and waste it in a big way. They may use it just for domestic purposes or also to water their garden or their animals or for small-scale irrigation. Water use may well depend on climate and definitely people will use less water when they have to carry it home from a public tap or well.

Some users also have an important influence on activities in the catchment area. They may have cattle grazing in the area, may carry out agriculture, or may contribute to deforestation and degradation of the catchment by cutting trees for firewood. Erosion is progressing quickly in lots of catchment areas in many countries, including Bolivia, Colombia and Ecuador, and it is actually becoming a threat to the continuity of many water supply systems, particularly in the dry season (Quiroga et al., 1997, Visscher et al., 1996a). Indirectly, humankind as a whole also has an effect on the availability of sustainable water resources, as we learn from emerging insights on the causes and effects of climate change.

The water committee

Many hand-pump schemes and piped water systems are managed by water c ommittees or similar types of community-based organizations (CBOs). The 88 communities reviewed in Wijk (2001), all had a 'local management organization' and only in one case was the service in practice managed by a single local leader. Some 85 percent of the organizations had received some kind of training. The least developed aspect of the management task of these committees was accountability, which in more than 50 percent of the cases did not exist at all. This is indeed a critical issue, but other aspects of management are also neglected. In the case of Ecuador, we looked at the change of coverage over time as a management indicator and in 32 percent of the communities found a reduction in coverage, among other reasons because newcomers did not connect, possibly because of the high connection fee (Galvis et al., 1997).

In the 88-community study, more than 54 percent of the organizations had no legal status or formal authority, but some 73 percent had established local rules on water management or use (Wijk, 2001). The study does not refer to the effectiveness of these rules, but the Seventh Video[6] has a very nice quote from a local peasant from Guatemala, who said: "Yes we have rules and these were written by the school teacher, I think some 48 in total and we cannot read Spanish. We understand it a little. We listened to all and said 'yes and yes and yes and yes' to all, but we hardly use four or five of them". It is positive that rules are used, but the statement suggests that there may be too many and that people agree to them without understanding them.

The CBOs, or water committees, may have very different origins, but often they are established by project implementing organizations. They may be elected or may just be

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[6] The Seventh Video was produced by Ton Schouten for IRC in the context of the community management project.

formed by individuals willing to take part in them. The composition of these committees can be very different and may sometimes be reasonably representative, but most of the time interest groups play an important role. In Colombia, water committees were legalized in May 1974 as autonomous entities charged with the administration, operation and maintenance of water supply and sanitation systems constructed by the National Programme for Basic Rural Sanitation. These committees, and water committees in other countries, have received some back-up support, but most have not acquired the necessary skills to manage their systems. The support that used to be provided by health promoters from the government has been stopped as a result of sector reform in countries such as Colombia and Ecuador.

Gender balance is often not well addressed in these committees. This is unfortunate, because the better sustained and used services often have more women members in the committee and, according to other women, both rich and poor, the women committee members are indeed having an influence (Wijk, 2001). In the Ecuador review, women were only formally present in 43 percent of the CBOs, though in one exceptional case women held four of the five positions. In practice, because the men work as migrant labourers, women take over the task of their men on the CBO, but formal decisions are still only taken when the men are there (Visscher et al., 1996a).

The CBO is the link to outside organizations. In theory this creates a broad network, but in practice the interaction is very limited. So the bottom line is that community members participating in the CBO, with little or no experience or training in the management of a water supply system, are responsible for it and have to orient the operator in his/her job. In Ecuador, 70 percent of the CBOs said that they did review the work of the operator, but in 20 percent of them the operator was part of the CBO – making it a kind of self control (ibid).

The operator

Water system operators are crucial to sustain the systems, but their role is under-rated in the sector and under-represented in decision making. It is interesting to note that community members value academic knowledge and look up to engineers and other government staff, but, in common with most engineers, they often look down on the operator of a water supply system. They do not realize that the operator actually is the most important person as he or she (although female operators are very rare) is safeguarding the lives of his/her fellow community members on a daily basis. Even a perfectly designed water treatment plant is useless if the operator does not look after it properly. System design therefore needs to facilitate the operator's task as much as possible. In some schemes, the job of the operator or caretaker is rather broad and includes not only the operation and maintenance of the system but also tap repair, relations with users and collection of funds. Undervaluation of the task of the operator is highlighted by the fact that operators trained for the job are replaced by inexperienced newcomers when a new local government or water committee is selected led by a different political party or interest group. Of the 40 systems evaluated in Ecuador, only half had trained operators and only one of them had adequate equipment to do a proper job (Visscher et al., 1996a).

The primary task of the operator is to operate and maintain the water treatment system, but without training and tools this is an impossible task. Operators manage as best as they can, using their own ingenuity but often without the insight needed to solve the problems properly, as we will see in the SSF case. Poor performance of distribution networks is partly caused by inadequate repair with locally available means. For certain tasks the operator sometimes receives support from community members, who are mostly not trained for the job either. Operators may seek support from outside often through their CBO. In Ecuador, operators of new systems said they did not need support at the moment, but would seek support later, when systems started to have problems – a common trend in all 40 communities (ibid). On the surface this appears a reasonable strategy. However some problems, like the condition of the distribution network and the performance of treatment systems, are not very visible to an untrained eye, so support may be requested very late and then involve higher cost and an increased hygiene risk.

The operator can have a great deal of interaction with users, as the job may go beyond technical management of the system and include collection of tariffs. I recall an important lesson in 1985, when discussing a caretakers' manual with my colleague Christine van Wijk. It was a nicely illustrated manual that also included the role of the caretaker in interacting with users. Below a drawing of a public standpipe with a broken tap, I had written. "If the tap is broken explain to the people how to use the tap properly". She criticized this: asking me if I truly believed that people could not operate taps. This showed my engineering bias, not questioning the technology but instead blaming the user. The text was revised and the new text reads: "If taps are not used properly try to find out why not, and try to find a solution together with the users". This manual is now available in English, Hindi and Spanish.

The external actors

A range of external actors may intervene in community water supply, particularly in the design and construction stage. This includes government staff, NGOs and private sector organizations. Government staff often sets the rules, establishes the control institutions, channels funding and tends to be involved in construction. This has changed somewhat as a result of structural adjustment, but they still have an important impact as they make the rules, often together with, or oriented by, staff from development banks (World Bank, Inter-American Development Bank, etc.) or donor agencies. Many of them have a technical background and come from urban areas. Because of their training and their background, they apply an urban perspective to the local setting to establish what they perceive to be the problem and the solution. They often share a 'culture', a set of common values, with other agency staff and higher-level politicians and administrators. "The key element of this culture is generalizing about consumers, intended beneficiaries, in a way that makes them objects of intervention instead of partners in development. Poor people in remote communities are seen not only as lacking material goods and adequate institutions, but fundamentally lacking insight about what is best for them and how to go about achieving it. Their belief systems are seen as unscientific and anti-modern, their values and practices are exotic and constitute barriers to rational problem-solving. At worst, ‘they’ are ignorant, lazy, irrational, stubborn and fatalistic” (Vaa, 1990 p. 17). To change this way of thinking would imply no less than a professional revolution, where reliance on knowledge acquired in schools and universities would be replaced by a willingness to “learn from below” and by seeing people’s perceptions, values and practices as resources rather than barriers (Chambers, 1985).

With its changing role, central government in many countries has passed responsibility for water supply to local government, whilst keeping responsibility for supervision through regulatory bodies and water quality monitoring. This change brings the responsibility closer to the community, but the available capacity of local government – often small municipalities – is limited and they do not have the human or financial resources to seek adequate advice.

Another important group of agency staff are health promoters and community-development workers, who often form the link between the agency and the community. Many of these staff members are used to bring messages to the community. With diminishing inputs from the government, their role is changing more to monitoring and their other tasks are taken over by staff from NGOs.

NGOs are a mixed group of organizations, often having a “social” mission to assist the poorer sections of society in their struggle for life. Most national NGOs are small and cover a limited geographical area. A variety of NGOs also exist at international level. Many are rather small, but some, such as CARE International, Plan International and Action Aid, are organizations with large networks and operate in many different countries. Because of the wide differences, only some features of NGOs involved in the water and sanitation sector will be highlighted. NGOs have a closer link with communities than government agencies; they are present for longer-term activities and are more inclined to apply participatory methods. Many still have a tendency to provide the communities with solutions, albeit sometimes with perceptions that are closer to community reality. Staff members of these organizations are usually more dedicated, not least because they often get somewhat better and more regular pay than government staff.

The private sector is a relatively new player in community water supply (except for local water vendors, who often sell water of dubious quality to consumers and local contractors). Private firms have a long track record in urban water supply, but are less attracted to rural water supply because of the smaller rate of return. Exceptions are the construction of water systems and particularly the selling of ‘package plants’.

Roles change over time

There is a big range of situations in developing countries, each characterized by different levels of interaction among the key actors involved. Figure 3 presents a schematic model of the key actor groups involved in different stages of a community water supply system. The roles and realities will not only be different in different countries and even within countries, but also will differ over time. So the levels of involvement marked in Figure 3 are only illustrative.

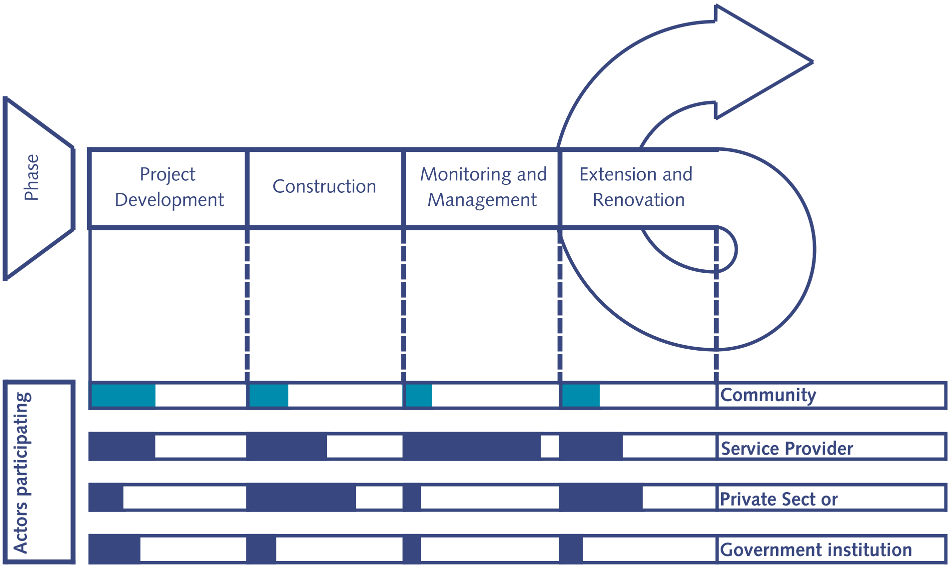

Figure 3. An example of possible distribution of inputs between different actors

The figure helps us to appreciate the changes and is a good indication of the need to analyze the real situation and to recollect that the process of providing safe water supply does not stop when the system is constructed. Over time, the number of people that depend on the system will change and the quality of some of its parts will deteriorate – as may also happen with the water source. Also, progressive improvements in the technology supported by economic development change quality and quantity criteria and may require adjustments in the systems. It follows that one intervention often will not suffice to build and sustain a system and it is good value for money to invest in capacity building in a community.

In many countries we see that the role of the external agencies strongly diminishes when construction is over. CBOs and the communities are pretty much left to themselves. “Some communities may alone bear the full responsibility for managing their water supplies, many will not. Community management can not mean that, following the installation of a system, the outside agency drives off in the sunset and everyone lives happily ever after. Indeed, a comprehensive and effective framework for institutional support is needed if we want to keep the systems working after ‘handing over’. The efforts and capacities of communities are crucial, but they must be supplemented with the efforts and capacities of governments, support agencies, NGOs and the private sector. Together, they can create a rural water supply service in which each stakeholder takes its share of responsibility in an institutional framework that addresses all the functions needed to provide water to rural people, including policy making, regulation, legislation, taxation and price policy, planning and construction, technical support, operation and maintenance" (Schouten et al., 2003).

Who takes the decisions?

With so many actors, the sector is characterized by different groups that all may influence decision making. The most important are:

- Policy makers at national level setting the boundaries for sector interventions, often together with staff from donor agencies and/or development banks;
- Agency staff and especially engineers who may be quite conservative and sometimes favour certain approaches because of educational background or politicallinks;
- Community representatives (mayors, women groups, political rivals etc.) and
- Users.

Some of these different actors may have organized themselves in a water committee, which then can be a platform for decision making which, according to Röling (1994), is a nodal point of social interaction between stakeholders, as I discuss further in section 6.5. For many of the actors, the situation is the same as the one Rogers (1995) describes for most farmers in developing nations: they are simply not free to implement their own innovation decisions. This is an important issue that is at the heart of quite a number of failures in the sector and it is worthwhile to explore it a bit further.

In large development projects, decisions are usually made by the funding agency in collaboration with central or regional authorities. Often these projects rely heavily on external consultancy firms and even suppliers of technology. They may be guided in their decisions by a framework of longer-term sector plans and decide on the service level, the choice of technology and methodology, the financial support and the required inputs from the community. Thus, in this type of project most decisions are still made **for** the users. Wijk (2001) indicates that this situation is changing in different projects in that more time is taken for the planning of projects and preparation is now more participatory, flexible and gender and poverty-sensitive. Yet she also indicates that this is only a partial change, with many of the characteristics of agency projects remaining unchanged.

With more funding being channelled through local government, decision-making processes change. Local governments may still have to live by the rules set by their national governments or by funding organizations, but they have more freedom when it comes, for example, to technology selection. This may seem positive, as they are closer to the community, but often there are political strings attached that may colour their decision making. Or they may be influenced, for example, by private-sector actors who want to sell package plants that do not necessarily solve the local problem.

In the case of NGO projects, the community appears to have a larger influence in decision making, but this too depends very much on the NGO and the perception of its staff. Some have the same characteristics as government staff and hence leave less room for community involvement. Also it may be relatively easy to manipulate decision making, as not all members of the community may have equal access to the necessary information to make informed decisions.

What is clear at the end of the line is that the user has ‘veto power’ over use. Users ultimately decide whether they will use a new system (provided that they have an alternative water source). Because of the trend to ask users to pay for the water, the users acquire a larger say. When they are paying, it is easier for them to claim their ‘right’ to be involved in decision making. On the other hand, as mentioned earlier, payment is not a panacea, and exceptions may have to be made for the poorest sections in the community. This can best be done in consultation with the community, as the local population often is well aware of the people involved and their needs.

3.5 Water treatment

I have already described the background to WHO’s water supply standards, which include maximum permissible values for the levels of chemical and bacteriological substances in drinking water. Based on these standards, water in which one or more faecal coliform bacteria are detected in a sample of 100 ml (the indicator used for bacteriological contamination), would be declared unsafe to drink. These standards proved to be overly stringent for rural water supplies in developing countries and WHO responded in 1983 by renaming its standards ‘guidelines’, a simple rephrasing that permitted countries to adopt their own standards based on their local conditions, as discussed in section 3.3.

If a water source does not meet these standards either, an alternative source needs to be found or the water will need to be treated. This can be done at household level, which places the burden on the individual user and does not benefit from possible economies of scale, or at the community level, or at multi-community level. Applying different barriers in water supply systems is important to reduce the risk of micro-biological contamination and to prevent the transmission of waterborne disease. Multiple barriers include: selection and protection of the best available water source; water treatment to remove or inactivate disease-causing micro-organisms; proper water storage; and the promotion of safe water practices among the users (Okun, 1991; Geldreich and Craun, 1996).

The protection of watersheds in Europe and the USA is set by advanced regulations that need further development because of recent problems particularly with flooding. In developing countries, this protection is still in its initial stage, with insufficient legislation, lack of monitoring tools and a lack of trained personnel to oversee the process. This aspect needs greater attention, particularly in rural areas, where tighter collaboration can be developed between communities and other entities in the water sector. It can be necessary, for example, to regulate the discharge of waste-water or the cutting of trees in remote areas, and this can often only be achieved through social control by the community that lives in the zone. It is possible too that it may be necessary to restrict the use of pesticides in some watersheds, which then presents the problem of compensation to the farmers of the watershed (Galvis et al., 1998).

Protection of the watershed is often not sufficient to ensure safe drinking water and this makes it essential to treat the water before use. Different water treatment technologies exist. Treatment using chemical coagulants, flocculants and rapid filtration has developed quickly over the last decades. It has great potential and is used worldwide. However, operation and maintenance of this technology continues to be demanding. In effect, the necessity to administer, buy, transport, store, and accurately dose chemical compounds is a strong limitation for the wide application of this type of technology in rural communities and small and medium-size municipalities (Galvis and Visscher 1998).

Three important concepts need to be taken into account when contemplating water treatment: multi-barrier treatment, integrated treatment and terminal disinfection.

Multi-barrier treatment

This concept has a long history and has evolved gradually, with increased attention on water quality improvement. According to the multi-barrier concept, there should be more than one stage of treatment to produce water suitable for human consumption. Together, these stages progressively remove the raw water contaminants and consistently produce water fit for drinking (Figure 4). Ideally, water of low sanitary risk should be obtained before the final stage of treatment, which then represents a safety barrier (Galvis et al., 1993).

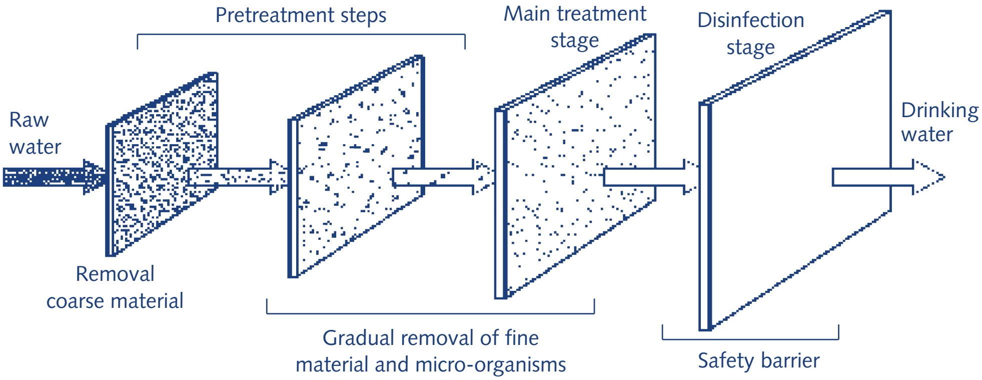

Figure 4. Combination of treatment concepts (Galvis et al., 1998)

Integrated treatment

In the application of the multi-barrier concept, not all the barriers have the same removal efficiency for the different types of contamination. Therefore, the concept of integrated treatment is important, as it considers the possibilities and limitations of each stage or barrier for removal of each type of contaminant. Removal should be quantified and balanced in such a way that all the contaminants can be removed effectively and in a cost-efficient manner (Lloyd et al., 1991). In general, it is convenient first to separate the heaviest and larger material and then to proceed gradually by separating or inactivating the smaller material represented by particles that include colloidal solids and micro-organisms.

Terminal disinfection

The last stage is usually disinfection and, for it to be effective, the previous barriers or stages need to remove virtually all the pathogenic micro-organisms and substances that can interfere with the disinfection process. This has to be achieved in such a way that the capacity of the disinfectant is sufficient to ensure a safe water supply under all circumstances. Adequate treatment implies that only a small and essentially constant dose of disinfectant is needed, making this last stage easier and more reliable.

SSF is a treatment process that has been applied to deal with several stages at the same time, because of the variety of treatment mechanisms that take place in the sand bed, as will be discussed in the next section. Performance of SSF systems operated as the only treatment step was often not satisfactory and led to the development of Multi-Stage Filtration (MSF), as described in section 3.7. Although properly operated MSF systems are a very effective treatment process, terminal disinfection is still advisable to ensure a safe water supply. Providing people with water through a pipe network brings with it the risk of a waterborne epidemic if the water is contaminated. Including MSF treatment greatly reduces this risk, but there is still a possibility that the treatment may not be fully effective, particularly directly after cleaning an SSF unit. Disinfection will cope with this problem and makes it much easier to check the quality by testing the residual chlorine – a very simple test that operators can carry out, and one that shows conclusively that disinfection is complete.

The distribution system

The distribution system needed to deliver water to users consists of a network of pipes and regulation devices. This system may itself affect the water quality in different ways. Water entering the distribution system may contain some organic material that could cause bacterial growth attached to the inside of the pipes. Iron and manganese deposits may also be formed. Although these effects, in general, are harmless to the health of consumers, it is important to clean the distribution system occasionally, by flushing the main pipes. A higher risk can occur if pipes need to be repaired or new connections are installed. If this work is done inappropriately, the result may be that pipes are leaking and, in systems in which the pressure sometimes drops, for example, because of intermittent water supply, this can lead to the intrusion of surface or even waste water, polluting the treated water in the mains.

3.6 Slow sand filtration

SSF is a treatment process in which water is passed through a biologically active layer of sand. During its passage, the water quality improves considerably by reduction of bacteria, viruses and cysts, removal of suspended and colloidal material and changes in its chemical composition.

Crude versions of SSF were used for industrial water supplies in Britain, and some may have been installed before 1790. One was certainly installed in 1804 at a cotton mill in Paisley, Scotland, and became the first water treatment plant for a city supply. John Gibb, owner of the mill, began selling and delivering water in carts to the households from the plant he had built to treat water from the muddy and industrially polluted River Cart. The early filters were never completely successful because an adequate cleaning procedure was not available to the operators. On January 14, 1829, Simpson's one-acre (4,000 m^2) filter at Chelsea, known as the first English SSF, was put into operation. This type of SSF became the classical model (Baker, 1981).

The effectiveness of SSF treatment was clearly established in 1892 in Germany. An outbreak of cholera in the city of Hamburg, which did not have a water treatment plant, resulted in 7,582 deaths (1.3 percent of the population), whereas in the adjacent city of Altona, taking water from the same river but treating it by SSF, only 328 persons (0.2 percent of the population) died (Huisman, 1982). A filtration plant was immediately constructed in Hamburg and came into operation in 1893 (Hazen, 1913, quoted by Bellamy et al., 1985). Other cities in Europe also adopted SSF technology and SSF continues to be an important component of several water systems, though it now has a different purpose. It is used as polishing step to remove organic material and is the last step in the treatment process in Amsterdam, for example, where chlorine is no longer added to the water after the SSF. This is a different application, as the water is already very pure before it enters the SSF and therefore the system can operate at a much higher rate than conventional SSF systems. Design criteria used for this installation cannot therefore be copied for use in developing countries.

The first SSF in the USA was built in Poughkeepsie, New York, in 1872. The short filter runs of the SSF units, related to turbid surface water in different regions of the USA, stimulated the development of Rapid Sand Filtration (RSF) (Bellamy et al., 1985). In 1940, there were 2,275 RSF plants and approximately 100 systems used SSF (Fox et al., 1994). A survey of 47 of these SSF systems (Slezak et al., 1984; Sims et al., 1991) showed that most (76 percent) served a population of less than 10,000 inhabitants, while three percent served a population of more than 100,000. Most (54 percent) took the raw water from small rivers, 41 percent from lakes or dams, and 5 percent used ground water. The average turbidity of these sources was low at 2 NTU, with peak values of 15

NTU. Some 88 percent of the water systems produced effluents with a turbidity below one NTU. The coliform levels in 80 percent of the water sources were below 100 FC per 100 ml and more than 70 percent of the systems produce effluents below one FC per 100 ml. The 1986 Amendments to the Safe Drinking Water Act stimulated the construction of new SSF units in the USA. By 1994, the number of SSF treatment plants had grown to 225, an increase of more than 100 since 1940 (Brink and Parks, 1996 cited by Galvis, 1999).

In Latin America and the Caribbean, SSF was used in the treatment of water for larger cities such as Buenos Aires, Argentina, and Kingston, Jamaica. However, most of the cities in these regions used RSF technology. Introduction of SSF in the region was in most cases carried out without adjusting it to local conditions and as a result its impact has been very limited. SSF plants presented major difficulties in design, operation and maintenance in countries such as Brazil (Hespanhol, 1969) and Peru (Cánepa, 1982; Lloyd and Helmer, 1991).

Similar situations have been encountered in Africa, in countries such as Cameroon, Kenya and Zambia and in Asia, in India, Pakistan and Thailand. For example, in India the first slow sand filter was constructed in 1865 at Palta waterworks near Calcutta (Sundaresan and Paramasivam, 1982) and in 1993 in Andhra Pradesh, there were more than 1,100 SSF systems but most of them had deficiencies in their design and functioning (Visscher, field notes 1993).

The SSF technology

The SSF unit basically consists of a box containing a layer of supernatant water on a filter bed of fine sand with an effective diameter of 0.15 to 0.30 mm and a depth of 0.5 to 1.0 m. The sand sits on a gravel bed that functions as a support medium and a transition stage to the drainage system. The operation is controlled by a set of regulation and control valves. The filtration rate to ensure a good operation of the SSF usually is in the range of 0.1 to 0.3 metres per hour (m/h)[7]. Figure 5 shows an SSF system in Colombia and Figure 6 a schematic drawing.

SSF has several advantages over chemical water treatment. It is robust, can be well maintained by a local caretaker with limited education, does not require chemicals, has hardly any moving parts and often can be built with local materials.

When a filter has been producing water of good quality for several weeks or months, the first centimetres of the filter will gradually clog, as a result of the accumulation of inorganic and organic material, including the biomass that is formed on top of the filter bed, the “Schmutzdecke”. The major increase in head-loss occurs in this top layer. Scraping off this layer restores the hydraulic conductivity to the level at the start of the

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[7] The filtration rate is the total volume of water that enters the filter in m3 per hour divided by the surface area of the sand in m^2. The unit for the rate is thus m3/m2/h, but this is often simplified to m/h, a practice that I will folow.

Figure 5. Photo of the MSF plant (SSF + pre-treatment) in Paispamba, Colombia

filter run. This is achieved by removing the top 1 to 2 centimetres of the sand bed. After several scrapings, when the minimum filter bed depth of some 0.5 m is reached, resanding is required. This activity involves recovering the sand that has been withdrawn in previous scrapings and placing it below the actual sand in the unit. This operation only needs to be carried out every three or more years.

The removal mechanisms

The water treatment in an SSF unit is the result of a combination of biological and physical mechanisms and chemical processes that interact in a complex way (Box 1.). It is impossible to identify the role of each mechanism in the reduction of the level of contamination in a SSF. Haarhoff and Cleasby (1991) identified a variety of biological processes that include: *predation,* algae were found in the intestines of bentic invertebrates and bacteria are consumed by protozoa; *consumption of detritus* by aquatic worms present in the lower layers of the sand bed, *natural death or inactivation* of bacteria because of the filter being a relatively hostile environment, and partial reduction of organic carbon by *metabolic breakdown.*

Physical mechanisms associated with the particles removal in SSF have been identified as: *Surface straining*, *interception, transport,* and *attachment and detachment mechanisms* (Yao et al., 1971; Amirtharajah, 1988; Haarhoff and Cleasby, 1991). *Surface straining* is efficient for the removal of particles larger than the pore size. This may mean larger than 20 to 30 microns, depending on the effective grain size of the sand, and is much larger

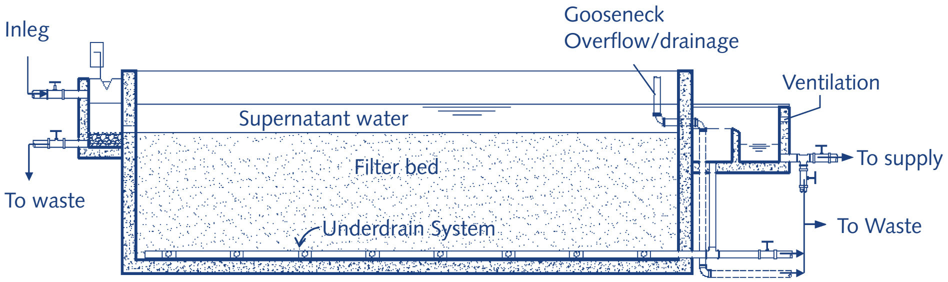

Figure 6. Schematic drawing of an SSF system

than the size of bacteria (0.1 to 10 microns), viruses (0.01 to 0.1 microns) and colloidal material (0.001 to 1 micron). Nevertheless, these may be also partly removed when they are connected to or encapsulated in larger particles. When larger particles are retained at the surface, the pore size reduces, increasing the probability that smaller particles are also trapped and removed.

Smaller particles that enter the pores of the filter may be captured if they are transported to the surface of the sand grains by processes such as sedimentation and diffusion. Once attached to or deposited on the grains, the pore size reduces and the drag forces increase which may detach particles and carry them deeper into the bed.
Chemical oxidation is also taking place in the filter and this process is responsible for the removal of chemicals such as iron and manganese (Huisman, 1982).

Efficiency and limitations

SSF is a very effective treatment that can produce an effluent low in turbidity, free of impurities and, even more important, virtually free of bacteria, entero-viruses and protozoa. Table 7 gives an overview of the removal efficiencies that may be obtained with mature[8] SSF systems for different parameters of sanitary importance. These efficiencies have been reported for SSF units operating in temperature zones above 5°C, with flow velocities between 0.04 and 0.20 m/h, filter depths above 0.5 m and effective grain sizes between 0.15 and 0.30 mm.

Despite the high removal efficiencies, frequently SSF technology alone cannot produce an effluent that complies consistently with prevailing water quality norms. This may be for the following reasons:

- The level of contamination of the raw water source exceeds the treatment capacity of the SSF. High turbidity levels are the most common problem mentioned in SSF treatment. Different authors suggest different levels ranging from 5 NTU (Cleasby, 1984) to 50 NTU (Ellis, 1985) – values that are frequently exceeded by many tropical rivers. Other quality problems may include excess iron and manganese or algae, all basically contributing to a quick clogging of the filters.

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[8] Maturation of the SSF, the time it takes for the biological process to fully develop, requires between one or a few days for a filter that is cleaned or several weeks for a new filter. During this period the water it not safe and should not be put into supply unless reliable disinfection (chlorinated) is provided.

Box 1. The biological process in SSF needs a caring touch

When a SSF is put into operation, a dirt layer, known as the Schmutzdecke or biomembrane starts to form at the surface and the top few centimetres of the sand bed. It includes retained suspended solids, organic waste, bacterial matter, algae, etc. The actual composition of this layer varies considerably from filter to filter and from one period of the year to another, depending on the material of which it is composed. With its population of algae, protozoa, bacteria, funghi, actinomycetes, plankton, diatoms, rotifers, bacteriaphages, etc., the Schmutzdecke is intensively biologically active. The organic material retained at the surface forms the substrate for the mass of heterotrophic bacteria and other micro-organisms derived from the water, which multiply selectively at this level. Dissimilation products from the biological activity in the Schmutzdecke will be moved down in the filter bed to serve as food for bacteria active in the upper part of the sand bed, until complete breakdown and assimilation is usually achieved. So the biological activity extends deeper into the filter bed, but the intensivty decreases with depth (Ellis, 1985). The biological activity requires time to develop. This is called the ripening period, which for a new filter may last several weeks. For a filter that is taken out for cleaning and put back into operation again within a day, the ripening process is much shorter and may take only two days. The biological process can be negatively affected by, for example, higher filtration rates and higher loads of suspended solids that may cover part of the biologically active organisms that are essential for good treatment results. This requires that the process is monitored and managed in a caring way, to ensure the best conditions for an effective biological process.

- Conditions that reduce or inhibit the treatment process. These include low temperature, low nutrient content and low dissolved oxygen[9] which all negatively affect the microbiological process (Galvis et al., 1998).
- Inadequate operation and maintenance processes including overloading or interrupting the flow and disrupting the "Schmutzdecke".

Comparing SSF and RSF

RSF and SSF are both used for water treatment, but the characteristics of SSF make it more suitable for water treatment in smaller communities particularly in developing countries. This is particularly the case because RSF needs chemicals and is technically more complicated. In a RSF system, the water passes downwards through a bed with coarser sand than used in SSF, about 0.45 to 1.0 m thick, at a rate of over 5 m/hr. The water is driven by gravity or by pressure, in which case the filter is contained in a pressure vessel. Cleaning of the bed is required at frequent intervals, usually at least once a day.

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[9] If the dissolved oxygen level in the inflowing water is low, the aerobic bacteria in the SSF will consume this oxygen completely. This leads to anaerobic conditions in the filter which are detrimental for the treatment process as they will result in the decay of the aerobic bacteria, development of odour and taste problems and the risk of a breakthrough of faecal coliforms.

Table 7. Typical removal efficiencies for conventional SSF units

Water quality parameter	Removal efficiency	Comments
Turbidity	Provides effluent turbidity < 1 NTU	The level of turbidity and the nature and distribution of particles affect the treatment capacity
Entero Bacteria	90 to 99.9%	Affected by temperature, filtration rate, size, uniformity and depth of sand bed, cleaning operation
Entero viruses and giardia quists	99 to 99.99%	High removal efficiencies, even directly after cleaning (removal of the Schmutzdecke)
Cercaria	100%	In good operation and maintenance conditions virtual complete removal is obtained
True colour acids	25 to 30%	Colour associated with organic material and humic
Iron, manganese	30 to 90%	Fe levels > 1 mg/l reduce the filter runs

Based on (Bellamy et al., 1985; Ellis, 1985; Huck, 1987; Rachwal et al., 1988; Haarhoff, 1991; Hrubec et al., 1991; Fox et al., 1994) cited in Galvis et al., (1998).

This involves ‘backwashing’ by forcing water, sometimes mixed with air, upwards through the bed for a period of time to remove the accumulated impurities. To enhance the treatment efficiency, chemicals such as iron sulphate are added to the water prior to the RSF to encourage coagulation of the suspended solids forming smaller and larger flocs that are more easily retained in the bed. Over the years, various modifications have simplified RSF, but, as can be seen from Table 8, it still remains far more complex than SSF. For water with high turbidity, SSF alone is not suitable and RSF may have to be applied with all the complexity it entails. This has led to many failures at high cost in developing countries.

A study in 1998 covering 127 water treatment plants in municipalities in the Cauca region showed that some 80% were RSF systems; the others were SSF or MSF systems. A number of RSF systems were also identified in smaller hamlets, but with virtually no information about their performance. Thirteen systems were selected for further review. These had a capacity ranging from 13.5 – 180 litres/s. Many had considerable problems. Five did not use chemical dosing because of relatively low turbidity values (below 5 NTU). In five other systems the operators indicated that they had problems to reduce the colour level sufficiently, because the low turbidity did not support the coagulation process. Water quality testing to establish the level of coagulant dosing was not carried out in nine plants and hydraulic performance of most plants was quite poor. Except for the four plants managed by ACUAVALLE, a regional water provider, management, maintenance and disinfection were not adequate. Systems also had difficulties coping with high turbidity peaks in the raw water lasting several hours. Performance in terms of removal of coliforms was low in three out of five plants that were selected for a more in-depth study. Deterioration of mechanical equipment was observed in all systems (Cruz et al., 1998).

In view of these problems with RSF and SSF, it is very fortunate that MSF treatment has been developed and that it gives such positive results for water with higher turbidity levels, as discussed in section 3.7. A less fortunate, but important, element is that some systems are not built for their technical merits (as the designers and builders are not held responsible for long-term functioning) but for financial gains (corruption). This favours RSF which has higher profit margins on technical components (pumps, valves, pressure vessels, etc.).

Table 8. Comparison of the key characteristics of SSF and RSF

Item	SSF	RSF[1]
Construction	Simple construction often with local materials	More complex construction that includes pumping equipment; also available as complete package plant
Surface area of filters	Larger surface area is needed	Surface area is smaller
Flow velocity	0.1- 0.15 m/h	> 5 m/h
Sand	Large volume of relatively fine sand is required that is often locally available	Smaller volume of sand is required, but has to match more stringent specifications
Sand (grain size)	0.15 – 0.3 mm	0.4 – 1.0 mm
Treatment efficiency	In general higher treatment efficiency and particularly effective in removing bacteria and organic matter	In general lower treatment efficiency
Backwashing	Not required, the filters are scraped manually	Required which almost always involves water pumping
Chemicals	No chemicals required except for safety disinfection	Required for chemical coagulation as well as for safety disinfection
Labour requirements	Low level of trained operators, but they need to understand the biological treatment process	More training is needed to ensure proper dosing of chemicals and handling of equipment
Vulnerability of system	The overall system is robust and requires limited maintenance except for a number of valves	The system is more vulnerable as it includes more mechanical equipment and requires pumping
Limitations	Labour intensive and only able to treat water with low turbidity levels[2]	Able to cope with high turbidity due to chemical coagulation and backwashing

1. Based on Huisman 1982; Cairncross and Feachem, 1983; Galvis et al., 1998; Smet and Wijk (2002).
2. This important limitation is considerably reduced by the development of simple pre-treatment systems that led to the establishment of Multi Stage Filtration (MSF) section 3.7.

The social dimension of slow sand filtration

The biological nature and the limitations of SSF technology mean that the effectiveness of treatment can be susceptible to harmful actions by the contractor, the operator or members of the community. Problems may start even in the construction stage, when the contractor may decide to fill the SSF units with sand that is not properly washed. This is tempting because it saves a lot of time. We came across an interesting case where an SSF system was producing water with a turbidity that exceeded the raw water turbidity, yet on the surface the sand appeared to be washed. Only after probing deeper into the filter did we find that just the top 10 cm was washed. This taught us a valuable lesson that the contractor too needs training, along with any sub-contractors, as this type of work may be delegated. It is also necessary to arrange for close monitoring, which can perfectly well be done by community members – men or women – once they appreciate the value of their water system.

The operator is the key to securing the proper performance of the system. The job is not that complicated, and does not need continuous supervision. The key to success is understanding the biological nature of SSF, which requires that water needs to keep flowing through the sand to ensure that oxygen and nutrients reach the biologically active micro-organisms. One problem is that cleaning the SSF is a laborious job, as the filter needs to be scraped and the sand needs to be washed. Some operators, not realizing the importance of the process, bypass the filter if it is clogged to postpone cleaning to a more convenient moment. Or they invent other detrimental practices, as described in Box 2. Or they may force the SSF to operate at higher filtration rates, which interferes with the effectiveness of the treatment process.

Community actions can also interfere with SSF performance. Community members may waste a lot of water and then press the operator to produce more. They may interfere with pipelines by making illegal connections. Or they may intervene in the catchment area by tree-cutting, agricultural activities, or allowing cattle to overgraze. Those actions lead to enhanced erosion and runoff that can pick up a lot of fertilizers, which in turn may lead to water quality deterioration and result in poor performance of the treatment.

3.7 Multi-stage filtration

This section presents the switch in thinking that was made, moving from SSF to Multi-Stage Filtration (MSF). This was the result of the integrated research and development project on pre-treatment alternatives that was implemented in Colombia by CINARA and IRC in parallel with the TRANSCOL project. This project was established to explore possibilities for overcoming the limitations of SSF to treat water that is high in turbidity. This is a very serious constraint in many tropical rivers, which are characterized by heavy peaks in the level of suspended solids. SSF cannot cope with this problem, as the filter would clog in a few days or even a few hours. This interrupts the process flow and means that no water is delivered to the community. The filter then has

Box 2. An 'invention' of an operator

When visiting one SSF system, we found that the surface of the filter showed a lot of 'holes' like small excavations in the sand. This was something we had not seen before. On questioning the operator, it turned outthat he used a pole to 'punch' through the Schmutzdecke when the filter was clogged. This indeed restored the output of the system, and so his problem was 'solved' as he could postpone scraping the filter. Of course, his action strongly interfered with the biological process because the filtration rate in the 'clean contact area' e.g., the edges of the hole, was much higher and so biological performance would be less efficient. So he put the community at risk, whereas he was convinced that he had a good solution. A second problem was that he pushed the 'dirt' deeper into the sand bed, making it necessary to clean a thicker layer when eventually his solution would not restore the production capacity. It was clear that the operator did not sufficiently appreciate the biological nature of the process.

to be cleaned, which is a laborious task. The solution is to condition the water by pre-treatment techniques prior to SSF. These pre-treatment systems include simple sedimentation, micro-screening, gravel filtration and, more recently in Europe, also ozone and activated carbon treatment to improve the removal of organic material (Galvis and Visscher, 1998). Several of these were tested, and gravel filtration proved to be a very interesting option. The combination of this technology with SSF was further developed and called MSF.

The technology

MSF is a combination of coarse gravel pre-filtration often comprising a dynamic gravel filter, an upflow gravel filter and SSF (Figure 7.). This combination allows the treatment of water with considerable levels of contamination well above the levels that can be treated by SSF alone (Table 9).

MSF retains the advantages of SSF in that it is a robust and reliable treatment method that can be maintained by operators with low levels of formal education. It has the advantage over SSF that it is less labour-intensive, as the scraping frequency of the SSF units is lower. It is much better suited than chemical water treatment to conditions in rural communities and small and medium-size municipalities in the South, as well as in more remote areas in the industrialized countries (Galvis et al., 1998). MSF technology can be preceded by other treatment processes such as simple sedimentation, sand traps and screens. Wherever possible, terminal disinfection needs to be included as a safety barrier after the MSF.

The **dynamic gravel filter (DyGF)** is in essence a shallow downflow gravel filter functioning as the first treatment step (Figure 8). It has a surface layer of fine gravel on top of a layer of courser gravel and the drainage system. An overflow weir is situated a few centimetres above the top of the gravel layer. The fine gravel layer will quickly clog if

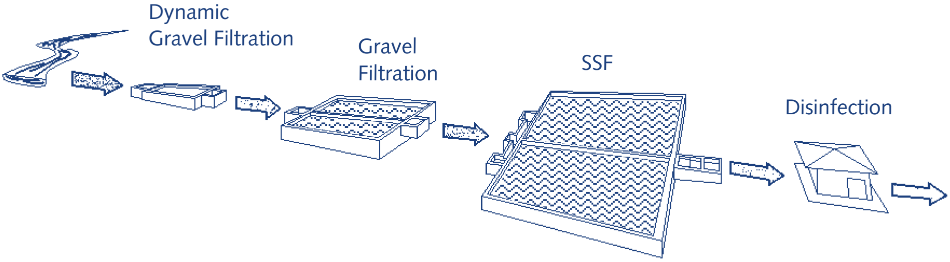

Figure 7. Components of a multi stage filtration (MSF) plant

high peaks of suspended solids reach the unit. It will then act as an automatic switch or valve that reduces the flow quickly or interrupts it altogether (Galvis et al., 1998). A drainage system is included. This is an important innovation developed by CINARA that considerably facilitates the cleaning process. Cleaning the DyGF is a simple task that involves raking the surface area and draining the unit by opening a valve. This is much simpler and far less laborious than cleaning a SSF.

Table 9. Summary of considerations concerning MSF treatment (Galvis et al., 1998)

Issue	**Comment concerning MSF treatment**
Quality of treated water	It is a good alternative to improve the physical, chemical and bacteriological quality of the water. In many areas and particularly those with a less developed infrastructure MSF is the only feasible treatment option.
Ease of construction	The relatively simple design facilitates the use of local materials and local manpower. There is no need for special equipment.
Construction cost	The construction in local materials and with local labour reduces the cost. Usually there is no need for imported materials.
Ease of Operation and Maintenance	After a short period of training local operators with a minimum of formal education can operate and maintain the system.
Cost of Operation and Maintenance	The cost of operation and maintenance and the requirements in electrical energy are minimum and less than required for other systems. There is no need for chemical products for coagulation.
Reliability	A low risk of mechanical problems or problems related to the changes in the raw water quality as these can in the majority of cases be absorbed without interrupting the service.
Cleaning	The cleaning process is simple although sometimes laborious but almost always involving low cost as in many countries labour is relatively cheap.
Requirements of surface area	For smaller communities a conventional RSF plant in respect to storage zones, management of chemicals etc., may require comparable areas to an MSF system
It is not a panacea	There are levels of contamination that surpass the efficiency or interfere with the treatment.

The next stage can be an **upflow, downflow or horizontal-flow gravel filter**. A comparative study of these three options showed that the option of UGF was to be preferred technically and economically over the DGF and HGF, although these also have good removal efficiencies. So here I will restrict myself to **upflow gravel filtration in layers (UGFL),** a system comprising different layers of gravel on top of each other, diminishing in gravel size in the direction of the flow) (Figure 9), and **upflow gravel filtration in series (UGFS)** – two or three units after each other with the first comprising the coarsest gravel and the last the finest.

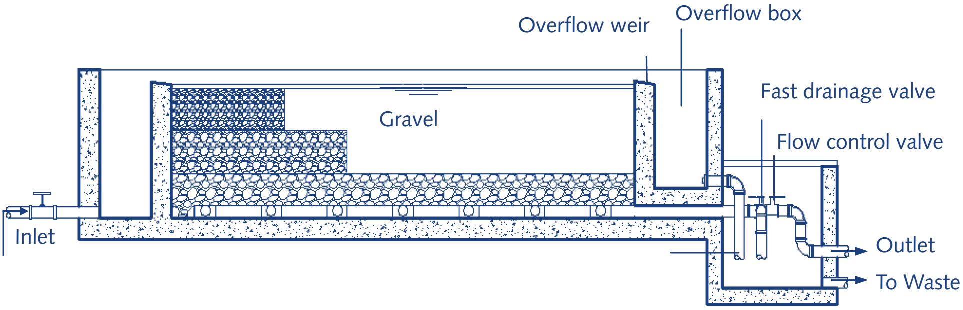

Figure 8. Schematic drawing of a Dynamic Gravel Filter

In most systems, filtration rates between 0.3 and 0.6 m/h are applied. A drainage system placed on the bottom of the structure serves to distribute the flow during the filtration period or to drain the gravel layers during periods of cleaning, discharging the water through the drainage system (Cinara and IRC, 1996).

The research on MSF was carried out in technical and full-scale plants in Valle del Cauca. The plants were taking water from three different rivers with different water quality characteristics (Figure 10). The Elvira and Pance rivers are highland rivers affected by deteriorating catchment areas. During most of the year, turbidity levels are relatively low, but when it rains erosion occurs and causes peaks in turbidity. Pance River passes a more populated area and is a popular recreation area, which explains the higher faecal coliform (FC) counts.

The Cauca River is a lowland river that receives water from the highland river as well as waste-water discharge from Cali and other municipalities. Comparing the data with the water quality requirements for SSF treatment only, the water of the Elvira River would be suitable, but requiring frequent cleaning of the filters. MSF has proved to be a suitable treatment process for all three rivers, which is quite a breakthrough as it confirms its suitability for community water supply treatment in a wide range of conditions.

Others have also carried out research on the combination of gravel filtration and SSF. Than (1978) experimented with it in Thailand in the 1970s. This led to the construction of horizontal gravel filters in the SSF project. Wegelin (1986) carried out research in Tanzania, also with promising results, but never as promising as those obtained by

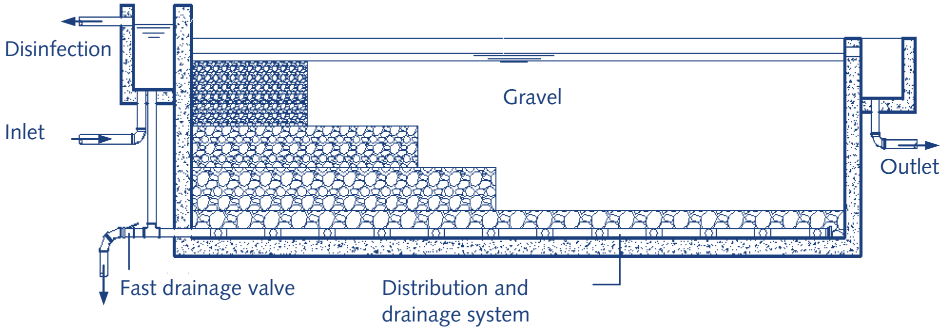

Figure 9. Schematic drawing of an Upflow Gravel Filter in Series

CINARA and IRC. Two important reasons are relevant. Addition of the dynamic gravel filter makes a great difference, as does the introduction of drain pipes that allow the deposited suspended solids to be removed by manipulating a drainage valve, instead of digging out the gravel, washing it and replacing it.

Cost figures vary considerably because they depend on local conditions (Table 10). Treatment may cost 25 to 40 percent of the total cost of the water system. In Colombia, costs are favourable for MSF in comparison with RSF at least for systems up to 10l/s.

The social dimension

MSF is part of a collective system and therefore the interaction with the community, the operator and contractors is very much the same as for SSF. The advantage of MSF is that it is less susceptible to quick changes in turbidity and therefore less vulnerable where erosion is likely, but this has a down side in that people may be less prepared to adjust their actions in the catchment area and this may have long-term effects[10]. There are also some differences in that the tasks for the operator are more regular but of shorter duration. Maintenance includes daily checking of the filtration rates and the head loss in the different units, raking the DyGF once or twice a week, draining the UGFs and removing floating debris and algae from the SSF. Another aspect is that the overall job requires less physical strength, which makes it more feasible to consider female operators.

As the treatment plant has more components, there are more activities going on, including cleaning of the DyGFs and UGFs. This implies that there are more opportunities for the operator to invite members from the community to come and visit the plant and look at these activities. This is very relevant for school children, for example, to make

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[10] Removal of vegetable cover may lead to erosion and loss of water retention capacity, i.e. rapid run-off after rains possibly resulting in flooding, and flow reduction in the dry season. The Roman general who founded Paris measured the summer and winter levels in the Seine for two years before contructing a fortification, the first record of such measurement in Northern Europe. The results were the same, which is astonishing because today these levels differ as much as nine metres, because of changes in the catchment areas (SLIM Project 2004).

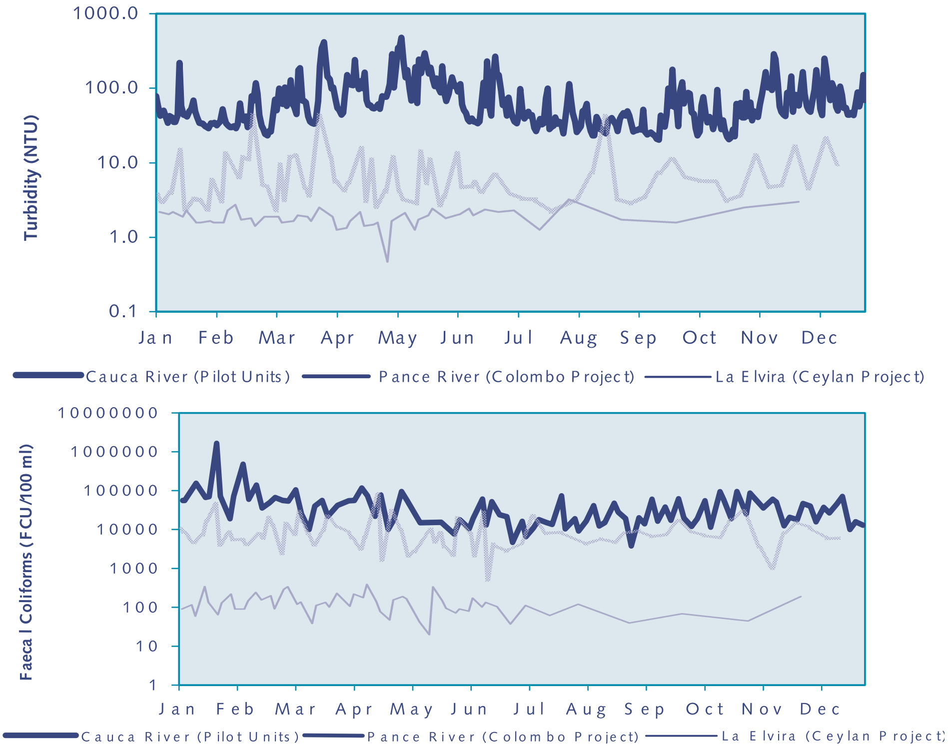

Figure 10. Turbidity levels and FC counts in 3 rivers in 1990 (Galvis, 1999)

them aware of the importance of the plant. This type of visit is also good for the self-esteem of the caretaker.

The DyGF also has an interesting social function in that it facilitates the work of the caretaker considerably. A caretaker of an SSF has to be very alert. When it rains and it can be expected that high loads of suspended solids will reach the plant, it is wise to go to the plant, even if it is in the middle of the night, to close the inlet valve to avoid the filters receiving a lot of suspended solids and having to be cleaned immediately. With an MSF system that has a DyGF this is no longer needed, as the inlet will close automatically – a big improvement in labour conditions.

Table 10. Cost comparison of RSF and MSF treatment in Colombia

	Construction cost per l/s	Annual O&M cost per l/s
MSF (2 – 10 l/s)	US$ 16700 – 27800	US$ 470 – 1375
RSF (2 – 10 l/s)	US$ 16700 – 46400	US$ 1375 – 3740

Cost are based on systems in four regions in Colombia at 1999 price level (Alzate 2000). Cost are only indicative as they may vary based on local conditions. Higher cost relate to smaller systems. In Colombia 1l/s (86.4 m3/day) represents the water supply to 450 to 600 persons.

With MSF we can bring safe water to future generations.

4. The initial conceptual framework of the SSF project

> *"The real voyage of discovery consists not in seeking new landscapes, but in having new eyes." Marcel Proust*

This chapter describes the initial conceptual framework that guided the development and implementation of the research and development project on SSF managed by IRC. It is constructed on the basis of project documentation and evaluation reports, as there was no succinct framework developed at that time. I will take a beta-gamma approach by looking at both technical and social aspects of the activities aimed at introducing SSF water treatment in community water supply in developing countries. I will show that the approach was embedded in the then prevailing but later strongly criticized paradigms of technology transfer and technology diffusion. This criticism I will refer to only in passing in this chapter, as it was not known at the time the project started. I will come back to it in more detail in the theoretical intermezzo in chapter 6.

The conceptual thinking behind the way IRC went about introducing SSF water treatment in developing countries is characterized by what we may now call the 'past' technology-transfer paradigm. Using the definition of a paradigm from Guba and Lincoln (1994 p.107), this paradigm represented the 'world view' of the IRC staff and its advisors – defining the nature of the 'world', the place of the organization in it and the range of possible relationships to that world and its parts. The beliefs are basic in the sense that they must be accepted simply on faith (however well-argued); there is no way to establish their ultimate truthfulness. The following set of basic beliefs was included in the technology-transfer paradigm of IRC:

- Technology transfer is seen as a one-way process, but it is recognized that the technology needs to be proven under the prevailing conditions;
- Autonomous diffusion of SSF technology will follow when successful implementation can be shown;
- Staff from government institutions are the main channel through which technologies are introduced in rural water supply;
- Community involvement is important and needs to include an emphasis on health education.

In addition, it was considered important to develop 'platforms for collaboration' as a means to promote and improve cooperation among the organizations involved. It should be noted that many of these basic beliefs that were the basis for the SSF project have been strongly criticized in later years, as I will show in chapter 6.

From the onset, the approach in the SSF project was interdisciplinary, but with a strong engineering bias. I will explore both technical and social aspects, accepting the risk of sometimes losing the reader. "There is a standard predicament associated with scientific work that wants to be truly interdisciplinary. Experts of a particular scientific field will find the parts of the text dealing with their own field too simplistic and inaccurate (= an uncomfortable feeling when reading about familiar subjects), whereas they will find the parts of the text dealing with less familiar topics obscure and too loaded of useless and irrelevant details (= an uncomfortable feeling when reading about unfamiliar subjects). This explains why genuine trans-disciplinary work is so difficult to sell. As readers we are all forced to handle unfamiliar types of narratives and disciplinary knowledge. Nobody can be a reputable scholar in many fields" (Giampietro, 2003 p. 17).

4.1 Technology Transfer; the model of the 1970s

Looking at technological development in the water sector, Reid (1978) states: "it was in effect a revolution, which enabled more people to be supported at a higher standard of living. Unfortunately, this process did not develop uniformly throughout the world, so gaps arose between different areas, which created the opening for technology transfer. Technology transfer can be conceived as going both ways, however by far the main direction of the transfer process is from the developed to the less developed countries". Reid claims that the transfer of technology to less developed countries has enabled them to reach more advanced levels of technological development in a shorter time. But he also admits that the direct transplanting of water and wastewater treatment systems to developing countries has not led to their satisfactory utilization. This, as I indicated already, is definitely the case for rural water supply treatment, as is shown by the failure of slow sand filters in Brazil (Hespanhol, 1969) and in Peru (Lloyd et al., 1987). Fewer failures were reported from RSF treatment included in urban water supply systems. The size of the urban plants made it possible to ensure a better supply of chemicals, recruit better staff and, when needed, to seek and finance external advice. However, as I keep repeating, the requirements for administration, buying, transporting, storing, and properly dosing chemical compounds needed for RSF, strongly limits the wider application of this type of technology in rural communities, and smaller municipalities (Galvis G., 1999).

Probably because of the better results in urban water supply, Reid stresses that in early stages of development there is a need to rely almost entirely on imported technologies, with efforts concentrated on adaptation to suit local conditions, resources, labour skills and social institutions. As the development process proceeds, local resources can be increasingly allocated to research and development and local manufacture, and so dependence on imported technology can be reduced. Developed countries spend 100 to 1000 times more money on research, but at any stage it would be wasteful to apply severely limited resources to re-inventing technologies already in existence and available through copying and licensing (Reid, 1978). A technology panel that gathered in October 1974 came to a similar conclusion, stating that technology cannot be considered a weighty constraint to progress and the main impact will come from the application of known technology (CWS-WHO, 1986).

Reid, however, did not take into account the important aspects of ownership and capacity development. The relative success of the India Mark 2 hand pump may be based to a considerable extent on the fact that it was developed in India, building on technologies coming from Europe but adapted to local conditions. In a similar way, the positive experience with RSF in urban water supply may have been strongly supported by the fact that Latin American engineers have made important improvements in the RSF process and in simplifying the equipment, facilitating operation and maintenance and reducing investment and operational costs (Arboleda, 1993; Di Bernardo, 1993).

In all, the approach was to introduce technologies from the industrialized countries, including for example hand pumps that had been developed for family water supply on farms, and that were put to a completely different and very intensive community use, which caused them to fail rapidly. In my first survey of the situation in the Cacheu region in Guinea Bissau where these types of pumps were installed, I found that none of them was effective. Some 80 percent of the pumps were broken and the other 20 percent was not used, as people preferred the water from their traditional wells.

The linear way of thinking about technology transfer is nicely reflected in the following statement: "Transferring water resources technology, it should be noted, is the purposive process of moving knowledge to users and encouraging its adoption or use through a variety of approaches. . . In its broadest sense "technology transfer" is a process which encompasses the collection, documentation and dissemination of scientific and technical information" (UNESCO, 1987). This phrase also shows that the term technology in the WSS sector is much narrower than its broad definition in social science studies in which it comprises machines, tools and processes as well as practical and theoretical knowledge required for their utilization. In the water sector, it is rare for any distinction to be made between technique or equipment and technology. Most "technological" literature is limited to the technical and economic aspects and at best deals with their social and institutional aspects separately but often does not include these aspects at all (Vaa, 1990).

So, it appears that in the 1970s the sector followed the conventional conception of technology transfer, in line with the thinking of Rogers (1995 p. 140) who stated that "technology transfer is the exchange of technical information between the Research and Development workers, who create a technological innovation, and the users of the new idea. The conventional conception of technology transfer is that it is a process through which the results of basic or applied research are put into use. This view implies that technology transfer is a one-way process. In this limited view the technology is seen as hardware, a physical product". At the same time Rogers (ibid) acknowledges that technology consists of software as well as hardware and thus that it is essentially composed of information, making technology transfer a communication process, a two-way exchange. "Even when a technology moves in one direction, such as from a university to a private company, the two or more parties must participate in a series of communication exchanges as they seek to establish mutual understanding about the meaning of the technology".

This narrow definition of technology transfer as the transfer of a technical solution does not include the learning environment to ensure that it matches the problems felt by the users. Even in its narrow definition, technology differs from scientific laws that have a universal character, in that it encompasses the historical fingerprint of the society which produced it. Technologies are usually developed to solve a specific problem; transferring it to a different context often leads to failure or deficient performance (Reddy, 1977 cited in Garcia, 1996), unless it is reinvented (adjusted to the new environment). Once the technology is adopted on a larger scale it can be argued that the technology in turn leaves its footprint on the society that uses it.

As I will discuss in more detail in chapter 6, the linear approach to technology transfer that was underlying the SSF project has been criticized by many authors (e.g., Chambers and Jiggins, 1987; Engel, 1995; Visscher et al., 1997; Röling and Wagemakers, 1998; Leeuwis, 2004).

4.2 Autonomous diffusion will follow success

'Automatic' diffusion was an important corollary to technology transfer for the project team. The potential benefits of SSF treatment were felt to be very clear. Implicitly it was assumed that water sector staff (with an academic background) would be sufficiently interested in providing potable water to rural communities to ensure the related health benefits. So, if the technology could be shown to be able to produce good quality water, they would go for it. Yet it was understood that the community would not necessarily feel the need for a safe water supply. Therefore a hygiene-education component was included in the project.

Rogers' model for adoption and diffusion of innovation

The thinking behind the approach used in the project therefore followed the line of thinking of Rogers (1995) who states that "diffusion is the process by which an innovation is communicated through certain channels over time among members of a social system. It is a special type of communication, in that messages are concerned with new ideas" (ibid p.5). An innovation is an idea, practice or object perceived as new by an individual or other unit of adoption. The newness means that some degree of uncertainty is involved. In his definition, diffusion includes both planned and spontaneous spread of new ideas.

Rogers (1995 p. 162) develops the approach for the adoption of an innovation in five consecutive steps (Figure 11). The innovation-decision process begins with the knowledge stage, where an individual is being exposed to an innovation's existence and gains understanding of how it works. It is essentially an information-seeking and processing activity in which the individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation. In the next step of persuasion, the individual (or other decision-making entity) forms a favourable or unfavourable attitude towards the innovation. This leads to a decision to adopt or reject the innovation. In the case of its adoption, the innovation will be put to full use – the implementation stage. This is followed by the confirmation stage, in which reinforcement is sought that the choice was right. If reinforcement is not obtained, earlier decisions may be reversed.

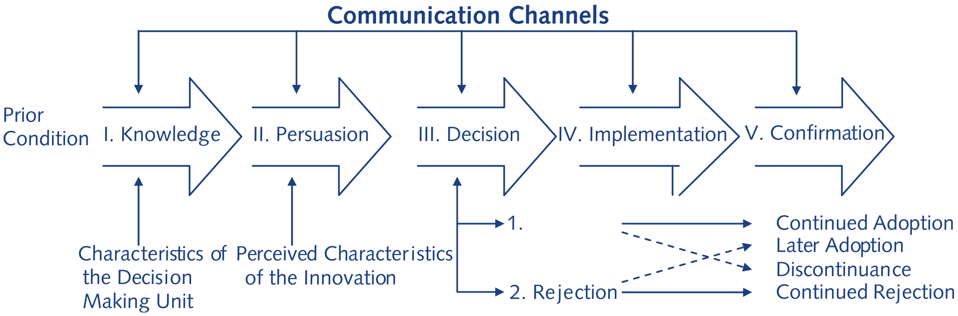

Figure 11. Stages in the Innovation – Implementation process (Rogers, 1995 p. 163)

As I will discuss in chapter 5, the process in the SSF project parallels the first two steps in the model. Technical-scale plants and village demonstration plants were included as a means to generate the necessary evidence (the knowledge), which was thereafter shared with sector staff in the dissemination phase to encourage them to adopt the technology (persuasion).

Rogers (1995 p. 207) identifies a range of variables that determine the rate of adoption, i.e. the uptake of an innovation. These include:

- Perceived attributes of the innovation where he distinguishes the relative advantage, compatibility, complexity, triability and observability;
- Type of innovation decision, differentiating between optional adoption at the individual level independent of others, collective decisions to adopt or reject made by consensus among members of a system, and authoritative decisions made by relatively few individuals with power over the other members. The last two relate to innovations adopted in organizations, which Rogers (1995 p. 371) considers “much more complex. Implementation typically involves a number of individuals, each of whom plays a different role in the innovation decision process. Further implementation amounts to mutual adaptation in which both the innovation and the organization change in important ways”;
- Communication channels (e.g., mass media or interpersonal);
- Nature of the social system (e.g., its norms, degree of network interconnectedness, etc.) stressing the role of opinion leaders who may be monomorphic (acting as leader on a single topic) and polymorphic (acting on a variety of topics);
- Extent of change agent’s promotion efforts, the change agent being the individual who influences clients’ innovation decisions in a direction deemed desirable by a change agency.

As is clear from the project documents, the project team was quite convinced that the perceived attributes of SSF, being a simple and robust water treatment technology, would be a positive asset and by showing that it worked through demonstration projects would establish a very favourable situation for widescale autonomous adoption. It can be argued that the team did not explore the issue of compatibility – the degree to which an innovation is perceived as consistent with the existing values, past experiences, needs, and socio-economic conditions of potential adopters. As I will point out in chapter 5, sector engineers had a clear preference for chemical water treatment involved in RSF. This aspect was not taken into account by the project team, whereas this preference may block the adoption of SSF, which does not involve chemicals.

Another aspect not taken into account in this stage of the project is the considerable criticism of the linear model. Röling (1988) argues that technology transfer is not a linear process, but a much more complex phenomenon. Crul (2003 p. 53) suggests that: "critics to the general model of innovation diffusion emphasize the pro-innovation bias of the model. Usually the actors involved in the projects/research want the innovation to be diffused and adopted by all members of a social system, want it diffused more rapidly and do not want rejection. As a result much more is known about innovation successes and not enough about innovation failures". Another limitation of Rogers' model that Crul mentions is that it was developed on the basis of experiences in agriculture where there are many small companies that are producing identical products for commodity markets (ibid p. 53). This situation is quite different for the water sector. I will not expand on the criticism and the shortcomings of the model here, but will deal with them in more detail in chapter 6.

4.3 The transfer channel

The project document of the SSF project states that: "both research institutes and governmental authorities have to be consulted with regard to the implementation of the activities planned in the project" (IRC-SSF, 1976). This matches the thinking at that time, as exemplified by Hommes (1983), who distinguished three different channels for technology transfer: commercial channels; acquisition of knowledge through entrepreneurs; and development projects of governments. He indicates that in both the commercial and the government channel there has been room for research and development to further develop the innovations. In many cases however this research has been carried out by international companies, as may be concluded from the fact that 99% of all patent rights are held by organizations or individuals in developed countries (Bell, 1992).

The transfer channels mentioned by Hommes are different from the communication channels referred to by Rogers (1995), who distinguishes between mass media and interpersonal channels. The difference, it can be argued, stems from the fact that Rogers looks at the means through which the information is communicated by the 'change agent', whereas Hommes looks at the actor-user relationship, in which the initiative may be on the side of the actor but also of the user.

IRC chose the government channel because it wanted to generate interest from both national and international organizations for large-scale rural implementation programmes on SSF. Commercial and entrepreneurial channels are more interested in large urban water supply systems for which international firms supported the design and construction of water and wastewater treatment plants and more recently have also obtained concessions to take over the management of these systems.

The international level indeed can be seen as another channel which is important for the rural water sector, because international agencies such as UNICEF, UNDP, the World Bank and international NGOs support development programmes to introduce 'new' technologies in rural areas. In the first chapter, I mentioned the development of the India Mark 2 and AFRIDEV hand pumps. Another example is the introduction of a new foot pump in 1979 in Guinea Bissau through the UNDP/UNICEF project that I worked in. This pump was modified by the factory three times in the course of three years, with the project paying for the required adjustments of earlier models. Decisions about changes were made at the factory level without any involvement of the user group or even project staff. So a clear top-down technology-transfer model was used. It was accompanied by some training of pump caretakers, but the technology was not matched with local conditions, nor was the institutional framework reviewed that was required for adequate maintenance. The international (UN) channel was attractive because IRC was well placed in this network of international agencies and in WHO had a good partner for implementation of the project.

Although the project documents placed considerable emphasis on transfer of knowledge and experience, linking the project to university training is not mentioned. This is though another important channel for transfer of technology. Students are exposed to 'new' technologies in the training they receive at their university or when they go abroad for training. The fact that this has not been identified as an important channel by Hommes (1983) is an omission and may underestimate the important impact this type of training can have. In principle, it broadens the number of technologies engineers have 'on the shelf', which is important. One of the points raised in relation to the failure of technologies is that they are not properly selected. They are "just grabbed from the inventory of machines most familiar to the engineers in the field" (Henry 1978 p. 369, cited in Vaa, 1990).

4.4 Community involvement

One of the central features proposed in the SSF project document was "the development of models for community education and participation involving the communities in all phases of the water supply programmes" (IRC-SSF, 1977). So, the project did see community participation as an important approach, which is very much in line with the thinking in the mid-1970s when community participation became an important theme in development cooperation. Community participation was seen as an approach that could overcome problems that the technology-transfer model could not solve. In studies of transfer of technology in the framework of development assistance, lack of success is usually explained in relation to problems at the receiver side. If the technology is not effective it must be the users that are at fault (Vaa, 1990).

The 1977 Mar del Plata conference in Argentina clearly placed the concept of community participation on the international agenda. It recommended that "countries adopt policies for the mobilisation of users and local labour in the construction, operation and maintenance of projects for the supply of drinking water and the disposal of waste water" (United Nations, 1977 p.25).

The emphasis in the thinking of the IRC team was very much on community education and information and not on community empowerment and involvement in decision making about the project. Two reasons are presented for the involvement of the community:

- To see how far the installation and operation and maintenance of systems involving SSF can be carried out by local people, given their level of skills;
- To ensure the intended health benefits from water purification, since improved health comes not only from clean water, but also from improved use and personal hygiene and sanitation practices (IRC, 1979).

Community participation was defined as "the active involvement of all members, or at least all sections of the population, in the various stages of the introduction of the development in question – in this case the planning, design, installation, operation, maintenance and use of the new water supply; as well as in the process of behaviour changes in relation to sanitation and personal hygiene" (ibid p.13). In the area of health education, the aim was to bring about voluntary changes in practices. Communication from the people to the community workers (but apparently not the engineers), as well as in the other direction, was considered essential. The best way of providing a continuous two-way communication is through community participation in the process of education itself (ibid p.13). Also it was recommended to involve women, in their capacity as mothers and users of water, as much as possible, at every stage of the planning, implementation and evaluation of the projects (ibid p. 16). This thinking is reflected in the report of the international project meeting on community education and participation held in the Netherlands with staff from the participating institutions.

Comparing these views with other approaches at that time, the thinking was ahead of many other projects. A typical quote that applied to many projects at that time comes from a programme that was implementing projects in Malawi: "The key to the success of these projects is the involvement of the whole community, and the setting up of an organization that can handle the large amount of work that has to be done and ensure that every one does his share. The first step is to hold a public meeting to announce the project. The chief will ask his people if they want the project and are willing to work for it. In this way self-help commitment is established" (Robertson, 1980 p. 10). Wijk (2001) quotes many examples of agency-led projects that were implemented in the 1980s and 1990s that had minimal strategies for community participation, whereby users (women) have hardly played a role. Subsequent evaluations of these projects often showed low sustainability of facilities.

An interesting background paper prepared by Röling for the Voorburg meeting indicated three different approaches that could be distinguished in extension work at that time (IRC 1978 p. 40):

- The do to approach; one first decides on the solution to be offered and then looks for people with the problem that fits the solution, an approach that often results in the better off getting the benefits;
- The do for approach involving a careful study of the target group and its problems. Then solutions are developed within the capacity of the change agent; a usual approach of the private sector;
- The do with strategy emphasizes priority problems of community members/authorities and community groups and focuses on removing bottlenecks when solving those problems. This approach was suggested as most useful for the health education component in the project.

With the solution (SSF) already chosen, it is not surprising that the issue of community involvement was considered important in relation to the selection of 'demonstration' villages in which IRC had a final say. "In selecting the villages it should be well recognised that the communities will not be equally receptive to public water supply, often due to the differences in the degree of development already obtained. Experience from many countries indicates that water supply systems are better maintained; less abused, and have a higher level of financial performance, if the villages to be served are selected because they express a real interest in having a new or improved system. In general terms, a good sense of responsibility for the water supply system is an important condition for effective community involvement (IRC-SSF, 1994). Whereas the project document clearly states that the intention is to work with the communities, the whole wording of this paragraph has quite a strong flavour of the do to approach, as will be further established in chapters 5 and 6.

4.5 A platform for collaboration

"The programme will have the character of a collaboration project between executing agencies in the field of: Community Water Supply and Sanitation, Primary Health Care and Research and Development Institutions in the field of Public Health and Environmental Engineering. The establishment of project management committees (PMCs) was proposed to promote and improve the collaboration between government authorities, ministries, universities, research institutes and executing agencies. It was seen as an important strategy to obtain the necessary strong support from the legislative and executive branches of the government. An adequate collaboration within the country was considered to be a basic pre-requisite for effective planning and coordination of the various activities, and a necessary condition for successful implementation" (IRC-SSF 1976).

Representatives of both national and local governments and universities or research institutions were to be the core of the PMC. Representatives of the local executing

agencies and additional advisors could also participate. Also it could be considered to include representatives of the communities concerned (ibid).
The PMC was supposed to have an integral responsibility for the organization, staffing and control of the project in the country and for the information and consultation of other national and local authorities. This responsibility included the selection of project communities, with IRC however having a final say in this. It was recognized that in establishing PMCs and in promoting a spirit of collaboration, a variety of socio-cultural and professional constraints might have to be surmounted, but without clarifying them. The concept of the PMC was new for IRC and for its partners and it appears to have been established on the basis of common sense, as no reference to PMCs could be traced in any of the project documents.

4.6 Information sharing and training

The transfer of appropriate information was regarded as an integral part of the project. In general, transfer to the community of appropriate information on various aspects related to realization of the village demonstration plant was considered to be essential for the motivation of the villagers, as well as for social acceptance of the system and promotion of local involvement. Preparation of such information was shared between the national PMC, the local agencies, and IRC (IRC-SSF 1976 p. 5). Training was also considered important as an integral part of all technical development programmes, with emphasis on on-the-job training for lower and middle technical levels (ibid p. 7). This focus, I assume, was based on the rather general view that failures in water supply systems were often caused by poor operation and maintenance and inadequate management, as also reported by Vaa (1990).

The focus on external information and training parallels the characteristics Long and van der Ploeg (1990 p. 228) attribute to intervention models of the 1970s and the 1980s, "where interventions are visualized as a discrete set of activities that take place within a defined time-space setting, involving the interaction between so-called 'intervening' parties and 'target' or 'recipient' groups. In these models a 'package from outside' is designed to stimulate the emergence of certain internal activities. The underlying rationale is the idea of transferring to the target group those capabilities or types of knowledge that they are assumed to lack. The situation chosen for intervention is deemed inadequate or needing change; thus local bodies of knowledge, organizational forms and resources are implicitly (and sometimes explicitly) de-legitimized". They criticize these approaches and state that "given their commitment to externalist solutions, intervening agencies will normally aim to subsume local conceptions and strategies of development" (ibid p. 232). This type of thinking was developed at a later date and did not enter into the project discourse during the period I am describing here.

The SSF project documents suggest that village demonstration plants were to play an important role in providing direct experience and know-how to the target audience. This matches the suggestion of Rogers (1995 p. 355) that "potential adopters of a new idea are aided in evaluating an innovation if they are able to observe it in use under conditions similar to their own. Change agents may try to increase the observability of an innovation, and thus speed up its rate of adoption, by organizing a demonstration of the innovation". In this case, the village demonstration plants can be seen as, what Myers (1978 cited by Rogers, 1995 p. 356) calls "*experimental demonstrations*, which are conducted to evaluate the effectiveness of an innovation under field conditions". They were however at the same time expected to function as *exemplary demonstrations* (ibid) which are conducted to facilitate diffusion of the innovation. The first type of demonstration is completed when the results are known, whether positive or negative, whereas the second has the intention to persuade potential adopters.

Another means of promoting the application of SSF was to take place through the series of guidelines on construction, maintenance and management of SSF plants. Interestingly, policy makers and local authorities were mentioned as specific target groups to be reached, but not, for example, university students.

Information provision was not the only element in the project. Information sharing was also envisaged among the individuals participating in the project and external advisors. In this aspect the project was different from most other 'intervention projects' at that time, in that it considered a more 'equal' relationship between the researchers from the developing world and the external advisors. International project meetings were planned for PMC members to discuss various aspects of the project, but also served to strengthen mutual contacts, stimulate international collaboration and promote effective information exchange. Expert meetings were seen as an important vehicle to create access to recent information generated in European water systems with respect to operation, maintenance and management that would otherwise be difficult to access IRC-SSF 1976 p. 8).

When reflecting on the conceptual framework, it is interesting to see that in a number of areas, such as the thinking about community participation and the project management committees or platforms for collaboration, the project was at the cutting edge of developments, whereas this was much less the case with the thinking about technology transfer. Here the thinking was still very much oriented towards the prevailing linear approach, which has come under a lot if criticism since, and which, as I will show in the next chapter, proved not to be very effective.

Preparing for the official opening of the SSF treatment plant in Borujwada, India.

5. The slow sand filtration project (Case Study 1)

> *"Why, given one hundred different innovations conceived of at the same time – innovations in the form of words, mythological ideas, industrial processes, etc. – ten will spread abroad while ninety will be forgotten." (Tarde, 1903 quoted in Rogers, 1983 p. 40)*

In this chapter, I review the SSF project and explore the adoption of SSF in the countries that participated in the project. The objective of the project was to promote application of SSF in community water supply. I intend to demonstrate that at its core this project followed the patterns of technology transfer and diffusion as described in the previous chapter. The emerging picture shows that the narrow focus on the "linear technology transfer model" was barely successful and required additional contextual action and a stronger emphasis on learning to have an impact. I entered the process as manager of the third phase of this six-country project, which was meant to be the final phase but was followed by an extension of two years.

5.1 Description of the SSF project

The SSF project was originally developed by IRC, with help from an advisory group, and implemented in close collaboration with institutes from developing countries. The first 'field project' of IRC, it was funded by the government of the Netherlands and was initiated in 1975. It aimed to demonstrate the feasibility of the technology under different conditions in developing countries and to promote the application of SSF for community water supplies in rural and urban fringe areas in these countries. It was stated that "the project enhances, among other things, the generation and diffusion of information needed for planning, design, implementation and the maintenance of large scale water supply programmes including SSF as a treatment component. The project also supported the further development of appropriate 'field delivery models' for such programmes, including the institutional and organizational infrastructure at national and local level" (IRC-SSF 1977 p. 1). The project document further claims that "the project is based on an integral approach towards the various structural problems and constraints related to community water supply in developing countries and therefore comprises a series of complementary and supporting activities of a multi-disciplinary nature relating to the technological, the organizational and the sociological aspects of water supply and sanitation programmes".
These were very ambitious goals which, when looking at the reporting over time, were watered down by focussing on the SSF component and on community participation, and much less on the overall water supply system and the supporting infrastructure.

The SSF Project had three phases:

1. Laboratory research in the participating developing countries to test the technology under tropical conditions;

2. Demonstrating the feasibility of SSF in full-scale demonstration plants in selected communities, including both technical and socio-economical aspects;
3. Dissemination through seminars and publications, to transfer the know-how and experience gained and promote the application of SSF.

5.2 The project partners and the project network

IRC developed and coordinated the SSF project. It involved the participating institutions through dialogue. Subsequently staff of these institutions carried out most of the activities. The project partners in the first phase (1975-1977) were:

- University of Science and Technology, Kumasi, Ghana
- National Environmental Engineering Research Institute (NEERI), Nagpur, India
- University of Nairobi, Kenya
- Institute for Public Health Engineering Research, Lahore, Pakistan
- University of Khartoum, Sudan
- Asian Institute of Technology, Bangkok, Thailand

The global spread of partners had the purpose of testing the technology in different climate zones. By working in different countries, it was also considered feasible to use a range of laboratory facilities at relatively low cost. All partners were research institutes but all of them also had a training role at university or practitioner level. Therefore they can each be considered a potential "transfer channel", although different from the ones suggested by Hommes (1983), provided that they included the research results in their training programmes.

In the second phase (1977-1981), the partners from Ghana and Pakistan no longer participated. They were replaced by the National Health Institute in Colombia and the National Water Authority of Jamaica. This change was the result of several factors. Progress in the two countries in the first phase had been very limited. Also, there was a wish to include activities in Latin America, as it was felt that that continent was more advanced in 'community education and participation'. Another reason was the interest to concentrate on countries where the Netherlands government was providing support to the water sector, so as to enhance the possibility for wider dissemination. Changes also occurred in the lead institutions. The lead was taken over in Thailand by the Provincial Waterworks Association (PWA), the agency responsible for provincial water supply (both urban and rural), and in Kenya by the Ministry of Health.

In this phase, as more partners became involved, a Project Management Committee (PMC) was established in each of the countries. The aim of these PMCs was to:

- Improve the collaboration between ministries, government institutions, universities and research institutions;
- Contribute to the development and improvement of a national infrastructure for water

and sanitation and hence to the development of local administration and management capabilities; and
- Coordinate project activities and ensure the staffing and progress control of the project.

Village committees were also established "for the planning and progress control of the various activities to be implemented. Representatives of the community were invited to participate in this committee."

The broadening of the number of partners in the second phase, particularly the involvement of government institutions, implied a new situation in which two potential "transfer channels" can be distinguished: the university and practitioners training; and government programmes.

In the third phase (1982-1983), the same partners continued to lead the project in their respective countries, with activities concentrating on national and regional seminars and development of training and information materials. This phase was supposed to be the end of the project, but reflection on the limited capacity of SSF systems to cope with high levels of turbidity and the difficulties with operation and maintenance, led to an extension of the project (1984-1986) being granted, to proceed with activities in the two most active countries, Colombia and India.

5.3 Phase 1: Exploration and laboratory research

The first phase of the project (1976 to 1978) focused on testing of the SSF technology by the participating research institutes. This included review of existing systems and some exploration of pre-treatment techniques that were primarily based on sedimentation. Gravel filtration was also tried out in Thailand.

Prior experience differed

The prior experience with SSF was very different in the participating countries. Some had very little experience with SSF or with rural water supply treatment in general. In India, Kenya and Sudan, a considerable number of systems had already been built under British influence. NEERI for example, made an inventory of 73 plants in India. Eighty percent of them were serving populations below 10,000 and almost all filters were preceded by plain sedimentation, in 30 percent of the cases supported by alum coagulation in the wet season. The latter is understandable as an approach to cope with high turbidity levels, but it changes the SSF concept completely, turning it into complex chemical treatment that requires a much more sophisticated operation. In Kenya, a survey was carried out covering 26 SSF systems (Soleman, 1976). In Sudan, some 200 SSF systems had been constructed since 1962 in the Gezira Irrigation Scheme. These did not perform satisfactorily as they were not regularly cleaned and the sand specifications were doubtful (IRC/NEERI 1980).

Technical-scale research

All the research institutes involved in the project carried out pilot-plant research, though it is better to call it technical-scale research as the plants were already the size of small full-scale units. IRC did not provide a standard pilot plant design but only a set of minimum specifications. These were used by the different research institutes to develop their own pilot plants. Differences in the designs were small, with almost all pilot plants being made with concrete pipes of 1.5 m diameter. Generally they had a height of 2.5 m, but in India this was 3.5 m to investigate declining rate filtration[11], a special way of operating the plant that allows interruptions in the pumping of raw water to the SSF. There were differences in the sand that was used, and in some cases it was too coarse for SSF treatment. The institutions also had considerable freedom in the research topics, but in most of the countries similar topics were selected. These can be summarized as:

- The performance of the system in terms of removal of organic matter, turbidity and coliform bacteria, related to the quality of the raw water;
- The effect of different filtration rates, shading and seasonal variation on water quality;
- The performance of existing slow sand filters in the country.

The research was of a very technical nature and interestingly did not reflect findings from the review of performance of existing SSF plants. These findings showed difficulties with cleaning and in several countries high turbidity was dealt with by chemical pre-treatment, which increased cleaning problems. This clearly called for a much greater understanding of these problems and more attention to pre-treatment. This was also to some extent suggested by the project advisors, but in my view not for the most important reason. They considered that "experiments with simple pre-treatment systems were necessary in view of the possible high turbidity levels that might be anticipated in the second project phase" (Soleman, 1976), whereas the main argument should have been that the poor performance of existing SSF systems was very much caused by high turbidity and the related maintenance effort that put the wider application of the technology at risk.

Trend to move to chemical treatment

Another element that emerged from the review of existing plants was the tendency to move towards chemical coagulation and RSF. In Ghana, for example, two SSF plants existed prior to the project. One was changed into an RSF, however, and the other used chemical pre-treatment prior to the SSF, preventing normal performance of the biological process. The chemically destabilised suspended solids form flocs that may be partly carried into the SSF and cover the bio-organism making it less effective or ineffective, or they may even block the filter completely. In Zambia, I visited an SSF where the surface of the sand had become blocked in that way and formed a very hard crust that was

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[11] Declining rate filtration occurs whhen the inflow to the SSF is interrupted whilst letting the outflow open. The supernatant water level will gradually decline as will the filtration rate as the hydraulic gradient decreases. When the inflow is resumed the supernatant level can increase again. This form of operation does not negatively affect the water quality and allows, for example, intermittent pumping of water to the SSF in pumped systems.

difficult to remove. Similar experiences were available in the other countries and in many of them RSF was the trend. Three important reasons may have supported this trend:

- High turbidity levels in the rainy season, common in tropical rivers, caused the application of SSF without pre-treatment to fail in quite a number of locations;
- RSF was considered a modern technology that was now applied in Europe and the USA, whereas SSF plants were no longer built there and were seen by many engineers in the participating countries as second-hand technology;
- Engineering training tends to be clearly urban-oriented. In urban areas, high volumes of water are needed, thus requiring large areas of land for SSF.

These trends in the direction of engineering thinking were not reviewed carefully at the time, whereas later in the project they proved to be an important limitation to the further dissemination of SSF technology.

Research process

The major part of the work was carried out by the participating organizations, while IRC staff coordinated the project. Institutions had considerable freedom in the orientation of their own research activities. This resulted in considerable differences in the volume of activities in the different organizations, with NEERI in India having the largest research programme. NEERI explored the effect of the filtration rate, the shading of filters, the height of supernatant water, the depth of filter bed, the size of filter material and the effect of declining rate filtration.

According to de Wilde (1980), an external evaluator, the staff from the participating organizations saw the role of IRC as ‘coordinating’ and ‘stimulating’, and clearly not as a funding organization. IRC staff saw its role in a similar way as:

- Coordination including particularly the intermediary and advisory function;
- Problem identification;
- Establishment of ‘guidance’ documents; and
- Mediation in fund raising for ‘follow-up’.

Guidance was provided through documentation, occasional visits by IRC staff and an international project meeting in the Netherlands in 1976. The guidance documents were developed by Europe-based experts in water treatment. Their development was not used to stimulate a participatory process among the partners in the project. This was a missed opportunity to establish a two-way process that could have led to a better understanding on both sides and a better support strategy.

Results

The results of the SSF research were positive, but with the limitation that, contrary to many field situations, testing was carried out with raw water that was low in turbidity. So, the filters were tested under relatively good conditions and, in most countries, produced water of satisfactory bacteriological quality – except for Kenya. It was concluded that “in case the turbidity is above 10 NTU, pre-treatment seems to be advisable, such as plain sedimentation or gravel filtration” (Soleman, 1976).

The results that involved pre-treatment were limited and basically related only to plain sedimentation. The exception was Thailand, where the Asian Institute of Technology (AIT) tested the new concept of “horizontal gravel filtration”. Interestingly, in a separate project supported by the International Development Research Centre (IDRC) from Canada, AIT, a member of the PMC guided the construction of an SSF plant preceded by a horizontal gravel filter in Jedee-Thong, a village reasonably close to the AIT headquarters. AIT wrote a research report on it, but these results did not appear in the report of the SSF project in Thailand. In fact, the results were quite interesting, as the plant, taking water from a source with an average turbidity of 25 NTU (Than, 1978), produced a good quality effluent of 2 NTU (slightly above the WHO guideline values for water quality). These raw water turbidity levels were considerably higher than the two “demonstration plants” in the SSF project. On the surface, it appears that the interaction in the PMC in Thailand was limited to SSF project activities, ignoring parallel research by others.

The results of the research (see Table 11) were very relevant, especially those from India, as they increased insight into the performance of SSF, and allowed adaptations in the design that reduced cost or improved performance. For example, the lower construction height made possible by a shallower sand-bed led to cost savings in the construction and to improved operation of the process. A combination of cost saving and improved operation was established by strongly advising against the trend in India to include one or two extra units as stand-by. These units had been made available to be put into operation only when another filter was taken out for cleaning. This ‘malpractice’ shows that the biological nature of the process was not appreciated, because the ‘ripening’ of the stand-by filters would take several weeks before good quality water could be produced. The project clearly established that during a short period of a few days it was not a problem to increase the rate of filtration in an SSF unit while one of the others was out for cleaning. This makes stand-by units unnecessary.

The research results made it possible to establish new design criteria for SSF systems, to be used in the second phase of the project. The design criteria that were proposed are fairly similar to the once used by Huisman and Wood (1974), with the exception of a somewhat lower total filter height of 2.60 m and a lower filtration rate of 0.1 to 0.2 m/h instead of 0.1 to 0.4 m/h.

Reflection

In this stage the project was very much in the hands of researchers, who did a good job in testing the technology and showing that it worked under specific conditions. The conditions were unfortunately different from the reality faced by many water supply systems. From the available information, it appears that few links were established with practitioners from water companies and no links were created with water treatment plant operators. This seems a missed opportunity, as the learning about the technology was

Table 11. Key findings of the research

Issue	Finding
Filtration rate	Good results were obtained with filtration rates of 0.1 to 0.3 m/h, but, as may be expected, higher filtration rates lead to shorter filter runs (period between cleanings). Filtration rates can be increased temporarily, when one filter is out for cleaning
Intermittent operation	It was conclusively shown that intermittent operation (interrupting the flow for a few hours or probably less) does not lead to a reduction in removal of turbidity, but does lead to a deterioration in bacteriological quality of the treated water
Shading	Shading of the filters reduced the algae growth in the supernatant water level, but had no influence on the water quality produced
Sand	In many situations locally available sand can be used, provided it meets the specifications in terms of grain size and uniformity coefficient
Depth of sand	A minimum layer of 0.4 m of sand bed still gave good removal efficiencies
Ripening	The first time the SSF was put into operation, it took some five weeks for the biological processes to establish and produce good results; after cleaning (in one day), it takes only two to five days, because part of the biological population is still in the filter
Stand-by units	Should be avoided as they increase cost and do not perform adequately
Cost	Comparative studies between SSF and conventional systems in India show that SSF is more economic in terms of initial investment up to plant capacities of 35 l/s (3000 m^3/day). When operation and maintenance cost are also taken into account, the break-even point increases to 93 l/s (8000 m^3/day)

Based on Sundaresan and Paramasivam, 1982

now restricted to the researchers. As we will see later in the experience in Colombia, such closer links are beneficial for both the researchers and the others.

The project proposal indicated that it was anticipated that the comparison of the problems and results in the different countries would help to place things in perspective and would make the researchers more critical about their own work. De Wilde (1980) suggests however that the latter only occurred to a limited extent. The following example supports this observation. The research in Kenya was done with very coarse sand, which is normally used for RSF and is definitely not suitable for SSF. Interestingly there was a recommendation to continue the research with finer sand, but this did not materialize. The consequences of this weak intervention were apparent seven years later. In 1983, I participated in the dissemination meeting in Nairobi (Phase 3). At this meeting, the senior Kenyan researcher concluded that SSF was not very suitable in Kenya as it did not remove bacteriological contamination very well. He was publicly corrected by peers from India and a young engineer from Tanzania who all pointed to the coarse sand being used in Kenya. They received a strong round of applause from the audience. This was quite awkward, as the senior Kenyan researcher really lost face. An earlier intervention in the research design would have prevented this and would have led to more meaningful results. This example suggests that there can be serious consequences if an approach is used that includes providing guidance documents and making general agreements at the start, but subsequently providing only limited guidance as the research proceeds.

What is clear from this phase is that IRC was the central point in the network, but did not play a forceful correcting role, while bilateral relationships between network-members did not develop, and were not encouraged (de Wilde 1980). No doubt this was influenced by the limited means of communication at the time. Today it would be much more feasible to organise a multi-country project as a ‘community of practice’, stimulating the communication among the partners through internet and video conferencing.

The research process helped to build the technical capacity in the participating organizations to develop the project for the second phase. It did not, however, provide the basis for the socio-economic components, as all activities in the first phase were strictly of a technical nature. Also, the level of research and the resulting capacity developed was quite different in the different countries. India was well in the lead, with the NEERI staff publishing their experience in several journals, which was not the case in the other countries.

5.4 Phase 2: Development and demonstration plants

The project document of Phase 2 (1979 to 1981, continuing in some countries through 1982) is very ambitious. It lists:

- Three overall objectives to: improve public health in developing countries; promote autonomous development; and further international collaboration;
- Four long-range objectives focussing on: creating awareness regarding SSF at all levels; promoting national plans to include SSF; improving national infrastructure; and generating interest for large-scale SSF programmes;
- Seven short-term objectives: adapting SSF to local conditions; exploring pre-treatment; developing guidelines for both; gaining experience with village demonstration plants; demonstrating the technical and socio-economical suitability of SSF for developing countries; showing the public health and socio-economic impact; and developing an appropriate method for introducing water supply in rural communities in developing countries.

In subsequent documents, these objectives were summarized in two key objectives:

- To demonstrate at village level the effectiveness of SSF as a simple and reliable purification technique able to produce safe drinking water at low recurrent cost. This is to be accomplished by the implementation of a number of so-called village demonstration plants and integrated water supply projects in selected villages;
- To develop, test and evaluate models for the organizational and institutional

infrastructure, at national and local levels, required for the replication of SSF projects within the scope of large-scale implementation programmes (Heijnen, 1982).

Process

The implementation of the project was placed in the hands of the PMCs, which comprised different types of organizations including water supply, health and/or community development organizations at the national and regional level, and national research institutes in public health and environmental engineering. The number of organizations involved ranged from two each in Colombia and Jamaica, to seven each in India and Sudan.

To guide the implementation in this project phase, key documents were produced by external advisors from well recognized Europe-based institutions. These included:

- An outline of the community extension component of Phase 2 of the SSF project (White, 1977);
- Socio-Economic Studies for Phase 2 of the SSF project, a practical guide (Curtis, 1977);
- Public Health Studies in Phase 2 of the SSF project, a practical guide (Feachem, 1977); and
- Two guidance documents, one on SSF design and construction and the other on operation and maintenance.

These documents give a good insight into the technology and have been widely quoted, but again they were developed by external advisors who did not have a direct relationship with the project teams in the countries. The only exception were three field visits in 1980 by social scientists from IRC, who visited Colombia, India and Sudan to review progress but not to help design the intervention strategies.

Selection of demonstration villages

In each of the participating countries, villages for the demonstration plants were selected on the basis of the following main criteria:

- Surface water as only water source and suitable for SSF treatment;
- Adequate water supply a priority need of the community;
- Community willing to participate actively in planning, construction and management;
- Ensuring validity of results by incorporating sufficient diversity of climatic and geographic conditions and socio-cultural and socio-economic settings.

These criteria are quite specific and the first three make it impossible to ensure validity of the findings beyond these rather restrictive settings. Initial selection was done by the main implementing agency in each country or state and submitted for approval to the PMC and IRC. Subsequently, the implementation process followed the normal procedures of the country concerned, as part of the funding had to come from country budgets. The consequence was that the rate of implementation differed considerably between countries. The reasons given in the progress reports included: worsening of the economic situation; lack of construction material; change in priorities; and elections leading to change in the municipal and national government organizations.

It is interesting to note that, in preparing this phase of the project, important emphasis was placed on health aspects. Technical guidance was limited to the development of guidelines for design and operation and maintenance of SSF systems and did not include guidance on water source protection or the distribution system. Another interesting aspect is that project documents stressed the need for an integrated approach, which implied that technical, socio-economic and health aspects needed to be taken into account. Unfortunately, this integrated approach was not put into practice, allowing field staff with a technical background and those with a social background each to "do their own thing" instead of starting to work more as a team, as I will discuss in chapter 7.

Community education and participation

The roadmap for the 'community education and participation approach' of the project was developed with staff from the participating institutions in a 5-day meeting in Voorburg in 1978. This meeting agreed on a fairly detailed set of aims and innovative principles to be used for this component of the project:

- Women should be involved in all stages;
- Benefits need to reach all sections of the community, if necessary including a subsidy for the poor;
- Information should be gathered on the communities and information on the project should be brought to the community;
- Operation and maintenance must be carried out with the collaboration of the community and the agency;
- Health education should be participatory (two-way communication);
- Community members' intimate knowledge of their situation should play as important a role as the expert knowledge of the health educator in deciding on the behaviour changes to be targeted (IRC, 1978).

After the Voorburg meeting, individual participating countries were very much left to interpret their commitments in their own way. As a result, what was done in the demonstration villages was more implementation of approaches and methods customarily used in each country (albeit in a more concentrated form at least in India), than the more innovative approach agreed in Voorburg. In fact, in three of the six countries demonstration systems were not even built, though this was partly balanced by the fact that in India demonstration schemes were built in four different states. Despite these deviations, IRC, as the principal change agent in the technology transfer model, was not inclined towards or capable of playing the required 'authoritarian' role.

The basic approach in the demonstration villages started with a preparatory stage that focused on establishing a dialogue involving the community worker and community members, village authorities, and village groups. It also included implementation of community and technical surveys and agreement with the community (i.e. their leaders) about their participation in the SSF project. During implementation, the emphasis shifted to mobilization of community support, community resources and hygiene education (IRC-SSF 1977).

As White (1984) noted, implementation of the demonstration schemes was not much different from the 'normal' approach in the countries, i.e. a water agency carrying out construction of a water supply combined with the top-down implementation of a health education programme. Users had no choice; the procedure was not recommended for adoption by them but just implemented after they agreed to some key conditions to safeguard their 'participation in the project'. In the Thailand case, for example: "Villagers are quite eager to participate in the village meeting. They were informed that they had to participate in the project to some extent. The preliminary survey has revealed that they agree to provide free labour materials and a contribution towards a water meter for their house connection. The financial equivalent of the community contribution amounted to respectively 5 and 10 percent of the cost of the system. In Colombia this share was considerably higher amounting to some 25 percent" (IRC-SSF 1980).

In Colombia, which had a stronger tradition of community participation, the approach also followed the normal procedures of the National Health Institute (IRC-SSF 1980). This included the following five steps:

1. A study of the sanitary, economic, social and cultural aspects including the water quality analysis and the importance the community attached to the construction of a water system;
2. Project preparation by an engineer including a topographic survey;
3. Motivation, promotion and organization of the community by a health promoter, contacting influential groups, authorities and residents, ending with the formal signing of a contract between the institute and the community that also stipulated the administrative responsibilities once the system was completed;
4. Construction, with frequent visits of the health promoter to organize the community and some visits of an engineer responsible for verifying compliance with technical requirements;
5. Handing over and delegation of management to an elected water committee.

The approach to hygiene promotion was rather naïve in assuming that change is brought about by providing information about the relationship between the use of clean water and individual and community health. It included explaining the benefits from a bacteriological point of view of drinking treated water (IRC-SSF, 1976 p. 5). In India the 'educational treatment given to the community' included house visits during which respondents were asked to name signs and symptoms of 16 different diseases, along with their causes, treatment, etc. Answers were classified as right or wrong, and when wrong the respondent was taught the right answer. This is clearly an example of a very top-down approach to health education without any dialogue. Another health survey questionnaire dealt with more relevant questions, such as the sources from which people collected water and the way they stored it, including a note for the interviewer to observe whether the water container is covered and whether there is a ladle. This could have been a basis for a more meaningful dialogue, but it seems that the external agent told the people what to do.

Paramasivam and Sundaresan (1982) claim that the health education has had a favourable effect and support their claim by indicating the experience of Borujwada, where people stored drinking water properly in their houses in pots that were well covered and used a ladle to take the water out. In a survey of 25 households, all samples of stored water proved negative for faecal coliforms, which indeed is a good result. In the other three communities in India, water storage also improved as did their knowledge about disease, i.e. the number of 'correct' answers. They argue however that "bringing about, through health education, a favourable attitude and behavioural change in tradition-bound village folk with low level of general education and poor economic conditions is a slow process that needs sustained efforts from both communities and service agencies" (ibid p. 76).

Community involvement in decision making was not much of an issue. In Colombia and Thailand, the approach was oriented more towards creating community participation in construction and in making a financial contribution, whereas in India there was no participation of this nature. In all countries however, local project committees were formed and the agency staff working in the project considered them very important. Although these committees did not take the decisions, they had a very important facilitating role that included:

- Calling community meetings;
- Transferring information to the community (extension);
- Coordination of the inputs from the community; and
- Data collection for and advice to the institutional intervention team.

What could not be established from the discussion with staff from the implementing agencies was the influence of local power structures in these committees, which without doubt must have been present (de Wilde, 1980).

Community members were selected and trained for operation and maintenance. This was mostly on-the-job training and included attention to the distribution systems. It is important to note that, with this limited training, the operators, in some cases in consultation with the water committee, were responsible for the entire running of the treatment plant and the water system.

Field research in Colombia

In Colombia, where earlier research had not taken place, a small research component was included, comparing up-flow and down-flow SSF in the full-scale treatment plant of Alto de los Idolos. This was the consequence of an initial diversion from the project concept, in that the design was by an engineer from National Health Institute (Insituto Nacional de Salud, INS) in Colombia, who opted for an upward-flow slow sand filter, and this was not ‘corrected’ by the IRC team. So when initial results showed that removal efficiency was too low, it was decided to change one of the two filter beds to a down-flow system and compare the performance of the two units.

I find it amazing that this type of research could be done in full-scale plants, as this would never be allowed in industrialized countries. In my view it shows that the community was not truly involved in decision making, because they accepted that only part of the system was changed, while the other part continued to produce water that was less well treated. It also shows lack of leadership by IRC, who contributed to the cost of the modification of one of the units and not the whole system. The result of this research, which should have been done on experimental scale, just as in the other countries, showed that the normal SSF system (down-flow) was more efficient. “However the limited number especially of bacteriological samples taken does not allow for firm statements with regard to the performance of either type of filtration” (Heijnen, 1982). The plant was more than six hours drive from a laboratory. This highlights an important flaw in the project in that, with the exception of Borujwada in India, distances to the demonstration plants were so large that they hampered frequent testing.

Results

A total of eight demonstration schemes were built for communities ranging from 1,000 to 15,000 population (Table 12). Most included some form of pre-treatment. In four cases, water is taken from irrigation canals and fed to a storage reservoir. In one case, Borujwada, the system was preceded by river bed filtration. Both systems in Thailand included a horizontal gravel filtration unit designed by the Asian Institute of Technology in the context of the SSF project. A similar plant was included in one of the systems in India.

In the other three countries, no demonstration plants were built. Although finance was available, it was not spent on demonstration systems, but used later for dissemination seminars. The end result was that, instead of 12 SSF demonstration plants in six countries, eight were built in three countries, including four in four different states in India. Interestingly, in Jamaica, water supply schemes were built in the two demonstration villages, but without including SSF treatment. At first, construction of the SSF was “delayed”, but when the project ended in 1983 they still had not been constructed. This suggests that delivering water quantity was considered more important than its quality. In Sudan, there were already a lot of SSF systems, but apparently the project partners were not able to establish a link with the responsible agencies to change some into demonstration systems.

Performance of the systems

All systems were managed by local operators who received training before starting their jobs. The reported performance of the systems was reasonable to good in terms of removal of suspended solids, with turbidity of the treated water often meeting the WHO guideline values (Table 13).

Table 12. Demonstration villages with completed SSF plants in 1980

Countries	Demonstration villages[1]	Population
Colombia	Alto de los Idolos	850
	Puerto Asis	14000
India	Abubshahar in Haryana	8700
	Borujwada in Maharashtra	780
	Kamayagoundanpatti in Tamil Nadu	8500
	Pothunuru in Andhra Pradesh	4000
Thailand	Ban Bangloa	2000
	Bhan Thadindam	1320

1. An important limitation was that all schemes except the one in Borujwada were located several hours drive from a research institute. In Jamaica, Kenya and Sudan no systems were built in the context of the SSF project and the available project funds were later used for seminars to disseminate project findings.

Table 13. Performance of some of the SSF systems

Location	Inlet of SSF		Outlet of SSF	
	Turbidity NTU	FC/100ml	Turbidity NTU	FC/100ml
Abubshahar	0.2 – 2	50 – 2000	0.15 – 0.6	0 – 8
Borujwada	0.5 -3.5	10 – 9000	0.2 – 1.4	0 – 100
Kamayagoundanpatti	1.5 – 19	10 – 250	0.4 – 4	0 – 20
Pothunuru	5 – 13	90 – 4600	0.5 – 5	0 – 23
Bhan Thadindam	1 – 2	20 – 80	0.3 – 0.7	0 – 1
Ban Bangloa[1]	40 – 200	20 – 35	20 – 100	0 – 1

1. The case of Ban Bangloa is different from the others. Despite the horizontal gravel pre-treatment system, the turbidity level was high but this did not lead to immediate clogging as coarse sand was used in the SSF. The performance of the system is inadequate.

Faecal coliform counts were also considerably reduced, but showed variations between plants and within plants over time. For all plants the risk was reduced considerably, to a level that could be catered for with final disinfection, and for some the levels were very close to meeting the standards for most of the time, even without disinfection. The conclusion in one of the reports indicates that “the village level SSFs operated at normal filtration rates and with widely differing conditions of raw water quality, produce a filtrate of turbidity less than 1 NTU with faecal coliform removal as high as 90 percent” (Sundaresan and Paramasivam,1982 p 68). This however is too positive, in the light of the results in Table 13, and leaves too much room for misinterpretation, because the raw water quality was not really widely different between project locations. If others took this conclusion at face value, they might apply SSF in situations where it will not perform well. So instead of helping to promote the technology, this type of statement might actually back-fire.

There is hardly any reporting on the way that the SSF systems were being operated, but from the notes from White (1984) it appears that, for example, the operator in Kamayagoundanpatti did not operate the SSF on the basis of need but on a time-table indicating that one filter should be scraped every two weeks. After scraping, filters were not left to mature. The water was allowed to run to waste for half an hour and then the filter was put back into supply, although the operator thought that two hours might be better. This should not be much of a problem, because the water is supposedly disinfected before being put into supply, as mentioned in sections 3.5 and 3.6. However, experience shows that disinfection equipment may not perform well, or chlorine may not be available, so there is a considerable risk of bacteriological contamination after a filter is scraped. Also, the filtration rate was judged by the eye; no records were kept and it was clear that the operator did not understand the biological character of the treatment process. In the case of Borujwada, the situation is very different. This plant is frequently visited by NEERI staff, so the operator is in a sense closely supervised and helped to understand the process and to maintain the system in good condition.

In the project documentation some, but too little, information is available about the beneficiaries from five of the systems. The information shows that in three of these systems only part of the community is connected. Bang Banloa, the system with the poorest water quality, had the lowest level of connection – just 34 percent of the families, whereas in the other community in Thailand, with much better water quality, the connection rate was 100 percent (PMC-Thailand 1981). In Alto de los Idolos in Colombia, some 80 percent of the population did have a connection; in particular, poorer sections of the community were excluded as they were not able to pay the connection fee (INS-IRC, 1984). In India, everybody in Borujwada has a connection, whereas in Kamayagoundanpatti severe access problems are reported but not quantified (White, 1984).

Community participation and hygiene education

According to White (1984), a good part of the Community Education and Participation work of IRC developed through the SSF project. However, he also indicates that there could have been a more direct influence from the development of approaches and methods adopted under the project in the participating countries. In practice, many of the good ideas were not implemented. “It appears that the staff of the participating agencies responsible for the health education aspects of the projects was not fully aware of the implications of the recommendations, in terms of changes implied in the ways they normally work. This applies even to the recommendations directly related to their own observations at the meeting: It is a matter of the difficulty of applying theory in practice” (White, 1984). This is an interesting observation that also seems to apply to the IRC staff, even though it comes from an IRC advisor.

Not much is documented about the impact of the project in terms of changes in hygiene behaviour, health impact, or the desires of the community. It does seem though that the communities attach less importance to water quality than quantity, as is suggested by the reasons given by the community in Alto de los Idolos in Colombia as to why they would want construction of the water system. Some 18 percent mentioned health improvement, whereas 82 percent indicated time and work savings. Hence, the treatment of drinking water was clearly not much valued. The same study indicates a significant reduction in the prevalence of diarrhoea and skin disease when 80 percent of the population was receiving treated water from the SSF system that was considerably better in quality and quantity than that from their traditional sources. The report also indicates that in terms of sanitation coverage, despite motivational house visits by a health promoter, only very few people improved their sanitary facilities (INS-IRC, 1984), with some 80 percent still using open-field defecation.

Reflection

IRC maintained a similar approach to the project as in the first phase, i.e. providing ideas and some guidance from a distance. Hence the organizations in the countries were quite independent in the way they went about the project and their rates of progress were very different. They also had freedom in selecting the locations of the demonstration plants. It appears that choices were made on the basis of available opportunities and financial resources, and not with a view to future dissemination. Most of the plants were quite far away from the organization that was leading the project in the country. The sites were intended to be suitable for proving the feasibility of the technology and so communities were chosen that had relatively good water quality and access to financial resources to build the systems.

In three of the six countries no demonstration systems were built, despite the fact that financial means were available in the project budget to co-finance construction. This 50 percent achievement seems rather limited, though it is partly compensated by the fact that in India systems were built in four states. It is difficult to assess whether IRC could have taken additional steps to encourage the counterparts to increase their efforts. It should be remembered that IRC's own staff resources in the project were limited, with one project manager for six countries and fewer means of communication than are available today. Also, the available counterpart capacity, particularly in Kenya, Sudan and Jamaica, was limited and often occupied with many other tasks, including working on other externally supported projects with much higher budgets.

De Wilde (1980) indicates that working in parallel in different countries is only feasible if activities in each of the countries do not depend on progress in the other countries. He agrees with IRC's choice not to adopt a strong central control of the project, but more an advisory role, which meant that the countries could choose their own pace without being bothered by pressure from the centre. This implies that differences in progress were acceptable, but this was only partly correct, because the flexibility of the project time frame was limited, as the third phase was to be initiated in 1981. This meant that in three of the six countries the experience was very limited when the time frame of the project forced them to disseminate the results of the 'successes' of the three more advanced countries. For the slower countries, the dissemination stage clearly came too early, and in fact forced them to publicize their own ‘failure’. With hindsight, a different approach should have been considered.

Another limitation that becomes apparent from the project documents is the limited information on the users and the use of the systems. Although issues such as community participation and health education were discussed in the project meeting in the Netherlands, it appears that the country project teams maintained a strong technology bias. This shows that a single meeting, in combination with a few short term missions by IRC staff, did not establish the necessary change in mindset. Also with hindsight, it is clear that far too little attention was paid to comprehensive monitoring and evaluation, thus missing an important opportunity to obtain better insight into what really happened.

5.5 Phase 3. Dissemination seminars and publications

The third and supposedly final phase was initiated in 1981. It focused on disseminating the results obtained in the SSF project through the development and dissemination of publications on the subject and the organization of (inter)national seminars. A few research activities were also included in this phase, focussing on some further fine-tuning of SSF technology. Unfortunately it did not include research on pre-treatment, although a clear need existed to be able to deal with water with higher turbidity levels.

Process

In each of the countries, a seminar was organized under the responsibility of the national organization leading the project, together with IRC. The first meeting was held in Colombia in 1982, followed by meetings in India, Thailand, Jamaica, Kenya and Sudan in 1983.

In this phase of the project, I came in as project manager with a few years of experience in Africa and earlier exposure to India and Thailand as a student. My role was to manage the project, help organize seminars in six countries and guide the finalization of the pending publications on design and construction of SSF plants and one on operation and maintenance. The orientation was clearly a promotion of SSF and the assumption was that this aim would be supported if the participants in the seminars recommended the technology for application in rural water supply and highlighted the need for community participation. My state of mind at that time is well reflected by the question which Röling (1988) indicates as the starter question of many students in extension science:

“How do I get them where I want them”.

The answer to this question was encapsulated in the approach that we took. All country meetings were organized in a similar way, except for the types of participants that were invited. In India, sector staff was invited from different States and the meetings in Colombia (in Spanish), Jamaica and Kenya had both national and regional participants. The meeting in Thailand was special in that it was held in the Thai language to cater for the limited command of English on the part of the participants. After a general introduction about the water sector, the situation in the country and the specific experience of the SSF project, key lecturers were brought in to present the positive experience of the project. They were clearly 'SSF adepts,' who also stressed the community role. Information materials provided had the same connotation. Participants were then asked to discuss these findings in groups and provide recommendations concerning both the technology and the community aspects. These were condensed into a number of recommendations that were discussed in a plenary session. Subsequently a report was published with the recommendations and the key papers that had been presented. This report was sent to the participants and used for wider dissemination.

In parallel with the dissemination process, the project started to finalize two main documents. In both cases, the writing process was led by IRC, but an important change from the past was that the writing was done as a process that involved staff members from the participating organizations as well as external advisors.

Results

It should not come as a surprise that the reports of all six country meetings were very positive in their recommendations with respect to both SSF and the importance of community participation, as can be seen from the following recommendations from different reports:

- SSF is a very suitable method to treat surface and spring water and therefore it should be further promoted by the ministries and other agencies active in the water sector;
- Community participation is essential to ensure the proper installation and operation and maintenance of water supply systems;
- Local communities can operate and maintain SSF systems if proper training and regular supervision are provided. They should be encouraged to participate in the provision of their own water supply and to make regular contributions in cash or kind to ensure proper operation and maintenance;
- Health education is vital to ensure the health impact of a water supply system. There is a pressing need to start dialogues with interested communities on their existing health practices and needs, prior to the planning and construction of a water supply system. Sufficient time should be allowed to establish this dialogue.
- Whilst men, women and children should all be reached by health education related to water, women should be most actively involved as prime users of water and as being in a key position to influence family health.

Despite the positive recommendations in the meetings, some critical remarks were also made. The following factors were mentioned as hindering the wide application of SSF:

- Limited capacity of the technology to treat surface water high in turbidity;
- Existing SSF systems that are not working satisfactorily because of deficiencies in design and operation and maintenance;

- Tendency of engineers to select more sophisticated treatment systems because they are better trained in them and have access to "standard" designs.
- Technology selection on the basis of construction cost and not on 'total life-cycle cost'. The latter would be very much in favour of SSF with its much lower operation and maintenance cost.

Reflection

The seminars helped to enhance discussion on SSF and community participation. The recommendations very much support wider application of SSF, which, after all, was the aim of the project. They also appear to be very much in line with the views of the core group of researchers in the project. The question is whether one could have expected a different outcome, since all inputs were controlled by the SSF team, participants were invited and reimbursed for their travel costs and paid a daily allowance for housing and meals. So we obtained the results we wanted but whether the participants were truly convinced of SSF, only time could tell, as will be discussed later on in this chapter.

A positive point was that in preparation for the meetings, core staff had to write papers and this helped them to structure their experience and share it with others. Subsequently several of them have published papers in different journals about their findings and results. It was also positive that some limitations were brought up, as this offered the opportunity to go back to the funding organization to explain that good progress had been made, but that some shortcomings had to be remedied. This was in fact the basis for subsequent projects and ultimately resulted in the development of the MSF technology.

Experience with the seminars showed very clearly the need to have a demonstration system close to a good seminar venue and within easy reach of the institutions involved in the research and training (see Box 3). In hindsight, the usefulness of the seminars in the three

Box 3. A missed learning opportunity in Colombia

In Colombia, the SSF system in Alto de los Idolos was more than six houirs drive from Neiva, the regional centre where we held the SSF dissemination seminar. Fortunately another SSF system, although not part of the project, was close to Neiva and this wasa the one visited by 70 seminar participants. This SSF was actually not operated very well. The falling water level in the filter during the visit showed that it was operated at some 1 m/h, way above any reasonable filtration rate, and so not allowing a good biological process. 'Fortunately' this went unnoticed by the visitors and I did not bring it up because the project's thinking was that we had to demonstrate success! In retrospect this was a missed learning poppertunity. We could have shared the problem with all participants, calrifying the need for good operation and control, instead of being afraid that showing this type of problem could hamper the wider spread of the technology.

countries without demonstration schemes has been extremely limited. It should have been an issue of more reflection at that time, because it used up part of the project resources to expose the 'failure' of the local project team in not being able to complete a demonstration system, while visiting team members from India showed their success stories.

5.6 Extension of the SSF project: Pre-treatment and training

An extension of the project (1983-1986) was established in response to the limitations observed in the previous phase, such as the limited capacity of SSF to treat water high in turbidity, the existence of filters with problems in design and operation and maintenance, and the trend of engineers to select RSF as a more sophisticated technology.

The project extension had three main areas:
- Applied research of different pre-treatment systems using gravel filtration
- Simplification and cost reduction of SSF design
- Development of information material including:
  - a training package for plant operators
  - an SSF manual (design, construction, operation and maintenance)

Process

This phase was continued only in the two countries where project results had been promising: Colombia and India. In India, NEERI continued as the leading partner, but the other partners in the PMC were no longer actively involved. Initially, INS continued as the leading partner in Colombia, but, in close consultation with IRC, its role was later changed and the lead was handed over to a small working group at the University of Valle in Cali. Two years later, the role of INS in rural water supply was ended by the government of Colombia.

The process changed in comparison with previous project phases. With only the two most productive countries to deal with, closer contact could be kept with the project partners in Colombia and India. The earlier approach of guidance from a distance changed to teamwork. Problems were faced jointly, sometimes leading to intense discussions. Friendships developed, and papers were prepared together.
A more participatory approach was also adopted in the countries. In response to the problems identified in existing SSF systems, a workshop approach was established to bring design engineers together to jointly reflect on their own SSF designs and to review the new ideas that had emerged in the SSF project. There was considerable apprehension, particularly in India, that this process of self-evaluation would not work and that engineers would not be open about their mistakes. At the start of the workshop, time was spent on an integration exercise and an external advisor presented one of his own designs. He admitted that the design included several mistakes that he had remedied in time because he was in the fortunate circumstance that someone else reviewed his design. This clearly helped to set a tone for a rather critical but positive review of different designs made by some of the participants. They received two

challenging questions: What changes would you make to the current design if the plant was already constructed, in the light of the new insights about the SSF technology? And how would you design the SSF system if it was not yet constructed?

Results

Important results were obtained that can be summarized as follows:

- *Critical review of designs* in the review workshops in India and Colombia (Table 14) led to improvements in the designs and a cost reduction of SSF, for example, by using a new drainage system based on the use of corrugated[12] pipes and by adopting inlet control as the preferred option, because it still provides similar treatment results but does not require constant supervision.

- *Development of simple tools.* These included: flow-rate detectors; simple valves that could be locally produced; a silt test to establish the cleanliness of the sand; and a visual turbidity measurement tool. Pilot plant studies (Figure 12) on pre-treatment using up-flow, down-flow and horizontal-flow gravel filtration proved very effective and were recommended to be taken up for full-scale research. Good results were obtained particularly in Colombia. Instead of carrying out the research in one location, the University team started small pilot units in parallel with three existing water supply systems using conventional treatment, all within half an hour from the university.

  In one case this involved a system with poorly performing chemical treatment providing water to a higher-income neighbourhood (El Retiro). In all three systems, the results of gravel filtration plus SSF were better than the full-scale conventional systems. For the El Retiro community, which included staff from the university, the evidence was strong enough to persuade them to reconstruct the plant, with support from the working group at the university, into a MSF plant, the first one built in Colombia. The research however was still in a preliminary stage and further research was needed to develop suitable design guidelines for the pre-treatment component. This triggered the development of the Integrated Research and Development Project on Pre-treatment.

Papers were presented by the project staff from the different institutions and several new publications were prepared as outputs from this phase of the project, including:

- A new IRC technical paper on SSF co-authored by two staff members from NEERI in India with hands-on experience in the research and two staff members from IRC (Visscher et al., 1987).
- A training package of different manuals for operators of SSF plants was developed and tested. This included a hands-on caretakers' manual for operation and maintenance of SSF that also addressed the wider responsibilities an operator may have in the water supply system as well as the relation with the community and other actors (Visscher

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[12] Corrugated pipes are ribbed pipes that are used as drainage systems in agriculture. The advantage of using such pipes in SSF is that they have a lot of small holes, which allows the use of smaller gravel than in conventional drains and so reduces the height of the drainage system, buut because of the ribbed structure corrugated pipes retain their strength.

Figure 12. A pilot plant for pre-treatment research in El Retiro, Colombia

Table 14. Some results of SSF design workshops in India and Colombia

Key design problems identified in India in existing plants with capacities ranging from 2.5 to 100 l/s (216 to 8640 m^3/day)	**Key design solutions** applied in Colombia in new plants with capacities ranging from 3.2 to 10 l/s (276 to 864 m^3/day)
24 hours operation not guaranteed	All designs reviewed were gravity systems. Some however adopted a very high filtration rate of 0.2m/h, which was reduced to 0.15m/h
Costly designs because of extra height or provision of extra (stand-by) filter beds to be used when others are cleaned	Filters adopted the SSF design from the SSF project with a total height of 2.35 m (because of lower underdrains)
Inadequate and costly underdrain systems often including unnecessary ventilation shafts	Underdrain system was modified using corrugated PVC pipe, which reduced the height to 0.2 m
Inlet arrangements were inadequate, involving the risk of scouring and not allowing for drainage of the water on top of the sand bed	In all systems gravel pre-treatment was included as well as proper inlet arrangements A goose-neck overflow cum supernatant water drainage valve was applied, developed by CINARA
No arrangements for backfilling the filters with treated water	Backfilling arrangements were made between adjacent filters
Several valves placed under water making operation and maintenance more difficult	Simple gate valves were developed that were much cheaper than commercial valves. These were combined with weirs with a flow-measuring device. All filters were inlet controlled making operation much easier

References NEERI/IRC, 1987; UNIVALLE, 1987

Figure 13. Illustrations from the SSF caretakers' manual, English and Hindi version.

and Veenstra, 1984). This manual was produced in English, Spanish and Hindi, and illustrations were adapted to the individual countries, as can be seen from Figure 13.

Reflection

The excellent results from the research in Colombia and India with pre-treatment systems at pilot scale received a positive response from the Government of the Netherlands. It was particularly enthusiastic about the dynamic approach in Colombia, and the very good conditions for continued research with a pilot plant that was close to the university (a few kilometres away) taking water from a river that had periods with very high turbidity and very high coliform counts, while a number of full-scale plants were already being designed that were also close to the university. The downside was that the funding organization was willing to continue only in Colombia (1989). With that the research on pre-treatment in India stopped.

An important achievement in this phase was that the participatory workshop approach to review SSF designs worked very well. The spirit in the workshops was high, with very enthusiastic participants voluntarily making long working days and providing a good output (Table 14). This marked the beginning of a stronger emphasis on learning that grew stronger and stronger over time. In India, the workshop was attended by senior design engineers from eight states and in Colombia by sector staff mostly from the southern part of Colombia. Essential for the meetings was facilitation of both the process and the content. In the process, all participants were encouraged to join in, with an emphasis on searching for 'dialogue' and the exchange of meaningful ideas, not just 'discussion' (the process in which parties feel that they have to show that they are right and as a consequence, a process with winners and losers) (Senge, 1990). With respect to the content, probing questions were used, adopting the idea that people have a wealth of knowledge from their personal experiences. The problem-posing dialogue builds on these shared experiences. By introducing specific questions, the facilitator encourages the students to make their own conclusions about the values and pressures of society. Freire (1970 p.68) refers to this as an "emergence of consciousness and critical intervention in reality". It is evident however that a snag with this idea is: what are the right questions? Clearly an experienced SSF specialist has a powerful position and can pose leading questions that guide the participants to specific answers. This can become a trap for the expert and actually prevent him or her from learning and acquiring new ideas. Hence, it is crucial to create a really good mindset among all participants in the workshop, to allow local insight to break through, and to distinguish between the process facilitators (who do not have a bias about a technical outcome) and the "resource persons". One limitation was that the workshops in India and Colombia did not include plant operators as key resource persons, although they had first-hand information and suffered most from the limitations in the designs made by design engineers. This crucial role of the operators was recognized in the TRANSCOL project that will be described in chapter 7.

5.7 Exploring the research questions

In this section, I will review the case study of the SSF project against my main research questions. I will use the framework of analysis presented in section 2.5 to discuss the emerging properties and conditions of the innovation process.

Q1. How successful was the introduction of SSF?

This question generates different answers at different levels.

Uptake at personal level

Starting at the personal level, it is very clear that several SSF "adepts" have emerged from the project. They include particularly the researchers from India and Colombia and the IRC staff involved in the project, who continue to promote the technology and publish papers about it.

Uptake at demonstration-system level

At community level, SSF demonstration systems were established in eight communities in three of the envisaged six countries. When I look at the performance of the system and the way maintenance tasks were carried out, seven of these systems were quite successful.

The performance of the systems seems to be reasonably good. In a review meeting in 1991, the leading scientists from Colombia, India and Thailand came together in the Netherlands to look back at technology transfer in the SSF project (IRC-SSF, 1991). They indicated that the SSF systems in all the demonstration villages were still operating. Hard data about the level of performance were not obtained at that time or later, but the fact that all systems were still operating after more than 12 years is positive. I learned from a telephone contact with NEERI in 2005 that the system in Borujwada is still operating very well, but no information is available on the other systems.

The quality of treatment is a different issue. Seven of the eight systems were treating water that was low in turbidity (between 0 and 20 NTU). Most of the time the turbidity of the water to be treated was well below 10 NTU and in three cases it was always below 5 NTU. Data from five of the systems show that they were all producing water that was below 1 NTU for 90 percent of the time. In two cases, the turbidity occasionally increased but never above 5 NTU.

According to the WHO guideline, the appearance of water with a turbidity of less than 5 NTU is usually acceptable to consumers, although this may vary with local circumstances. No health-based guideline value for turbidity has been proposed. Ideally, for effective disinfection, median turbidity should be below 0.1 NTU and changes in turbidity are an important process control parameter (WHO, 2004). However, 0.1NTU is a very stringent level that will be impossible to achieve in most systems in the world.

For example, the USA does not apply this level, although its turbidity standards have become more stringent over time. Prior to 1962, a turbidity level of 10 NTU was acceptable in the USA. With growing economic development, this level was lowered to 5 NTU until 1976, when it was lowered again to the present level of 1 NTU for SSF treatment and 0.5 NTU for RSF treatment (Galvis, 1999). So we can say that for most of the time, the project systems meet the current US standard, and all the time they achieve what WHO suggests is acceptable to consumers.

The system in Ban Banglao, Thailand, is very different from the others. This pumped system draws water from an irrigation canal with a turbidity level in the range of 70 – 275 NTU. In the dry season when the turbidity level was ‘relatively’ low, say about 100 NTU and faecal coliform counts in the range of 90 – 170, the system, comprising horizontal gravel filtration and SSF, was, according to the Thai researchers, producing water with a turbidity of about 25 NTU and zero faecal coliforms, which they considered to be acceptable. They also indicate that the quality could be improved by using finer sand, as the sand that was actually used was much too coarse (PMC Thailand, 1981). This quality is acceptable for the faecal coliform counts, but is way outside any reasonable norm for turbidity. The potential of pre-treatment was still under-rated at this stage, but the very positive results with the pilot tests raised the interest particularly in Colombia, as will be discussed in more detail in chapter 7.

The way the operators carry out their operation and maintenance tasks is difficult to establish, as the only information available comes from reports that did not pay much attention to this aspect. This suggests a technology bias in the project in the countries. Whereas at the central level of IRC the important role of operators was underscored in publications and training material this did not reach out sufficiently to the field level. The lack of data indicates that monitoring and evaluation were not sufficiently developed in relation to the achievement of key objectives. From the available information, it appears that the operators all received some technical training and their role was typically described as: routine running of the treatment system; keeping the area clean; controlling the filtration rate; and cleaning the SSF at the end of the filter run. The quality of their work therefore cannot be judged, but the impression exists that it leaves a lot to be desired. A review of 47 SSF systems in Thailand concluded that operation and maintenance of a majority of the SSF plants was not very good, but the systems still provided water that was low in turbidity. The operators did not have sufficient background information to wash the sand properly and re-sand the filters in the way that this is prescribed. Most operators and supervisors did not know about the ripening process of the SSF (PWA, 1984).

These results are moderately successful but raise the question as to why the impact was limited to only three countries (Colombia, India and Thailand), and did not include the other three (Jamaica, Kenya and Sudan). For a start, conditions differed, as research activities had been considerably stronger in India and Thailand. In India, NEERI had good contacts with the government organizations involved in water supply construction. These organizations apparently considered the financial contribution from the project towards construction costs as sufficiently attractive to provide matching funds to build the plants. In Thailand and Colombia, the PMC was chaired by the main implementing agency. In both countries, staff members from these agencies were positive about the project, also encouraged by the co-financing arrangement.

In Jamaica, no prior research took place, but locations were selected for the demonstration plants and designs were made. Then, unfortunately, a hurricane created a great deal of damage in the water sector and priority shifted to repairing existing systems, which was still ongoing when the project ended. In Kenya and Sudan, very little human capacity was developed in the first phase. It appears that it was not the SSF technology in itself, but the absence of champions, the low priority for water quality and the worsened economic situation that virtually stopped further project development in these two countries. This lack of progress was sad, particularly in the two African countries, where water needs were high. An important reason, which I have not found in any of the project documents, may have been that the project was very low-budget in comparison with other donor-supported projects and therefore perhaps less attractive – the more so because it concerned research, which has a low priority for most governments in developing countries. It cannot be established whether a stronger input of IRC could have changed this situation, but it would certainly have needed a change in strategy, taking active steps to encourage the main financing agencies to take a keen interest in the technology. In retrospect, a closer link could have been established with these agencies by, for example, involving them in the PMCs. Even then it might have been difficult to obtain their support, because many of these agencies were more concerned with the development of hand-pump programmes.

Uptake at national level in countries with demonstration systems

The third level of uptake of the technology to review is national level. Were new SSF systems being built using the designs of the project? I limit the analysis to the three countries with demonstration systems. In the other countries, activities with the partners ended shortly after the dissemination seminars. Contacts were sustained for longer, but did not result in a revival of activities or requests for further information and support on SSF. So, it is fair to assume that the impact of the project and the dissemination seminars was limited in the absence of demonstration plants in these three countries.

In 1991 it was established that in Thailand, despite the satisfactory performance of the demonstration systems, only three new filters had been built and all without pre-treatment. It cannot be established whether this was due to the fact that only one of the two systems was operating well, but the project manager from Thailand suggested that the main reason was that the engineers involved were very much in favour of RSF, which was the only technology they had learned about in their formal training (IRC-SSF, 1991).

India was different. In 1991, some 250 new SSF systems had been built to the design specifications that originated from the project, but only after these specifications had been included in the Central Public Health and Environmental Engineering Organisation (CPHEEO) manual and the Indian Standards (Box 4.). Another positive aspect was that the demonstration plant in Borujwada was very close to the research institute of NEERI in Nagpur, which made it easy to visit and to use it for training. Interestingly NEERI still portrays this plant on the internet as an example of the institute's knowledge about SSF.

In Colombia, some 20 new plants had been built by 1991, but this seems less a result of the SSF project, and more of the subsequent work by staff from UNIVALLE University in Cali (ibid). Although the figures for India and Colombia are positive, it is fair to conclude that, despite the project, SSF was not really picking up in most places. It was an uphill battle, as the technology was suited for relatively clean water, but water quality was deteriorating throughout the world because of erosion and pollution. A broader approach was needed, to look at the whole picture of limiting factors, going well beyond the technology itself, as I will discuss in chapter 7.

Q2. How has facilitation of SSF introduction emerged?

The project followed a logical sequence to establish the capacity to facilitate the wider introduction of SSF. It started with a review of the situation and laboratory research by leading researchers in the participating countries, followed by the establishment of demonstration plants. In these plants, other actors responsible for implementing water projects became involved. The established experience and expertise was subsequently used in the dissemination phase. In the countries where the expertise was not established, because no research was carried out or no demonstration plants were built, researchers particularly from India and IRC staff filled the gap by presenting their experience in a national meeting. This created a very different situation, as the organizations in these countries did not obtain hands-on experience that could help them to advise on further implementation of the technology and cater for possible problems. Another limitation was that water sector practitioners were not involved in the research stage. It can be argued that this could have given a more hands-on approach to the research and could have contributed to the feeling of ownership on the part of these practitioners.

Colombia entered the second stage with demonstration plants and did not develop research capacity at that stage. This was remedied later, but in the meantime several SSF systems were built, for example in Boyaca, which failed because the original design was copied without sufficiently appreciating the local situation and the biological nature of the process.

In reviewing the way facilitation emerged, it is necessary to look at the different actors involved in the project. Although the project was led by IRC and on paper by the national PMCs, in fact it has been very much in the hands of a few researchers and some staff of the implementing organizations from the participating countries working at community level. De Wilde (1980 p. 7) states that “almost unanimously staff from the participating institutions agree that the national PMCs have not worked as a management unit”. It proved very difficult to get the members together and more so if they had a higher position. This is in line with the observation of Groot et al. (2002 p 199) that “there tends to be an imbalance in the amount of attention facilitators dedicate to each level of the system at stake. In the context of development cooperation, for example, social

Box 4. Slow sand filter diffusion in India

An important element that hindered the diffusion of the new thinking about the SSF technology and the new designs in India was the fact that they were not initially included in the official manual of the Central Public Health and Environmental Engineering Organisation (the CPHEEO Manual) – the bible for water engineers in India. This manual ‘prescribes’ the design of water supply and treatment systems. The thinking is that by providing design prescriptions, guidance is provided to the staff of technical agencies that will ensure that good systems are being built. This we can call a “blueprint technology approach” and it can also be found in other developing countries with large-scale programmes. The strategy is based on the need to implement a large number of systems quickly to meet the needs of the population with limited technical capacity available. The assumption is that by providing a standard design, staff, even with limited experience, will provide good quality systems. Once the information was included in the manual and in the Indian standards, the implementation of SFF really picked up.

On the one side this is very positive, but the downside is that it also resulted in the construction of several plants with important maintenance problems. Further SSF refinements, including, for example, the need to add pre-treatment, would need to go through the sameprocess of updating the manual. So far, they have not been included.

learning processes are often characterised by the absence of higher level policy makers and their reluctance to become fully engaged".

The formation of the PMCs does however seem to have led to bilateral contacts between higher level staff of these institutions that otherwise might not have occurred. In this way it may have contributed to a somewhat better collaboration among the different organizations involved. But this does not take away the fact that the real work has been done by the project coordinators, who were not always members of the committee. With hindsight, the weakness of the PMCs was an important factor limiting the wider spread of SSF because, as I will discuss in more detail in chapter 8, sustainable water supply and treatment requires changes in the supporting institutional framework. This makes it essential to closely involve policy makers and leaders of the institutions, for which a PMC is an appropriate platform. Perhaps the PMC could also become more attractive by calling it a "project governing board", as its members are not intended to be concerned with the management of the project. A flaw in the PMC was that it did not include representatives of the local population or of community-based organizations. This limited the possibility to establish necessary links among all the key actors involved.

It can be concluded that facilitation of the process by IRC and its advisors did not focus sufficiently on policy makers and management of the leading institutions involved in the sector. Nor did it provide much hands-on guidance, other than through project documents, which appear to have had limited impact. Guidance was particularly limited with respect to the approach to community participation and hygiene promotion – areas where the technical researchers who were involved in the first phase had no experience. The social scientists coming into phase two did not benefit from the 'trial period' of more than two years that their technical colleagues had had. They had to go on the job in the demonstration villages with their own expertise and some guiding documents, but no training. As a result, their approach in the demonstration communities was very much the approach normally used by the implementing agencies. For example, the method of health education proposed in the Voorburg meeting emphasized dialogue, including the formation of a committee in the community to discuss which behaviour changes needed to be made, whereas in practice the orientation was to deliver 'popular lectures' on issues such as personal hygiene, water use, etc.

This makes it very clear that inviting a few staff members from the participating institutions to a meeting in the Netherlands to let them agree upon 'innovative strategies' is not sufficient to change the routine 'safe' approaches that they normally use. The project tested, and to some extent improved the technology but was much more limited in influencing the implementing organizations. In the last phase, efforts were increased in this respect and, particularly in India, promotional activities were aimed at engineers working with the implementing agencies. A rather conventional approach was followed consisting primarily of lectures and presentations, including a field visit to the demonstration plant in Borujwada and the provision of information material. It appears that these activities were successful. A more innovative approach that moved more towards knowledge sharing was followed in the design review workshops in India and Colombia. These were important as they moved towards creating a dialogue with staff from the implementing agencies in India and the private sector in Colombia.

The question arises as to whether IRC could and should have played a different role. White (1984) concludes that "there might have been more direct influence from the approaches developed by the advisors upon the practices adopted under the project in the participating countries, if a more interventionist stance had been taken and IRC staff or consultants would have gone to the countries more frequently". Yet he also suggests this to be a dilemma, by indicating that it may be argued that such 'close advice' is out of place unless specifically requested. With hindsight, I believe that IRC could and should have taken a stronger stand by confronting the project partners with the progress, or lack thereof. A good monitoring system combined with regular progress discussions, say at least twice a year, would have helped to create the setting where progress could have been reviewed by partners and IRC. This would have resulted in early identification of problems and necessary changes in the project. I am convinced that this would also have led to specific requests for a more interventionist stand, as indicated by White. Hence, I would say that in this case the 'dilemma' would disappear, as partners together take responsibility for project progress.

Q3. Have the conditions been created to sustain the technology?

The short answer to this is no. This is obvious in the three countries that failed to build the demonstration plants, but also in Thailand, where only three new SSF systems seem to have been constructed after the ending of the project. In Colombia, an interesting development occurred in that sector staff started to copy the SSF design in a number of cases, but inadequate knowledge and experience led to systems with huge maintenance problems. That leaves India, where at least 250 new SSF systems were built. It can be argued that by including the design guidelines in the CPHEEO manual and the Indian standards, the conditions were created to apply the technology on a wider scale. These conditions however were not sufficient to sustain the technology and ensure its proper functioning.

As discussed in Box 4 in this section, the manual resulted in a blueprint approach, in which designs were copied without looking at the problems that full-scale plants were facing. It is feasible to adopt standard designs for certain components, such as the dimension of pipes in relation to the required flow, but not for the water treatment process. The guiding principle in water treatment has to be the desired water quality to be provided by the system. This requires designs being made by capable staff or at least under good supervision, insight into existing water quality, information about treatment results of different treatment systems, and possibly field testing if no prior experience exists. However, such an approach is rarely followed in developing countries. Many plants are designed on the basis of even a single water sample and designs are copied from textbooks. Against this background, it is not surprising that many treatment plants are performing below standard or not at all.

This limitation of the use of standard design was confirmed in a workshop in 1994, eight years after the project ended, in Ongole in Andhra Pradesh (AP). The implementing agency in this state built an SSF scheme in Mallavolu in 1970, taking water from a summer storage tank that was part of an irrigation system. This system was operated 'successfully' by local youths and thereafter SSF was chosen in most schemes. This was further reinforced by the positive experience of the SSF project in Pothnura (IRC-SSF, 1994). In the workshop, it was reported that some 1100 SSF schemes (some 9 percent of all piped water supply schemes in AP) had been constructed since 1970, with the more recent systems following the new SSF design guidelines included in the CPHEEO manual. In the workshop, it was established that many of these SSF plants had important operation and maintenance problems, among other reasons because of insufficient pre-treatment. The workshop report stresses the need to establish an SSF Task Force for AP with several participants expressing keen interest to participate. Unfortunately, this recommendation was not taken up by the agency management, possibly because it was not much affected by the problems because maintenance had been handed over to the Gram Panchayats (IRC-SSF, 1994). Despite these problems, the number of SSF plants has since increased to over 2000, even though severe operation and maintenance problems continued[13]. A complication is that the systems in AP take water from ponds linked to irrigation systems and include a pump to take the water from the pond to the filter and one to take the water after the filter to the water tower. With power supply only available for a few hours per day, the SSF is operated only during these intervals, although it has been conclusively shown that intermittent operation interferes with the biological process and does not guarantee good water quality.

Maintenance was an issue that was addressed in the SSF project by on-the-job training of operators and the materials used for this training stressed the important role of the operator in safeguarding the health of the community as well as in taking care of the biological process in the filter. "The best way to assist the micro-organisms with their important task is to keep the filtration rate as constant as possible" (Visscher and Veenstra, 1984 p.5). Although too little information is available on the way in which they carried out their tasks, it appears that, as in Andhra Pradesh, operators followed a mechanical approach to maintenance.

In Table 15 I have summarized how the project supported the development and dissemination of SSF using the knowledge system framework from Röling and Jiggins (1998) discussed in section 2.5. The table makes clear that the project influenced only part of the elements of the knowledge system and therefore did not create the conditions to sustain the technology.

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[13] Information obtained from a staff member of the Byrraju Foundation in Andhra Pradesh and partly reported in Internet (http://www.byrrajufoundation.org/watervision.htm).

Table 15. Analysis of the supporting knowledge system framework

Elements	SSF water supply treatment	Comments
Stakeholders involved	Researchers, staff from implementing key agencies, community members and operators, but in a support capacity	It appears that a critical mass of key stakeholders was not reached; in particular the 'decision makers' and those responsible for engineering training were not much involved.
Sound practices for dealing with SSF systems	The technology was tested and design improvements were made; Training manuals stress the importance of the biological process; An innovative approach to community participation and to a lesser extent hygiene education was developed on paper.	Including the sound practices in guidance material and training manuals proved not to be sufficient, as operators as well as engineers clearly lacked the insight into water ecology that is needed to sustain the performance of an SSF. The same applies to the approach to community participation and hygiene education. Pre-treatment systems were not sufficiently developed.
Learning to support the SSF practice	Researchers learned on the job and had ample time. Implementation staff was not prepared for their role in the project and did not receive training. Operators were trained on the job in a relatively short period of time.	Practitioners were not involved in the research, which reduced their learning opportunities as well as the possibilities for the researchers to obtain insights from the field. If training took place it appears to have been top-down instead of adopting a learning philosophy.
Facilitation to support the learning	The facilitation of the process was very much from a distance through a few meetings and guidance material developed by external advisors, which in the case of India resulted in the inclusion of SSF in the CPHEEO manual. No efforts were made to change the institutional training programmes that favoured RSF treatment and a top-down approach to community participation and hygiene education	Researchers have not been able to transmit the crucial importance of the water-ecology side of SSF treatment to staff from implementing agencies and operators. IRC staff seems not to have been very effective in introducing the innovations particularly in the field of community participation and hygiene education. IRC did not take an interventionist stance.

Continued over

Table 15. Continued

		No structured participatory evaluations were made that could have supported the learning very well. The exception was the participatory evaluation workshop in 1991.
Institutional support system	Except for participation in the PMCs, the management of the implementing agencies was not involved and no institutional change was suggested to support wide-scale SSF application.	The assumption that the PMC would be a crucial tool to influence the institutions proved not to be correct. A much more strategic approach is needed that clearly establishes a common objective, such as the provision of sustainable safe water supply.
Conducive policy context	The dissemination seminar focused on obtaining strong statements in favour of SSF Inclusion of SSF information in the CPHEEO manual and the Indian standards (although not planned by the project) had an impact on the policy context.	It can be argued that the statements were aimed at changing the policy context, but no clear evidence can be found that they had an impact; The changes in the manual only happened after the project ended.

5.8 Conclusion

The overall picture that emerges from this case study is that the project re-invented and improved on SSF technology. It stimulated interest and reached out to a wider audience, but did not really result in wide-scale application, although it can be argued that it had a positive influence in Andhra Pradesh and had an impetus in Colombia. It is also becoming apparent that the project did not treat SSF technology at the level of complexity that it requires. It truly is a complex system that includes interactions between the biological processes and the human actors and in that sense is different from chemical water treatment.

It is comparable to the difference between ecologically sound agriculture and conventional agriculture where the former makes special demands on learning and facilitation (Röling and Jiggins, 1998). The SSF project may have underestimated these special demands, but they certainly gained ground later in the TRANSCOL project that I discuss in chapter 7.

Underrating the importance of pre-treatment contributed to the limited uptake of SSF technology, as it limited its application to relatively clean surface water sources. Despite this limitation, uptake should have been better, if we follow the line of thinking of Rogers

(1995). The project established positive examples of the technology, created change agents, and showed that it was cheaper than other alternatives, which often were not even realistic in view of their negative performance record.

So we had the knowledge and the persuasion, but decisions to implement SSF systems along the new design guidelines were few and resulted in systems with important operation and maintenance problems due to poor understanding by operators and design engineers of the water ecology involved in the technology.

Other factors playing an important role in technology transfer will be further discussed in chapter 6. One of these concerns the context, which was very different in the participating countries, but clearly was not sufficiently taken into account. In India, it was essential that the SSF design should appear in the CPHEEO manual (Box 4) before Indian engineers would adopt it. In Colombia, new designs were adopted very quickly by entrepreneurial engineers, who in turn convinced local actors, such as mayors or implementing agencies who had the freedom to implement systems as they saw fit. Without much experience, these engineers copied designs, constructed systems and then left them to local operators who were not able to solve the operation and maintenance problems, which eventually resulted in total failure of the SSF system.

A similar thing happened in Colombia in the field of wastewater treatment. A pilot plant was built in Cali to test the application of Upflow Anaerobic Sludge Blanket (UASB), an anaerobic wastewater treatment process that was being used for the first time in Colombia. This was done in the context of a research project of the University of Wageningen, the University of Cali and Haskoning, a Dutch consulting firm. The technical-scale UASB system in this pilot project, which I evaluated in 1983, performed very well, reducing the Biological Oxygen Demand of the wastewater by some 80 percent. Faecal coliform counts were not much reduced however, because of the anaerobic nature of the treatment. The positive results led to rapid construction of some 12 UASB systems in different locations in Colombia in parallel with the pilot project. These systems experienced performance problems comparable to the SSF systems, because of design limitations and inadequate maintenance. The end result of this positive ‘unguided’ uptake of both SSF and UASB turned out to be negative, because the performance problems that occurred, often because of the biological nature of the systems, were not sufficiently understood and were taken as a failure of the technology and not of the designer.

The analysis of the SSF project shows many similarities with observations by Colin (1999) about the introduction of new hand pumps based on the VLOM concept discussed in section 1.4. As he observes about VLOM, the positive results of the SSF technology should have led to wide-scale adoption. This did not happen for several reasons:

- The SSF technology has important potential but was introduced before it was “ripe”;
- Operation and maintenance problems became apparent when research funds had more or less dried up;

- Costs involved in water treatment were a deterrent, as preference was given to water quantity over quality;
- Lack of understanding that SSF water treatment is not simply a technical concept.

SSF water treatment not being just a technical issue seems to be the most important bottleneck. It means that a more complete technology transfer process is needed that includes users and operators as active learners and pays attention to the contextual situation, including the establishment of back-up support capacity.

A reasonable question to pose at the end of this section is: How realistic are my conclusions and my perception of the project? With respect to the performance of the systems, I am confident that my conclusions are fair as I have used hard data which match the basic requirements for positivist research. My other findings are more of a constructivist nature, so the relevance of these findings needs to be checked against the quality criteria suggested by Guba and Lincoln (1994). By the extensive use of project documents produced by different authors and triangulating these with my own field experience I feel that it is fair to say that my findings are **credible**, in that they match the reality of the actors in the different situations presented in this chapter.

In terms of **fairness,** I must admit that it was not possible to seek confirmation from some of the key actors as a long time has passed since the end of the project. However, I have based my conclusions on, and often used literal quotes from, project and evaluation reports that at the time of their development have been shared with different actors involved in the project for comments and adjustments. Also, my review is quite critical and does not show a rosy picture emerging from the project, whereas it could be argued that, because of my involvement as project manager, it would be in my interest if a nicer picture had emerged. So, I trust that I have been able to give fair treatment to the project information and results, the more so because my findings have very clear parallels with the findings of Colin (1999) with respect to the experience with VLOM hand pumps.

This leaves me with the question about **authenticity**. This is a difficult issue. My study comes a long time after the end of the project, and several of the actors have already retired, so it is impossible to argue that the study will empower them to act and to learn. The main point I can raise in this context is that several of the conclusions can be helpful for other projects and part of the conclusions come from evaluation reports that have helped to shape the project over time and have stimulated the participants in the project to adjust their activities. The leading project managers in India and Colombia were also able to learn and become empowered in the participatory evaluation workshop in 1991, which has served as an important input into my conclusions.

Operators at work on slow sand filters.

6. Intermezzo: Re-thinking the approach

> *"If one poses the proper questions, people, by themselves, will discover the truth about every issue." Plato*

In this chapter I revisit the conceptual framework presented in chapter 4 and indicate the changes that led to the theoretical perspective that formed the basis for the TRANSCOL project. I have used slightly revised headings to reflect the change in thinking that emerged from experience with the SSF project and the overall changes in thinking in the sector as it moved towards a more people-centred and decentralized approach. The new conceptual framework places more emphasis on the context, stakeholder involvement and learning (knowledge sharing). It is also different in that it was no longer driven primarily by IRC and its advisors, but developed jointly with the project team from the University of Valle in Colombia.

I will show that the approach moved away from the paradigm of one-sided technology transfer and diffusion and placed considerable emphasis on a human-centred (interactive) approach. I maintain a beta-gamma approach by looking at both technical and social aspects of the introduction of biological water treatment in community water supply in Colombia. I will compare the approach particularly with literature based on experience in the field of agriculture and natural resource management.

Initially the conceptual thinking of the staff involved in the project, at that time mostly engineers, still comprised many elements of the technology transfer paradigm, but gradually, influenced by the involvement of social scientists, the thinking moved much more in the direction of what we called a 'knowledge dialogue paradigm'. The following set of basic beliefs was included in this new paradigm:

- Technology transfer is seen as a two-way process that builds on both academic and community knowledge;
- Wider application of the technology and methodology will follow when sector staff has been able to appropriate the technology by being actively involved in the implementation of some 'learning projects';
- Staff from government institutions and universities are the channels through which technologies are being introduced in rural water supply;
- Community involvement is essential and needs to be rooted in the history of the community while emphasizing the benefits of good quality water supply;
- An inter-institutional and interdisciplinary approach is needed to ensure a sustainable improvement of water supply systems.

The true interdisciplinary nature of the approach was strongly encouraged by involving social scientists in key positions in the project, while also keeping an eye on the gender balance of the team. It should be realized however that the team was working with sector institutions and universities in Colombia, where engineers strongly outnumbered social scientists and had a much stronger say in decision making.

6.1 Technology transfer refined

Introduction of SSF in the initial SSF project countries can be only partly described as technology transfer in the strict sense. In all project countries, and particularly in India, SSF systems were already in place before the project started. These existing systems, one could argue, were the result of technology transfer from developed countries (in this case, England) to developing countries, as proposed by Reid (1978) as the most effective way to quick development. On the other hand, it was an innovation for most participants in the SSF project, in that the project was their first experience with SSF.

Particularly in India, the SSF project allowed national researchers from NEERI to re-invent SSF and then to promote it, with different levels of success. In Colombia and Thailand, the situation was different, as these countries had much less of an SSF tradition, so the transfer process had a larger level of uncertainty, making research and demonstration even more necessary. In Thailand, research was carried out in the first phase of the project and included the first experiences with gravel pre-treatment. It was different in Colombia, where the National Health Institute, the institute in charge of the SSF project, had a large rural water supply programme, but no previous research experience before implementing the demonstration systems. Project staff in Colombia relied entirely on the information they received from IRC and from the other countries. Only towards the end of the SSF project, was a much stronger research component included in Colombia by involving a new partner with a research mandate, the University of Valle in Cali. From the beginning, its research focused not on SSF alone, but always in combination with pre-treatment. Although this gave good results, the staff members involved were very cautious and indicated that further research was necessary to develop and test the technology.

Based on the research results, and possibly influenced by the strong positive bias towards SSF of the IRC staff and their advisors, the researchers in India and Thailand were so convinced about the need to promote the technology that they even down-played its limitations. For example, they conveniently generalized research results, stating that: "The village level SSFs, operated at normal filtration rates and under widely differing conditions of raw water quality, produce a filtrate of turbidity less than 1 NTU with E. coli removal as high as 90 percent" (Sundaresan and Paramasivam, 1982 p. 68). In fact, as I have shown in chapter 5, this was definitely not the case for all systems at all times. This seems to confirm one of the criticisms of the model of Rogers, as mentioned by Röling (1988), Crul (2003 p.53) and Leeuwis (2004), that it contains a strong pro-innovation bias. Nevertheless, a much more neutral view was established towards the end of the SSF project, as encapsulated by the following statement: "Experience shows that SSF is not a panacea. Careful analysis of the water quality is required to assess whether SSF is the best choice and what type of pre-treatment process is needed" (IRC 1991).

So it appears that technology transfer worked at the individual level of the staff participating in testing the technology. It can be argued that an important element in

India and Thailand was that the leading researchers were able to re-invent the technology. That resulted in design adjustments, but, most importantly, helped the national staff to understand and experiment with the technology and obtain ownership. In Colombia, this aspect was not an issue, and there it appears that the Colombian project manager, who was well respected in his institution, believed in the IRC staff and the information they gave him, and saw an 'opportunity', in that the SSF project co-financed construction of the demonstration plants.

Although the core team was convinced of the potential of SSF technology, important differences exist in acceptance of the technology at institutional level in Colombia, India and Thailand. These differences appear to confirm the view of Röling (1988) that: "technology transfer works if the interests of the clients coincide or come close to the goal of the institution that promotes the innovation". One can argue that IRC was this initiating institution interested in the transfer. In the case of India, NEERI embraced SSF, re-invented it and started to promote it, as it fitted very well with NEERI's interest to support community water supply. In Colombia, INS led the SSF project, but, except for staff closely involved in the project, did not, as an institution, start to promote SSF. Actually it appears that INS placed less value on water quality than on quantity. Hence its interests did not coincide with those of IRC, nor had it established the necessary expertise. This was very different from the University of Valle team, who, after having been involved in the research, started to actively promote SSF, as this was in line with its interest in community water supply.

In Thailand, the transfer did not work because only a few individuals, closely involved in the project, were promoting it, while the engineers in the PWA, the leading water agency, were more concerned with chemical water treatment for which they had a large number of ready-made designs.

Despite the limited rate of progress in the different countries, the SSF project team (IRC staff and their key partners) maintained a stance that was closely linked to what Leeuwis (2004) criticizes as a one-dimensional view of the innovation, instead of understanding that: "most innovations have collective dimensions (i.e., they require new forms of interaction, organization and agreement between multiple actors). This has important implications in that we need to put more emphasis on collective processes, and deal with issues such as diverging interests, different actor perspectives, and conflicts, and hence shift our attention to processes like conflict resolution, organization building, social learning and negotiation"(ibid).

These new views were not fully embraced by the team in 1989. Attention focused on further development of the technology and particularly the pre-treatment technology, which was facilitated by another important research project – mentioned in section 5.7 – that was implemented in parallel with TRANSCOL. It was not yet understood that, although further improvement might make SSF more attractive in terms of technology choice by managers and engineers, this would not be sufficient to ensure its sustained performance. That is affected not only by proper design and construction, but also by important interactions between the different actors involved in the operation and use of the systems and their environment, as I will discuss in chapter 7.

The thinking was still very much based on transfer of the technology as developed by the researchers, but it was also recognized that researchers were not the only ones that could contribute to knowledge development. The performance problems of many of the SSF systems made it clear that technology transfer is a two-way process that can benefit from both academic and practitioner knowledge. More emphasis was therefore given to dialogues with operators and technicians who were running existing plants. They became involved in the pilot research that was carried out on these plants. This has clear parallels with the developments in agriculture, where insight-increased innovation is not so much the outcome of formal research but of inventions developed by farmers themselves.

6.2 Diffusion needs context, actors and insights

Rogers indicates that the characteristics of an innovation, as perceived by the members of a social system, determine its rate of adoption. He distinguishes five attributes of innovations: relative advantage, compatibility, complexity, trialability and observability (Rogers, 1995 p. 208), which I presented in section 4.2. Looking at these attributes, they cannot sufficiently explain the differences in the rate of adoption in the countries that participated in the SSF project. Rogers (1995) indicates, under the heading of the *relative advantage* of the innovation, that market forces undoubtedly are of importance in explaining the rate of adoption of farm innovations. But he also indicates that they are not likely to be the sole predictors of rate of adoption. This is even more the case in the water supply sector, where there is little incentive to come up with solutions that are most cost-effective for the users, partly because the users are not involved in decision making and often do not pay the required price for the services. The improved SSF design developed in the project had the advantage that it was considerably cheaper, but this was of no concern in India until it was included in the CPHEEO manual.

Rogers (1995 p. 234) states that “the compatibility of an innovation (e.g., compatibility with values and beliefs, previously introduced ideas, needs) as perceived by members of a social system, is positively related to its rate of adoption”. This is an interesting point that has wider implications than Rogers seems to recognize. It implies that the attributes are socially constructed and therefore their relative value may differ considerably among the actors involved in the process. Looking at the potential application of water treatment in community water supply in developing countries, SSF is much simpler than RSF and hence more compatible with requirements for community water supply. This, however, does not prevent the installation of shiny RSF systems that subsequently perform at a substandard level or not at all. In this case, the higher compatibility of an SSF system is relative, because an RSF package plant can be loaded on a truck and assembled on location in a few days, whereas the design and construction of an SSF system requires a much longer period of time. So for a mayor or city council it is much easier to engage in an agreement with a representative from a factory that builds turnkey RSF systems.

Röling (1988) characterizes the thinking about the diffusion model very nicely by stating that it was thought that: “diffusion works while you sleep, just like corrosion”. Once the first people in a community are reached and have adopted the innovation, the others would be reached indirectly by autonomous diffusion processes. However, he states that this has often not been the case – as was confirmed in the SSF project. A strong limitation was that it was assumed that the innovation was equally important for all members of the social system. This automatically made non-adopters into laggards and emphasized lack of knowledge and motivation as the main causes for non-adoption, rather than, for example, lack of access to resources or ecological conditions reducing the capacity to innovate (ibid).

This view is supported by the fact that the autonomous diffusion that should have followed successful implementation of the demonstration systems, showed a much more diverse picture in the SSF project than can be expected on the basis of Rogers’ (1995) model.

In Jamaica, Kenya and Sudan, where no demonstration plants were built, it may be argued that even the minimum conditions for diffusion were not in place, although some staff had witnessed the positive experience with SSF in India, where they went to a meeting of all project partners and visited the SSF system in Borujwada.

In the case of Thailand, the SSF project manager confirmed that, although she felt that the SSF systems had worked satisfactorily (which actually was only the case in one of the two systems), only three new systems were built because the Provincial Waterworks Authority tended to favour RSF. She attributed this to the main emphasis of Thai engineering training. An additional element may have been that RSF involves much more technical equipment with higher profit margins, giving much more scope for corruption.

In India, diffusion only started to work when the SSF design was included in the CPHEEO manual and the Indian Standard, as explained in Box 4 in section 5.7. But then it went very well in terms of replication and a considerable number of SSF systems were built, particularly in Andhra Pradesh. So, once this stumbling block was removed, the diffusion process seems to be more in line with the thinking of Rogers. The unfortunate situation arose however that the new SSF design was copied without looking at local conditions, which is like using a medicine without consulting a doctor, and involves a high risk of failure. Results were dramatic in that many new systems were built, but many have important operational problems. So, although diffusion occurred once the design was in the CPHEEO manual, it did not seem to be based on the true attributes in terms of operational performance, perhaps because the decision makers (engineers) were not communicating with the operators.

In Colombia, the positive experience with some SSF systems also resulted in the copying of designs by inexperienced engineers, leading to the construction of new systems that subsequently faced important maintenance problems. Unfortunately, in this case the problems were mistakenly attributed to deficiencies in the SSF technology and not to the poor performance of the engineers who had produced inadequate designs.

Hence the attributes themselves are not neutral and cannot sufficiently explain the rate of adoption of an innovation. In the absence of a supportive environment that makes it possible to apply and sustain the technology, autonomous adoption will not take place. Even with a supportive environment, the actors that have to take the decision need to appreciate the technology. This may mean that they have to be familiarized with it in their university training, as many keep adopting solutions that they have on their own shelf, as Vaa (1990) describes it. An additional problem is the way that decision makers or advisors (often engineers) perceive the problem that needs to be solved in relation to the prevailing situation. With university training placing more emphasis on advanced technologies, many design engineers in developing countries have an urban bias and favour chemical water treatment, apparently ignoring their poor performance track record and limited fit with prevailing local conditions.

Recognition that autonomous diffusion did not really come about in the SSF project broadened our thinking about the 'Rogers' diffusion model and made us realize that it was necessary to move much more towards a dialogue approach, to understand better the different perceptions actors may have about the attributes. This worked very well in the review workshops for design engineers that were held in the final phase of the SSF project. Here the strength of Plato's idea that 'if one poses the proper questions, people by themselves, will discover the truth about every issue' became quite clear. As I will show in chapter 7, the dialogue idea developed further in the course of the TRANSCOL project, strongly influenced by the involvement of a larger number of social scientists in the team and the positive experience in the projects.

It is important to realize that at the beginning of the project we did not move away from the normative models about rational decision making that, according to Leeuwis (2004), are at the roots of the original conception of Rogers' model. Leeuwis argues that "rational decision making is often a practical impossibility and experience shows that the way in which people go about altering practices often bears little resemblance to decision making models". He suggests that Rogers (1995) also attempted to move away from such models, but did not succeed because his remaining concern with decision making was logically connected with the idea that the adoption of innovations is largely an individual affair. Yet it is important to realize that decision making is not so straight forward even at the individual level. Snowdon (2002) provides an interesting view that: "Humans, individually and collectively, work on the basis of contextual pattern recognition, often at a non-conscious level". He argues that decisions are not made on the basis of a rational evaluation of carefully considered alternatives, but through a first-fit pattern matching with past experience. Those patterns are ingrained, based on our

own past experience and the collective experience of our culture, often communicated through stories – national and organizational.
Another important aspect is the question of who takes decisions in the water sector. In many countries, the sector is being decentralized, implying that municipalities take the decisions. In practice, it is a 'hybrid' sector in terms of decision making. In countries that have advanced with the decentralization process, there are still organizations, programmes or lending schemes that steer the decision-making process of the municipalities. Even in the absence of such external institutions, decision making can be influenced by many factors that are not directly related to the innovation.

Although the thinking of the team took on board the insight that innovation is a collective process, it still maintained the position that wider introduction of SSF technology would need an improvement in some of the attributes that were not sufficiently addressed in the SSF project. By bringing in pre-treatment and shifting to MSF, we enhanced the *compatibility* of the technology. By bringing demonstration projects closer to the actors, we increased the *observability* and the *trialability*. At the same time, the team was convinced of the need to look at the technology in the broader context to ensure its sustainability and use, as discussed in section 3.2.

6.3 Adopting different transfer channels

Looking at the experience in India and Colombia, different channels were involved in the transfer and diffusion process and only partly those envisaged in the initial conceptual framework. The following five channels were mentioned in chapter 4 based on Hommes (1983) and our own experience:

- Commercial channels
- Acquisition of knowledge through entrepreneurs
- Development projects of governments
- Development projects of international agencies and NGOs
- Universities

Of these groups, the development projects of governments provided the main channel for diffusion of SSF in India and to a much lesser extent in Thailand and Colombia. In Colombia, several systems were established by small entrepreneurs. Universities were not used much as a transfer channel in the project, and they often still had a bias in favour of chemical treatment, except for the team that was directly involved in the research in the University of Valle and the NEERI team that was organizing SSF training at different levels. A positive development was that researchers from a university in England and a research centre in Switzerland started to initiate SSF and pre-treatment research (Lloyd et al., 1986; Wegelin 1988). These were in contact with the team from the TRANSCOL project, thus broadening the resource base for the technology.

Development projects of international agencies and NGOs did not play a role at all, partly because organizations with many water projects, such as UNICEF, were particularly interested in hand-pump water supply and were not much concerned with water treatment. Although some small entrepreneurs promoted SSF, another part of the commercial channel actually worked against its diffusion by strongly promoting, often very poorly performing, RSF systems.

Reflecting on the transfer channels, the project team decided that wider introduction of the technology in Colombia required a combination of actors in the different channels, but with a strong emphasis on universities, which had had only a very limited role in the SSF project. According to the project proposal (UNIVALLE, 1987), working groups would be formed in at least seven regional universities, to work closely with the regional Health Services and the implementing agencies in the regions involved in the project. So the choice was made at this stage to work primarily with two channels, the university and government institutions, with the clear indication in the project document that in this way the universities would be associated with solutions that the government needed, without losing their identity and academic function.

Involving both groups in the development work from the beginning, in addition to the communities, was an important change, in which the development stage and the dissemination stage of the innovation, which Rogers (1995) sees as distinct, began to merge. Later in the project, an effort was also made to include the private sector. UN agencies and international development projects were not included, as these do not play an important role in the implementation of water supply systems in Colombia, and the commercial sector was in fact the competitor that was strongly promoting RSF. In retrospect it would have been very interesting to explore whether it would have been possible to involve the private sector more actively in the project, accepting the fact that, according to different authors including Leeuwis (2003), Engel (1995) and Röling (1988), innovation is a complex process that makes it necessary to deal with issues such as social learning, conflict management and negotiation. Although understanding of the social organization of innovation became apparent in the course of the TRANSCOL project, this was still very innovative for the water sector, whereas in the agricultural sector thinking about these issues did advance more rapidly.

6.4 Community involvement in a different light

The intention in the SSF project to develop new approaches to community education and participation did materialize on paper. It resulted in important IRC publications in this field, but was not put into practice in the project. The approaches applied in the demonstration communities followed the daily routine prevailing in the countries, and did not benefit from the important insights gained in the project meeting in Voorburg in 1978, nor from operational guidance and support from IRC and its advisors. The method of securing cooperation and acceptance in these communities is first to work with the local leaders, or, as was the case in Thailand, with the more influential residents, including the headman, monk, headmaster, etc. After their approval was secured, the rest of the population was informed by these leaders in a community meeting. The ‘approval’ comprised willingness to participate in the project and the related health education programme, establishment of a local committee to manage the project, selection of a local caretaker and, in the case of Colombia and Thailand, the contribution of land, labour and money was a condition for inclusion.

Community participation in the form of free labour was strongest in Colombia, with each household that wanted a private connection typically having to do one day of labour per week during construction of the system. As an alternative, households were allowed to hire labour. On the positive side, this free labour gave a feeling of ownership as expressed by one community member: “we built it with our own hands”. Free labour may also imply a cost saving, but this can be offset by the need for good supervision, as inexperienced construction of pipelines may result in quicker deterioration of pipes. Also special measures are needed to accommodate those households (often female-headed) that cannot provide the required labour. In the case of Alto de los Idolos, those not able to provide labour or pay a connection fee, were excluded from the system. The result was that only 80 percent of the households benefited from the partly subsidized water supply system.

This type of result made it clear that the approach to community participation followed in the countries needed to be revised and to involve much more dialogue. The difficulty in putting this into practice, however, was that, as Pijnenburg (2002 p. 298, quoting Adams and Hulme 1998) states about community-based natural resource management, it has become so evidently the ‘right’ approach, (…) that debate about its merits and demerits, (…) has been very limited. Lack of critical reflection has likewise been observed in connection with other participatory approaches, often being presented as the only way forward, with the consequent risk of imposed and cookbook-type interventions. In fact, this is a more general phenomenon that also applies to other interventions, including non-participatory approaches and, for example, the choice of treatment systems. Following embedded routines is the easy way, as was very clear particularly in health education.

The health education component of the project was carried out by health staff and little information is available on how it was done in practice. It appears however that field staff found it difficult to adopt a dialogue approach. One of the participants from Thailand in the Voorburg meeting said: “When a superior person from the capital (hopefully meaning important person, but not able to express this because of limitations in command of English), goes to the village and speaks the same language as the people, he is respected, but the low-level worker has to speak in a highly technical language, otherwise he is not accepted”. He then ended by stating “but training for dialogue is important”. From this example it appears that staff working in the project had not yet mastered a more horizontal working relationship with the community. The spirit was primarily one of convincing and teaching, to promote behaviour change that was seen as in the best interest of the local people – implying that the external agent knows it all, while the recipient community knows nothing. The staff in the SSF project clearly did not adopt the view of Paulo Freire (1970) that “adults should not be considered empty vessels which need to be filled up with information". The example shows the need to break with 'daily routines' and further nurture the idea of a dialogue that differs from the more common discussion, which has its roots in 'percussion' and 'concussion', literally a heaving of ideas back and forth in a winner-takes-all competition (Senge, 1990). Interestingly, all participants in the dissemination meetings in phase 3 of the SSF project agreed to community participation and hygiene education, using generic statements such as: community participation is essential to ensure proper installation, operation and maintenance of water supply systems; the community should be encouraged to participate in the provision of its own water supply; health education is vital to ensure the health impact of the water supply system; a dialogue with the community about existing health practices and needs is essential and should be started prior to implementation of the system.

The problem with such statements is that they still seem to present the community as homogenous and they are so generic that they do not provide much of a clue about how to go about it. This confirms that, as Chambers (1993) observed, the question many public sector institutions ask is not why to adopt participatory approaches, but how to go about it. What is needed is a learning process that develops and promotes new methodologies and changes prevailing attitudes, behaviour, norms, skills and procedures within the agencies. Community involvement, and adopting an inter-disciplinary approach, imply modifications in the dynamic of projects, changing them into learning processes (ibid). This change in thinking formed the basis for the TRANSCOL project, although this is not properly reflected in the proposal of the project (UNIVALLE, 1987), which was written by engineers and even suggested that the project staff would consist of engineers and that the regional teams would be guided by two engineers. Fortunately the thinking changed early in the project implementation, which resulted in the involvement of social scientists in the team at UNIVALLE and in the regional teams.

The interdisciplinary nature of the team very much stimulated emergence of a paradigm shift that transfers the centre of interest from the technology to the people (Korten and Klauss, 1984; Cernea, 1991; Max-Neef, 1986; Chambers, 1993). This new paradigm starts from the premise that the actors, both in the institutions and in the communities, possess knowledge and experience that can be built upon. In this concept, communities are not seen as beneficiaries, but as actors in search of their own development, who will be taking decisions throughout the development process. These actors have their own knowledge and views that they have developed as a result of the environment in which they live (Röling, 1988). On the other hand staff from universities and sector institutions have knowledge and experience that will enable them, by using participatory techniques, to contribute to development and to learn in a horizontal and transparent way to join forces with communities.

Viewing the community no longer as a beneficiary or as 'free labour', but as an actor in the process, is a considerable change from the approach followed in the SSF project. It is more in line with thinking expressed and ideas developed in the SSF project meetings on participation but not put into practice in the project. Another important aspect that started to emerge was that project staff began to distinguish between the role of men and women, which implies an important step in the direction of more gender-sensitive approaches.

6.5 Platform for collaboration is strengthened

The intention that the SSF project would foster collaboration between executing agencies in the field did not really materialize. Although PMCs were established at country level, they did not meet regularly and did not take forward an agenda of decision making. They were supposed to have integral responsibility for the organization, staffing and control of the project in their respective countries, but they had no joint control over the budget for the activities, as each organization involved contributed from its normal programme. It can be argued that the lack of guaranteed ‘project’ resources for activities at PMC level and the limited institutional commitment very much reduced the impact of the project at the institutional and policy level.

In comparison with the PMC in the SSF project, the concept of working groups in the eight project regions in Colombia indicated in the TRANSCOL proposal was somewhat more advanced. The proposal stressed that these working groups needed to include at least a university, the regional health service and an implementing organization. This was seen as the minimum composition and forming a larger group was encouraged.

Further progress in thinking was made in respect to the process that steered the work of these groups and the work at community level. This process was to be organized in such a way that the political, managerial, professional, technical and communal levels, together with the research institutions, all identified prevailing limitations and agreed on solutions to overcome them, so as to ensure that sector interventions and investments met their objectives and were sustained over time (Visscher et al., 1997). Gradually, the understanding developed that, because technology is deeply rooted in society, technology development and transfer need close linkages with the society and particularly with the prime actors in the sector, operating at different levels of decision making:

- the national and international political level (decisions at macro level);
- the institutional level (operational decisions); and
- the community level – end-users expressing their expectations and possibilities to sustain the service.

It was argued that all three levels need to be involved in technology development and transfer, to ensure that solutions develop in consultation and are reviewed from different perceptions (ibid). This view has important parallels with the concept of a platform for decision making for resource negotiation, which Röling (1994) defines as “a nodal point of social interaction between stakeholders to allow for integral decision making about a resource they perceive to be in need of management. Stakeholders coming together in a platform to manage an ecosystem must learn from scratch about the system, agree on its boundaries, share concepts about its sustainable management, and develop indicators for success and methods for making things visible".

In a later publication, Röling (2002) argues that increasingly there is common experience that resource dilemmas cannot be resolved (only) by technology and market forces. When no human decision-making capacity exists at the hard-system level at which problems are perceived to be solvable, platforms for managing resource dilemmas are deliberately created to provide the soft system that can complement the hard system. He then defines these platforms as "contrived situations in which a set of more or less interdependent stakeholders in some resource are identified, and, usually through representatives, invited to meet and interact in a forum for conflict resolution, negotiation, social learning and collective decision making towards concerted action" (ibid p. 39).

I will show in the next chapter that at the start of the TRANSCOL project the thinking about the inter-disciplinary regional working groups was still more limited, but gradually an understanding emerged that such platforms were needed to facilitate learning and conflict resolution at the institutional level. I will also demonstrate that different nested platforms are needed to cater for the interactions among different levels of decision making that exist in the sector. Also, I will compare the experience with emerging ideas about learning alliances (Moriarty et al., 2005)

6.6 From information sharing to joint learning

The orientation to training and information sharing in the SSF project can best be characterized as an externalist approach (see section 4.6) in which, as Long and van der Ploeg (1990 p. 228) call it, a 'package from outside' was designed to stimulate the emergence of certain internal activities. The underlying rationale is the idea of transferring to the target group those capabilities or types of knowledge that it is assumed they lack. This was very clear in the approach to hygiene education in which, for example, community members were asked about the 'correct' symptoms of specific diseases and when giving a wrong answer were corrected. Another example is the training manual for operators. This was prepared on the basis of mostly engineering logic and not operators' perceptions. The positive point is that materials were tested with operators and this led, for example in the case of India, to the adjustment of drawings to better reflect the local setting. Still this approach is not sufficient to ensure that local concepts and bodies of knowledge are given the importance they merit. That would require a much more interactive approach.

Village demonstration plants in the SSF project were felt to have made an important impact on knowledge sharing. This is in line with the views of Rogers (1995 p. 355) that "potential adopters of a new idea are aided in evaluating an innovation if they are able to observe it in use under conditions similar to their own". Most of the demonstration systems however, were more what Myers (1978 cited by Rogers, 1995 p. 356) calls "*experimental demonstrations*, which are conducted to evaluate the effectiveness of an innovation under field conditions". Only in Borujwada in India, can the system also be considered suitable for the second category of demonstrations, being *exemplary demonstrations* (ibid), which are conducted to facilitate diffusion of the innovation and persuade potential adopters.

The team partly embraced these concepts for the new project, by establishing guiding principles for the future locations of the 'demonstration plants', to ensure that these would be easily accessible and would be available for future training of sector staff. Yet the project team in Cali felt that this concept needed to become much more oriented towards participatory learning. The team is convinced that, in line with the approach of Freire (1970), participants need to be challenged to use their creativity to identify problems and possible solutions and to take action accordingly.

It was decided to change the character of the demonstration projects and give them the new name of "joint learning projects", which are projects that apply systematic experimenting in a 'safe' setting, where participants can share experiences and learn by probing a problem and implementing and adapting possible solutions, including 'new' technologies and strategies.

The creation of joint learning projects enables participants to introduce, validate and adapt technologies and methodologies, training tools and working strategies to local conditions and to come to grips with them in a creative way. These 'learning spaces' can serve the purposes of both demonstration and capacity building in the institutions and the communities. They help partners at institutional and community level to build self-esteem and find their own ways in problem solving and communication.

The projects combine experiential learning with some educational activities dealing, for example, with issues the community was less familiar with such as the MSF technology, or the causes of waterborne disease. The type of learning through experience that is reflected in Kolb's (1984) model of 'experiential' learning (Figure 14) is very powerful; "it appears that conclusions drawn by people themselves on the basis of their own experiences, tend to have a greater impact than insights formulated by others on the basis of experiences that learners cannot identify with. The model indicates that learning occurs from a continuous interaction and iteration between thinking and action" (Leeuwis, 2004, p.149). The essence of the learning projects was that they moved away from individual learning by involving different interdependent stakeholders in the process at multiple levels.

In the next chapter I will discuss this in more detail and particularly explore the issue of social learning that Röling (2002) describes as a move from multiple to collective or distributed cognition. Multiple cognition involves the existence, in one situation, of different cognitive agents with multiple perspectives who tend to maintain their mutual

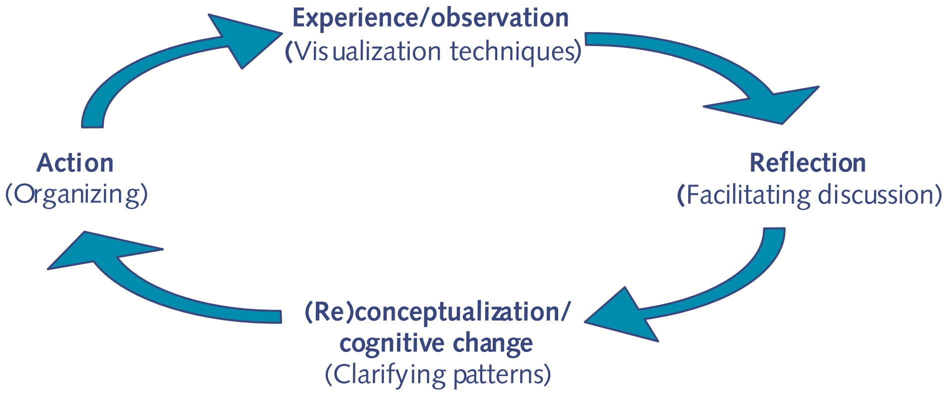

Figure 14. The learning cycle (Leeuwis, 2004 adapted from Kolb, 1984)
Examples (in brackets) show ways in which learning can be supported

isolation. By bringing these agents together in a platform (or in a learning project) these perspectives can grow into a joint rich picture and the agents can decide on concerted action. In this way it can evolve into collective cognition (which emphasizes shared attributes, i.e. shared myths, values and collective action) or distributed cognition (which emphasizes different but complementary contributions that allow concerted action).

This requires however that the agents realize that they are interdependent and that desirable outcomes are dependent on the activities of other actors. Leeuwis (2004) indicates that the idea of distributed cognition recognizes that stakeholders may well work together and engage in complementary (i.e. coherent) practices, while significant differences in perception remain. Ideas, values and aspirations may overlap, but are not necessarily shared. In his view, collective cognition and collective action are more likely to emerge within stakeholder categories, whereas distributed cognition and co-ordinated action are best achieved in a multi-stakeholder setting. These positions I will explore when looking at the cognitive changes that took place in the learning projects.

The learning projects resemble what Engel (1995), calls ‘theatres of innovation’ in which the actors are learning, receive training and are able to experiment in order to give a successful performance. They become spaces in which the authorities, the institutions and the community collaborate on an equal footing. These spaces enable the community members to draw on their experience and to review the history of their communities and their water and sanitation systems. Participatory techniques such as mapping help to visualize and clarify the situation and provide a basis for project development. Such a project needs to strive for the active and creative participation of all members of the community (men, women and children) or their representatives. This approach will show that differences exist between men and women in their access to resources, their involvement in decision making and in leadership – differences that need to be taken into account in a development programme.

The approach dramatically modifies the concept of the external agent who knows all, while the recipient community knows nothing. In the learning-project approach the external agent becomes a facilitator, who knows some things but also needs to learn. Hence, the external agent can share in the exchange of experience and empowers the community and the participating agencies to challenge the existing situation and to model it to suit their own objectives.

Packham et al. (1989) use the metaphor of a swimming pool, which I borrow as it nicely clarifies the learning-project approach. Participants are not thrown in the deep end and left to swim or drown! They are given instructions on the side. They see others swim in the pool, and they are encouraged to go in when they feel able. Some start at the shallow end, where they can touch the bottom, but all have eventually to get to the deep end. Some feel the water is cloudy, so when they come in they find others, who they thought were swimming, are really touching the bottom! Some wonder who is teaching whom, or saving whom from drowning.

In this context it is important to explore how we learn, how we acquire knowledge. To clarify this, I have chosen the comprehensive definition of Davenport & Prusak (1998) stating that: "Knowledge is a fluid mix of framed expertise, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates from and is applied in the minds of "knowers". In organizations it often becomes embedded not only in documents or repositories, but also in organizational routines, processes, practices and norms". The gist of most definitions of knowledge is that it is a personal capacity to act and that it clearly is more than information. Knowledge requires a "knower" and these knowers - consciously or sub-consciously - make a choice to use it or not and share it or keep it to themselves.

The approach of Weggeman (2000) helped me to understand better the elements involved in acquiring knowledge. He suggests that knowledge (K) can be expressed in a formula as a combination of information (I), experience (E), which in my view encompasses the theoretical basis that allows us to anticipate and predict, skills (S) and attitudes (A) including the effect of culture and beliefs. I prefer however to add action to the formula by replacing the K of knowledge with K_a knowledge acquisition.

$$K_a = (I \times E \times S \times A)$$

We apply a 'filter' to whatever information we receive through our five senses. This "filter" will determine whether we are open to new ideas, whether we can grasp new information, whether we accept that, although someone is from another culture, his/her ideas may be very valuable, etc. Lewicki et al. (2003) call this 'filter' a 'frame', "a (mental) construction that represents our interpretation of the world around us. . . . When we frame something, we put it into perspective by relating it to other information that we already know". When a person is convinced that neither he/she nor their ancestors got sick from their water supply, this ‘frame’ can be so strong that it does not allow him/her to accept a different ‘coherent world view’, making him/her reject information in favour of water treatment. To change this, a process of ‘reframing’, i.e. the adoption of a new ‘world view’, is needed, which may require considerable effort.

The filter also applies to the sender, as knowledge as such cannot be shared with someone else. It needs to be turned into information – oral, written, graphic, gestures or body language. The sender will use his/her ‘frame’ to interpret his/her knowledge and package the information in such a way that it matches his/her world view. The receiver in turn gets the information through his/her five senses, filters it and interprets it in his/her own way.

We all remember receiving lectures from very knowledgeable professors, which unfortunately we were not able to grasp, whereas other teachers, perhaps less knowledgeable, were able to reach out to us, using among others a series of emotions related to their work, in a transfer process that is difficult to explain (Sarriegi, 2002). So it is clear that knowledge acquisition and learning go well beyond the issue of information. They depend on the previous knowledge a person has, the style of presentation, the type of experiment, the learning style, attitude and perception of the receiver about the environment, the institute, the trainer, the colleagues, etc.

6.7 Summary

In an attempt to make it easier for the reader, I have summarized the main changes in the theoretical basis that emerged from reflection on the SSF project and the broader changes in the thinking about development stimulated by, for example, Chambers (1993). He called for the need to train a new kind of professional able to put ‘the last’ (the poor and the weak) in the centre of his/her work, so that they could be those who set the priorities and become the agents of their own development. The changes in ideas summarized here form the basis for the TRANSCOL project that will be discussed in the next chapter.

The thinking about technology transfer broadened

The introduction of SSF has collective dimensions. (i.e., it requires new forms of interaction, organization and agreement among multiple actors). This makes it necessary that a programme not only deals with the technology, but also with issues such as conflict resolution, social learning and negotiation. These new views were partly embraced by the team in 1989, but still attention focused on further development of the technology and particularly on pre-treatment technology. The thinking still was based in the transfer of technology developed by researchers to ‘others’, but it was recognized that these ‘others’ could contribute to knowledge development.

Guided diffusion with attention to the context

Autonomous diffusion did not really materialize in the SSF project and this led to the understanding that, on the one hand, the attributes of SSF needed to be improved, which resulted in the development of MSF, but also that multiple perceptions exist about these attributes. The team developed the new project in the belief that actors would need to get more hands-on experience with MSF to change their perceptions. This led to what is perhaps the most interesting change from the earlier ideas, adoption of the learning-project approach, in which all actors jointly learn and develop. The team also believed that this was not sufficient, and that a supportive environment would be needed as well, to ensure a wider uptake of the technology.

Development and dissemination channels begin to merge

The team decided that wider introduction of the technology in Colombia depended on a combination of actors: regional universities, the regional Health Services and the implementing agencies in the regions. In this way it was felt that the universities would be associated with solutions that the government needed, without losing their identity and academic function. This was an interesting change, in which the development stage and the dissemination stage of the innovation began to merge.

Communities acquire a more prominent role

Communities were no longer seen as beneficiaries or free labour, but actors in the process of their own development who needed to be involved in dialogue. It was also recognized that differences in roles and realities of men and women needed to be taken into account.

Regional working groups as platforms for collaboration

Working groups were established, comprising at least the university, the regional health service and an implementing organization, to create a platform for dialogue and to accompany development of the learning projects. The understanding was that the process that oriented the work of these groups needed to be organized in such way that the political, managerial, professional, technical and communal levels, together with the research institutions, identified and agreed on solutions to overcome prevailing limitations.

From information sharing to joint learning

The emphasis changed from information sharing and demonstration, to joint learning in the learning projects. This change is based on ideas about adult education and experiential learning, and is characterized by the shift implied in social learning from multiple to collective or distributed cognition.

Supporting communities to take their own decisions

7. The TRANSCOL project (Case Study 2)

> *"Studying in the solitude of mountains is not worth as much as sitting at a crossroad and lending an ear to what people say." Confucius*

In this chapter, I will review the TRANSCOL project (Transferencia organizada de tecnología simplificada para el tratamiento de agua en sistemas de abastecimiento en Colombia). This project was implemented between 1989 and 1996 to introduce MSF water treatment in Colombia. Reference will also be made to the Pre-treatment project, a parallel research project on pre-treatment technology that helped to further develop the MSF technology (CINARA-IRC, 1996a). Both projects were coordinated by the group of the University of Valle that was involved with IRC in the SSF project. This group established itself as a foundation called CINARA, which was closely linked to the University, to facilitate the management of these large projects. TRANSCOL received a grant from the Dutch government of USD 2.9 million and generated a national, regional and local contribution of USD 3.2 million.

I will also review some of the follow-up activities undertaken primarily by CINARA. I base my findings on the review of project documentation, evaluation reports, my own experience in the project and the findings of a revisit to several of the project regions in 2005, ten years after the project ended. I have been the manager of TRANSCOL and the Pre-treatment Project during the whole period.

In this chapter I intend to show that TRANSCOL was an innovative project that succeeded in introducing MSF in eight regions in Colombia, in a water sector that was in a state of flux. I will argue that communities need to understand the logic of the technology, the related social aspects, and the water ecology involved, and require a minimum of long-term support to manage and sustain their system. The latter issue emerges from the better performance of MSF systems that have received back-up support from CINARA. I aim to demonstrate that the project moved beyond the technology-transfer paradigm (Rogers, 1995), in adopting a learning approach based on a clear constructivist perspective, which, as Röling (1994) states, does not reject positivist science, but recognizes it as but one of the many ways by which people construct reality. This approach created the opportunity and the insights to develop what we called 'technology sharing through joint learning projects'. In these projects, staff from sector institutions and communities shared their experience in a joint-learning environment, characterized by mutual respect. I will argue that TRANSCOL became a multi-stakeholder learning project that has many characteristics of a Learning Alliance and that its positive outcome supports the view of Röling and Jiggins (1998 p. 285) that "humans acting effectively in the environment, depend on their ability to collectively learn, construct and share useful knowledge and technology". One of the outcomes was the insight that an effective water supply system is the emergent property of the interaction among multiple stakeholders.

7.1 Overall description of the TRANSCOL project

The TRANSCOL project was developed after the research and development activities in the SSF project in Colombia (section 5.5) had shown that a combination of SSF and gravel filtration was a very effective treatment process. Seeing these results, CINARA and IRC were faced with the question of how to transfer this technology to other communities in Colombia and how to make it part of the regular operations of drinking water supply development agencies. Immediate action was considered necessary, because the positive results already were leading to some autonomous diffusion, in that organizations and individuals in Colombia had started to build SSF systems, without having experience with the technology. Just copying the designs from others not only led to poor or non-performing systems, but could easily put the technology at risk of losing its credibility. Therefore a clear need existed to share the new experiences with the technology and establish advisory support capacity in the regions. This was stimulated by the fact that, following two newspaper articles about the experience with SSF in Colombia, several requests were received from small municipalities in different regions of Colombia wanting to learn more about this interesting technology (UNIVALLE, 1987).

This led to formulation of the TRANSCOL project and the parallel Pre-treatment project, both of which were initiated in 1989 with financial support from the Netherlands government and different Colombian organizations, who had already at that time agreed on the importance of water quality improvement. This was quite forward-looking as even today water quality remains an under-rated issue in community water supply. Having a parallel research project under the same management proved to be very positive, as it helped to develop the technology in an interactive way, receiving feed-back from the field as well as from the research station where a technology development team was based (Figure 15). This interaction has interesting parallels with the non-linear chain-linked model developed by Kline to understand the nature of innovation that linear models could not sufficiently explain (Kline, S.J. and Rosenberg N., 1986; Mahdjoubi, D., 1997), as I will discuss further in chapter 8.

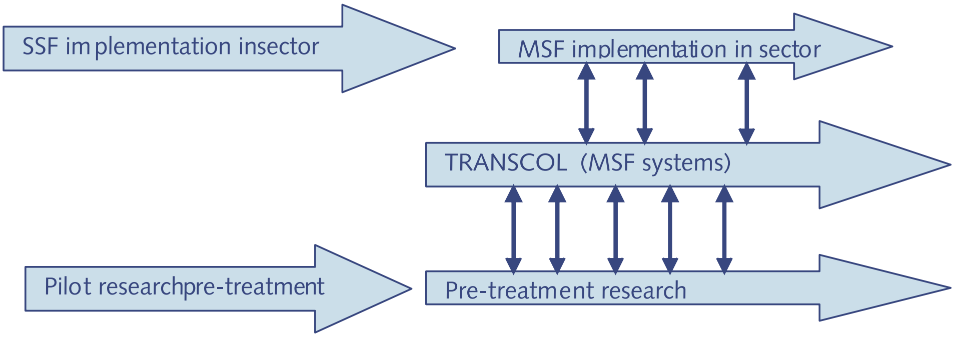

Figure 15. Linked implementation of TRANSCOL and the Pre-treatment Project

Objectives of TRANSCOL

The TRANSCOL project was developed for a three year period, which was later extended to six years (1989-1996). The project had two main objectives:

- To introduce MSF in eight regions through the development of 16 demonstration plants, two in each region;
- To establish working groups in these regions that could serve as future advisors on implementation of MSF technology in their region.

In the original proposal, the term SSF was used instead of MSF. This reflects the fact that the formulation of the proposal was still very much based on the earlier SSF project. The team however was already convinced that it was always better to use SSF in combination with pre-treatment. This conviction was further strengthened under influence of the parallel Pre-treatment project and soon focused on what we then started to call Multi-Stage Filtration (MSF), the combination of SSF with coarse gravel filtration. So, in fact the team was not transferring SSF but MSF, and I feel that this is better reflected by talking about MSF and not SSF in the objectives.

It is also important to mention that the formulation of the project was done by staff with an engineering background but having a broader view about development. This is reflected in the proposal (UNIVALLE, 1987), which still has the flavour of the technology-transfer paradigm, aiming at a guided diffusion of the technology to ensure that future implementers would gain enough knowledge about the technology and its implementation through their involvement in the demonstration projects in their region. Guidance was envisaged to be provided by engineers. The broader view of the engineers is shown in the project document, for example where it states that “the National Health Institute has important experience with involving the community in the implementation of water programmes, but this needs to be extended to also include them in planning, operation and maintenance and evaluation, adjusting the strategy in every region to the culture and the type of communities” (ibid p.10). It is also reflected in another interesting statement that: “the most important result of the project is intangible, it is the attitude, the wish to participate in the effort that is needed at all levels to improve the water supply service, in harmony with our technical and socio-economic reality” (ibid p. 26).

When the project started, the core team was extended with one, and later several social scientists, making it a very interesting multi-disciplinary team effort. This stimulated a significant change towards a constructivist perspective. The main philosophy changed from training sector staff to adopting a ‘learning by doing’ approach with a more prominent role for the community. The demonstration projects then really changed into multi-stakeholder learning projects in which the technology and the methodology were shared among the members of the working group and the communities, as I will explain in more detail later in this chapter.

Box 5. The main stages in the TRANSCOL project

- **Selection of the region**, taking into account the potential for MSF application and the existence of institutional interest to participate in the process.
- **Introductory seminar in the region;** After meeting with political and institutional leaders involved in the sector, a regional seminar was held to present the project, its objectives, philosophy, strategies and organization. Also the relation of the project activities with sector policies was presented and the important role that R&D can play.
- **Establishment of Inter-institutional Regional Working Groups (IRWGs);** The regional seminar resulted in the establishment of an IRWG in each region, formed by staff from all key sector institutions, and in agreements about the support by these institutions.
- **Selection of project sites** was carried out by a multi-disciplinary team of members of the IRWG, guided by two staff members of CINARA – an engineer and a social scientist. Selection started with a review of information available in the institutions followed by a one-day visit to each of ten pre-selected communities to discuss their interest and to verify and complement the information obtained. Subsequently two communities were selected, primarily based on the following criteria: good accessibility; existence of a water supply system with a water quality problem that could be solved by MSF treatment (section 3.7); willingness of the community to participate; presence of a sector institution to support the project; and the feasibility to implement it within a reasonable time.
- **Development of a project design for each community** started with a three-day field visit to collect additional information and establish initial agreements with the community. Thereafter, a two-week training of IRWG members was arranged in Cali to learn about MSF and the learning approach and to visit existing MSF systems in Valle del Cauca. Participants returned to their regions with an outline design of the MSF system and an initial socio-educative plan for working with the community in the different project phases.
- **Starting up the activities in the community** began with a creative workshop in which community members, both men and women, reflected on the potential health benefits of water quality improvement, and reviewed and approved the plans for the water treatment plant and for the socio-educative activities. They also discussed the costs and their possible implications for the water tariff needed to sustain the system.
- **Financing, tendering and construction** started with verification of available financial resources in the communities and agencies, and the levels of credit required. Tender documents were made by the IRWGs and tender procedures implemented mostly through the municipalities that subsequently made a contract with a contractor. Construction was organized in consultation with the community and included its participation in an official civilian monitoring committee. Training of water committees and operators (who had no experience with water treatment) started during construction.

- **Starting up the plant** began by accompanying the operator and the water committee in the process of initiating plant operation, filling the units with water, putting them into operation and gradually increasing the flow velocity when maturation of the biological layers proceeded. In this phase, efforts were also made to stimulate the community to enhance efficient water use.
- **Monitoring and evaluation** comprised several visits from the IRWG and CINARA staff to support the water committee and the operator to monitor the performance of the system and to analyze possible problems with its functioning and use. As part of the overall evaluation of the project, a national workshop was organized in which staff from IRC, CINARA and the IRWGs, as well as community members, participated.
- **Dissemination of results** was done through meetings and more continuously through advisory services, follow-up activities in the projects, including hosting of visitors interested in MSF, and development of new projects.

Preparation of the team

The team developed and discussed a systematic approach to guiding implementation of the project (Box 5). This approach was very useful, as it helped the team, comprised of many young professionals, to visualize the ambitious project that was to be implemented. It included long and sometimes heated discussions in the team and between the team and senior external advisors with considerable expertise and a good reputation. During my visits, I also participated in several of these sessions. In addition to discussing and fine-tuning the envisaged approach, several training sessions were held to better equip the team for the tasks ahead.

This training was very important, and particularly the non-technical part. It included training sessions with psychologists that helped the team members to reflect on their own motives and behaviours and supported team building and creativity. As I like to put it, it enabled the team members to ‘move out of their technical frame of mind’ and become more open to a multi-disciplinary approach, and to understand and accept that different views of reality exist. In the training it was stressed that mutual trust and good leadership are the foundation for teamwork. The team reflected on its role and the fact that most of them were to become ‘leaders’ in the regional activities.

The team jointly reviewed important leadership qualities which Bennis (1991) lists as: vision, passion and enthusiasm, empathy and integrity, suggesting that integrity, the quality that makes people trust you, comprises three essential parts: knowing oneself, being sincere and acting maturely, with the first perhaps being the most difficult. Knowing, accepting and confronting your own weak points is not something you learn in engineering education. It is very significant that, as I will discuss later in this chapter, most community members that were interviewed about the role of CINARA, referred to them as ‘really leading the project’, as having charisma, drive, patience and tolerance, which suggests a positive impact of the training.

7.2 The project philosophy

The strategy outlined in Box 5 gives the logical sequence of events that was followed, but is not the heart of the project. What really made the difference was the philosophy behind the project and the approach followed in the different steps. The project staff adopted a new approach, which they called the ‘joint learning project approach’ and is characterized by the following key elements:

- **A development paradigm centred in people**
  The centre of interest was transferred from the technology to the people. It started from the premise that the actors, both in the institutions and in the communities, possess knowledge and experience that can be built upon. Communities were not seen as beneficiaries, but as actors in search of their own development who take decisions throughout the development process. They have their own cultural identity that needs to be respected. Adopting the view of Paulo Freire (1970) that ‘adults should not be considered empty vessels which need to be filled up with information’, dramatically modified the concept of the external agent who knows all, while the recipient community knows nothing. In retrospect however, it is important to acknowledge that together we did not bring enough knowledge to the table, for example in relation to the situation in the catchment areas, primarily because we did not ask the right questions.
- **Dialogue and participatory techniques**
  By using participatory approaches, projects become a space in which the authorities, the institutions and the community share their experience. This space enabled the community to review the history of their water supply system and bring in their views about problems and potential solutions. Participatory techniques such as mapping helped to visualize and clarify the situation and provided a basis for project development. This helped to stimulate dialogue, where people exchange views in an atmosphere of respect, instead of discussion and debate, where getting one's views accepted is often the main intention of participants. Whereas emphasis was placed on involvement of the community in the activities, their participation in decision making was very limited and restricted to a yes or a no to participation in the project and some influence on tariff setting. Later this approach turned out to be too narrow, as it did not sufficiently address issues such as the interrelationship between the water supply system and the users, as will be further discussed in chapter 8.
- **Adopting a soft system orientation**
  ‘Hard’ system thinking has been at the heart of the WSS sector for a long time, seeing technology as the main solution to a straightforward problem of people not having adequate water supply. According to Checkland (1989), hard system thinking assumes “a relatively well structured problem in which there is virtual agreement on what constitutes the problem: it remains to organize how to deal with it”. This way of thinking has been persistent in the sector because of the dominance of engineers, who

in their educational background are very well equipped to think systematically and to focus on problem solving, and the virtual absence of users in decision making. However, the poor performance of many water supply systems shows that the problems are much more complex and require a soft-system orientation, questioning the problem in its overall context and leaving room for different interpretations. In practice, a multiplicity of views will emerge on both the problem and its potential solutions, suggesting that absolute truth does not exist (Engel, 1995). We deal with different interpretations of reality that are products of the experience, knowledge and views of participants.

- **Establishing an interdisciplinary and inter-institutional learning environment**
  Development problems are of such magnitude that they cannot be resolved from the perspective of a single discipline or a single institution (Max-Neef, 1987). The approach taken therefore was to try to break the barriers and create a space where the different disciplines and the community could meet, review developments and contribute their experience. This permitted actors to jointly explore the causes of problems, identify solutions and establish commitment about their implementation.
- **Ensuring good process facilitation**
  In view of the complexity of the problems and the differences in the background of the actors, facilitation played a crucial role. Taking the view of Freire (1970), that it is necessary to challenge the participants (from the community and the institutions) to use their creativity to identify problems and possible solutions and to take decisions accordingly, a learning environment was created in which participants could question and confront their viewpoints and perceptions. This needed good facilitation, helping the participants to gain self-esteem and autonomy and empowering them to challenge the existing situation and model it to suit their own objectives. Training of the CINARA core team therefore went beyond technical and socio-economical aspects. Preparation included working with participatory techniques and with a psychologist to help the team members to find their own stand in the project. Even after the preparation, the facilitation process was rather new for the core team and even more so for the members of the IRWGs, who had little or no experience with participatory techniques other than the training session in Cali. It is not enough to learn new methodologies – new ‘tricks’. What really counts is the need to adopt a learning attitude, and learn how to establish an environment of respect for conflicting views, even to the extent that they go against your own personal opinion.
- **Stimulating women’s involvement**
  TRANSCOL came about before full development of the gender approach that is now being promoted in the sector (see Wijk, 2001), but it did make special efforts to stimulate involvement of women through house visits and by organizing meetings at times and places that did not interfere with their daily work. Other forms of communication such as painting, music, theatre, modelling and poetry were used to bring participants closer together and stimulate sharing of experience. This also helped the less vocal participants (the unheard voices of often poor men and women) to gain self-confidence and ‘voice’ opinions, sentiments, preferences, objections and ideas in public.

7.3 Actors and the project network

The project involved a large number of actors operating in what can be viewed as different interacting and nested platforms for decision making (Figure 16). In view of the complexity of TRANSCOL this involved what Jiggins (2002 p.1) presents as “shared learning across political and administrative hierarchies, resource management jurisdictions, and divergent disciplines and domains of experience” for which ‘social spaces for learning’ need to be created. I will argue, on the basis of findings from TRANSCOL, that in the water sector we need to use different levels of platforms to create the ‘social places for learning’ that help stakeholders to operate with four logics: (a) the logic of the ecosystem, both in terms of catchment management and the management of the biological processes in the treatment and distribution system; (b) the logic of the social process by which human activities relate to cubic metres of purified water; (c) the logic involved in the water technology, including aspects such as flows through pipes, filtration rates, etc.; and (d) the logic of the organizational dimension.

CINARA with its team of multi-disciplinary advisors and IRC staff can be considered the **first level platform** having decision-making authority over the part of the project that was financed by the Netherlands government. They worked in collaboration with national institutions that co-financed the learning projects to test the approaches and strategies.

The IRWGs formed the **second level platforms** consisting of staff of different institutions involved in the water supply sector in the eight regions. Decisions at this level often needed the approval of political or institutional levels in the region, which were not directly involved in the IRWG. This was one of the reasons for initiating the project in each region at a meeting with the governor and his staff to inform him/her and get his/her support. Technical staff and, unfortunately, considerably fewer social scientists, as they are a minority group in the sector institutions, became involved in these IRWGs, albeit on a voluntary and part-time basis, with approval from their bosses.

The **third level platforms** were formed at the community level in each of the participating communities. First contacts were always established with the local formal and informal leaders. This was followed by a community meeting to inform as many community members as possible about the project. Dialogue and interaction between agency staff and communities was stimulated through participatory tools and techniques that helped people to gain insight into their own situation. Horizontal working relations were aimed at, respecting different opinions and stressing that everybody has contributions to make.

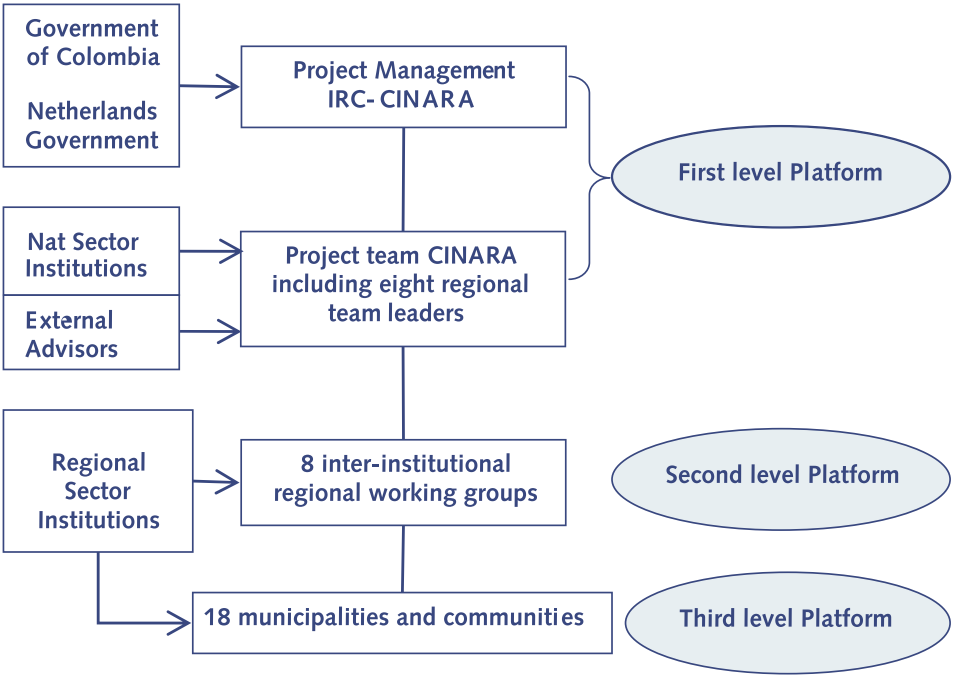

Figure 16. Organizational chart of TRANSCOL with its platforms

7.4 The experience with implementing TRANSCOL

In this section I will expand on some of the stages indicated in Box 5 and will include the longer-term effects of the implementation process.

Selection of regions

A number of key issues were taken into account when selecting the regions:

- Eight regions were chosen because the Ministry of Health had grouped Colombia's 32 regions in eight different zones. Preference was given to regions with a considerable number of existing piped gravity water supply schemes that get water from surface sources. This was done because introducing any type of water treatment in non-gravity supply systems is more costly, as it usually involves double water pumping.
- Existing interest in water quality improvement in the regional sector agencies as well as potential funding to take it forward.
- Availability of partners who covered all aspects of water supply development including: legislation, planning and design, construction, operation and maintenance, training and water surveillance.
- Spreading the project locations over the country so as to obtain a broader impact.

Introductory seminar in each region

The first step in each region was very new to the team. It concerned getting support from political leaders and the management of sector institutions. Although decentralization of the sector had been initiated, the role of the institutions was still quite strong and they held the key to resources in terms of funding and staff. The team had to 'sell' the idea of MSF and to reach agreements with these institutions about making available staff and resources. Fortunately the evidence of the excellent performance of some full scale MSF systems that were developed in Cali (Box 6) was sufficient to overcome the sceptical views of some of the technical staff with a strong bias towards RSF.

After obtaining support from the governor and the management of key sector organizations, the introductory seminar could be held. Participation in these seminars was good. It varied between 35 and 60 persons in the different regions, showing the interest of sector institutions.

The development and functioning of the IRWGs

In the regional seminar, the establishment of the IRWG was announced and 'volunteers' were invited to register. The response was positive and the eight IRWGs started with a total of 161 staff members from 86 institutions who, often to their surprise, found that part of their work was overlapping. Seven years later, there were still 43 staff from 34

Box 6. Important examples of MSF systems that made a difference

Two water supply systems within 30 minutes drive from CINARA have been (and still are) very supportive of the introduction of MSF systems in Colombia and elsewhere.

The MSF system in el Retiro. This system replaced an existing chemical water treatment plant, and provides water to a better-off neighbourhood and to a number of private schools. It has shown that the technology can outperform chemical treatment and is used by 'educated' people who can easily afford to get the best solution to their water problem. Visitors to this system, which is in very good shape, get a good explanation by the operators of how the system operates, and easily come to the conclusion that if these 'rich' people choose MSF, it must be good.

The MSF system in la Sirena, a low-income settlement at the border of Cali. Initially it was built as a SSF system, but later was transformed into a MSF system. This system, which is managed by a water committee, is in good shape and performs well. Visitors to the system, which has a beautiful architecture designed with an eye for detail, feel that it is a good system that is in the capable hands of a local operator and is very much 'owned' by the community. The case of this community was chosen as one of the best practices in latin America in the Second Habitat Forum in 1996.

institutions involved in the IRWGs. Reasons for the gradual reduction in participation over the years include people being interested only in the initial part of the work (planning and design), but also staff changes and changes in the sector that created uncertainty and unstable jobs. With the projects already in an advanced stage, it proved difficult to involve newcomers.

In most of the IRWGs, personal commitment and enthusiasm for the approach were perhaps the main reasons for many members to continue their participation. But this in itself was not always sufficient if their institutions did not place MSF high on their priority list. An important lesson is that this type of project has to establish institutional commitment from the very beginning and formalize the expected inputs and results in an agreement with the organizations involved. This is easier said than done because ‘political’ interests often hinder institutional collaboration.

Discussing possible locations for the projects in the IRWGs proved interesting, as it showed that the members had both complementary and conflicting information in the data bases of their organizations. This was even clearer in a later project for the rural area of Cali, where a great deal of overlap appeared in information available in the different institutions, while none of the data bases proved to be accurate and complete.

Training of IRWGs involved formal workshops, in which several participatory techniques were used, and field visits during which participants acquired access to existing experience with the technologies. These workshops also emphasized the inter-disciplinary nature of the work. Box 7 shows that the interaction among participants with different backgrounds is complex and requires time and effort.
It was intriguing to find in 2005 that many of the CINARA staff and ex-members from

Box 7. Stimulating multi-disciplinary thinking

Participants in one of the training workshops were asked to plan different stages of a water supply project. They were provided with cards that presented key activities in a project including issues such as contacting leaders, making the design, discussing tariffs, collecting water quality data, etc. They were also allowed to add cards if they felt that key activities were missing. Initially small mono-disciplinary groups (3 to 4 people) were formed to sort the cards. Almost always, these groups agreed rather quickly about the sequence of activities, sometimes adding or removing one or two cards. The next step was to form multi-disciplinary teams (6 to 8 people), by merging one group that included social scientists with another with a technical background, asking them to share their previous ideas about the desired approach and jointly agree on one approach to be taken. These groups were then left to themselves. Usually it took well over an hour to reach agreement and often full agreement was not reached, showing that bringing different perception together from different disciplines is complex and requires time and good facilitation.

the IRWGs alike, indicated that TRANSCOL was their 'life experience', and that it helped them to better understand and value the interdisciplinary nature of the work and to appreciate the communities and value their experience (Box 8). They all indicated that the most important gain was in their own professional life. Since the project, several have been involved in the design and implementation of other MSF systems, but, except for CINARA staff, far less in in-depth work with communities.

The downside of this enriching experience was that the envisaged continuation of the IRWGs has not happened. This was considered unfortunate by several ex-IRWG members, who indicated that: "they never had such a satisfactory inter-institutional collaboration since then. It led to changes in attitude at institutional level at that time but this did not continue" (Field notes Perez, 2005). One reason for the disappearance of the IRWGs was that the role of CINARA as facilitator and engine in the process was not taken over by a regional organization, although some universities tried, but did not have the financial resources. Perhaps the main complicating factor however was that the roles of the institutions changed dramatically as a result of the decentralization process. Most activities are now dealt with at municipal level and no longer at regional level.

Box 8. Quotes about TRANSCOL from CINARA and IRWG staff in 2005

- It was my real "learning school" that gave me a good working methodology.
- We really learned to look at issues with an open eye. Working with different institutions makes you see that they all look at things with different eyes.
- The approach really helped the community and agencies to work together but is was hard work to make it happen.
- With the type of technical training engineers receive in Colombia, this type of project that allows you to construct a world can turn you crazy.
- Ultimately this project was about social change and that may not be convenient for many people.
- I do not have much illusion about changes in institutions but yes in the introduction of changes in some people in these institutions.
- People saw our dedication and saw that we believed in what we did and that it came from the heart.
- It was a very enriching experience, but the continuity was not very good as many people from the agencies changed position after the programme.
- Our participatory methodology made people feel respected, that they were able to contribute. They really appreciated that agreements were kept and no false promises were made.

Developing the projects with the partners

A very comprehensive process was used to develop and implement the projects (Box 5) which I will describe here. In chapter 8, I will come back to this process and its potential for replication.

The process started with the identification of potential project locations with the IRWGs. A long list was established on the basis of data provided by the IRWG members. This was reduced to ten possible locations that adhered to the key criteria mentioned in Box 5 (easy access, existing water supply system, water problem solvable with MSF, institutional support, willingness to participate and quick implementation). Subsequently, each of these locations was visited for discussions with the community and to review the local situation. Visits always started with the local leaders and/or the water committee, and several of them, together with the operator and other community members, accompanied the visiting team led by two staff members of CINARA during the day. Results were discussed with the local leaders and the water committee at the end of the day.

The two most promising locations were selected as potential project sites. After a two-day training, a team comprising several members of the IRWG and two CINARA staff members, implemented a three-day participatory assessment of each of the selected communities. These visits started with the community leaders and ended with a community workshop to present the TRANSCOL project, share the findings from the visit and explain the next steps. Different techniques were used during the assessment, including:

- Participatory mapping of the water supply system and the catchment area, to obtain a shared understanding of the situation, posing questions such as: where are pressure problems? where do poorer sections of the community live? etc. This proved to be a very good tool to visualize the situation and the problems in an understandable way. In retrospect, however, an important limitation was that the mapping did not sufficiently cater for potential conflicts between different water users or other claims on the catchment area;
- Sanitary inspection of the system and the catchment area, to obtain insight into the potential ‘water quality and quantity risks’ that needed to be overcome. The inspection did not include discussions over water rights, as the water supply systems already existed and therefore it could be assumed that rights were established;
- Transect walk to get a good impression of the community. This included also some household visits to gain more insight into the interest of the community and the actual performance of the water supply system. In several communities, video registration was used and proved very powerful to initiate discussion in a community meeting held in the evening;
- VENN diagram to explore the different organizations that were involved in the water supply system and were supporting the community.

The assessment visit and some further technical fact finding about the topography, the soil characteristics and the availability of local materials provided the required information to undertake a preliminary design and propose an implementation plan. This was done by staff from the IRWGs during a two-week training workshop in Cali.

Thereafter, the workshop participants returned to their regions, where, together with CINARA staff, they initiated activities in the communities. The work began with a creative workshop (Box 9) in which community members, both men and women, reflected on the potential health benefits of water quality improvement, and reviewed and approved the treatment plant design and the socio-educative plan. They also discussed the costs and the implications of the water tariff needed to sustain the system. A scale model was used to explain the functioning of the MSF.

In San Felipe, Ms. Ramos was a member of the water committee during TRANSCOL. She is positive about staff from CINARA, "who really taught us how to take care of the system". She remembered a very nice workshop where they had to paint the system and talk about its history. "At that time we were all working together but now perhaps because of the economic situation this is less. Perhaps some 20 percent really cares" (Field notes Perez, 2005).

During project implementation, training and 'learning' continued through a number of activities, including:

- Community workshops on different themes (catchment protection, efficient water use, hygiene promotion);
- Workshops with the water committee on leadership, legislation, decision making, communication, financial administration, relationship with users, key aspects of a water supply system and MSF;
- Training sessions with the operators (daily routine MSF, less regular activities, emergencies and trouble shooting, water quality control and monitoring).

Another important activity in the communities was the development of posters (wall journals) to inform the community about the project, its progress and agreements. All activities were organized in such a way that they called upon the creative capacity of participants and stimulated them to take the lead in their own development, matching the suggestion of Nyerere (1973) who indicated that: "It is not possible to develop a community, they have to develop themselves. It is possible for a stranger to build the house of a man, but not to give him the pride, confidence and self-esteem as a human being. These are virtues man has to develop his own action. Man develops by what he does, by taking decisions, by enhancing his understanding of what he does and why; by increasing his own knowledge and ability and by participating fully in his community as one among equals."

Nyerere's comment however does not seem to take sufficiently into account the complexity of the local situation and the positive role an external agent can play. When asked about the project in 2005, many community members had forgotten details and

Box 9. The creative workshop as a learning environment

The creative workshop provides opportunities to enhance self-esteem. A considerable number of persons (say up to 50) can participate in this type of workshop that helps to strengthen their cultural identity, give room forcreativity and stimulate integration. The topics that are addressed may be different from workshop to workshop, but the approach is generally similar.

Each workshop starts with a session of getting to know each other, using techniques of group dynamics, followed by a creative way of seeking the views of the participants on the theme at hand, through theatre play, painting, music, modelling or poetry. These views are further consolidated by a discussion guided by the facilitator. The workshop always concludes with proposed action points and nomination of a person responsible to see they are put into practice.

Art is used in the workshop to enhance the perception and sensitivity of the participants – faculties often dormant or undervalued in modern society. These faculties (vision, sound, feeling, taste) provide the basis for change of behaviour, which is often required in projects related to water supply, sanitation and protection of the environment. It is just not enough to provide information, people need to become sensitive to the need to do things better. This also provided a sound basis for the intercultural dialogue that is often needed in technolgy transfer processes.

said that ten years was a very long time to remember. Yet they came up with interesting statements (Box 10) and all confirmed that CINARA's role was fundamental. "Their willingness to work at times convenient to the community, their charisma, their drive but also their patience and tolerance, because the sensitive issue of water meters for example, creates tension and leads to insults" (Field notes Perez, 2005).

TRANSCOL contributed to community members gaining self confidence and learning new things, sometimes at great personal risk. "In Triana and Zaragosa, some two years ago, the leaders that had developed skills in the context of TRANSCOL were killed by an external group that occupied the communities and considered them to be socialists. One of the victims was a man who was very proud that he had learned to read designs, which helped him to direct the construction activities of the plant. Nevertheless when we came back to the villages some time ago we found that the plant was working. This holds an important lesson. We can see that after people have truly identified with the system and are dedicated to it, this does not drop easily. The people really do not want to lose the positive results" (Field notes Visscher, 2005).

It turns out that communities faced difficulties in continuing to use what they learned in TRANSCOL. Without the help of CINARA as a "process facilitator" they did not manage, for example, to fight political interference. In Paispamba, the community

Box 10. Some comments from community members in 2005

- If it wasn't for CINARA we probably would not have had the MSF plant; many people thought we never died from the water we use now, so why treat it.
- The community is satisfied because earlier even worms came out of the taps when it rained.
- It was because of CINARA that the people decided to support the project.
- I learned from CINARA that if you are organized you can achieve a lot.
- I remember the workshops to convince people that the water needed treatment. Many people came; the techniques CINARA used were very nice, but some people also got fed up with too many workshops.
- Once a year we invite all users to visit the plant, but only some come.
- The CINARA team was very helpful and had a lot of human qualities.
- For me MSF was very new and it impressed me. We saw contaminated water coming from the source and after passing the filters it had no contamination.
- For political reasons new persons are put on the job and they don't even send them to a course.
- Participation in this process strengthened me. It was also nice to have events with people from other communities.

wanted to proceed with the CINARA approach in a new project, but the new municipal government did not accept this. Instead, it used the 'conventional approach' in which construction is often carried out by "befriended" contractors, resulting in less transparent decision making and limited community involvement. An aspect that influences the return to 'old methods' is that only part of the community has acquired experience, and only during a relatively short period. Some of the community members thereafter became side tracked because of local politics; others moved and several passed away after the project ended ten years ago. Therefore, too little experience remains in the community to sustain a more participatory approach, without clear external institutional support to facilitate this type of process (Field notes Perez, 2005).

A similar case of political interference happened recently, when the Municipal Health Authority implemented a number of compact RSF plants in black communities around Cali. This was done despite considerable community protest which, strikingly, never made it to the newspaper. It can be expected that these RSF plants will face operational problems and will be difficult to sustain. This example makes it clear that, at the institutional level, people who hold powerful positions may not like the community to learn, because when people know what they are talking about, they may try to get their way and ask for transparency in decision making (Field notes Visscher, 2005). This example also shows again that facilitation of change is needed equally at the political and institutional level, if sustainability is to be secured.

Development of the MSF plants

Financing, tendering and construction started with the verification of available resources in the communities and agencies, and of the levels of credit required. Tender documents were made by the IRWGs and tender procedures implemented through the municipalities. Contracts were made between the municipalities and construction companies. Construction was organized in consultation with the community and included their participation in an official civilian monitoring committee. In Colombia, this type of committee is obligatory for construction works that are partly financed with public funds. This positive obligation has a lot of potential, but in the absence of adequate training and support to reduce political interference, the effect is small. Those who are against this interference are at some risk or can become "persona non grata" particularly in rural areas where the situation can be very difficult.

The team therefore decided to train committee members to be able to monitor construction, and to inform the community about the long-term advantage of having a good quality system. Ms. Ramos from San Felipe remembers this training. She indicated that she was very alert when things were needed from the municipality and that she followed the construction carefully to take care of 'what is ours' (Field notes Perez, 2005).

Establishment of the monitoring committee was also discussed with the contractor, to create understanding of the importance, to avoid conflicts and to reduce political interference. In this discussion, it was stressed that better quality construction would extend the life of the system and would be a good recommendation for future work for the contractor. In this way, the mindset was directed to long-term opportunities instead of quick gains by, for example, reducing the quantity of cement.

Both water committees and operators were already in place in the communities, but they had little experience because the existing systems did not include treatment. Training of water committee members and the operator started during construction. The operator and the water committee were accompanied in the process to initiate plant operation. This included testing water-tightness of the tanks before putting in the sand and gravel, putting the units into operation and gradually increasing the flow velocity as maturation of the biological layers proceeded. A monitoring schedule was prepared to check some key performance indicators such as flow velocity, head loss and turbidity. This schedule indicated what action to take when parameters were outside their normal operating range.

An important advantage in this stage was that CINARA together with IRC was implementing the parallel research project on pre-treatment. Interaction between this project and TRANSCOL led to improvement of the MSF systems (Box 11).

Dissemination

Project results were disseminated in different ways. Experience was presented by CINARA and IRWG members and community representatives in a national seminar aimed particularly at the political and management level involved in the sector in Colombia. Project results were also spread by CINARA and IRWG members through university programmes. However, with exception of the postgraduate programme in UNIVALLE, the focus in the universities was on the technical aspects of MSF.

Other mechanisms to share results included visits to MSF sites in Cali (Box 6) and in the TRANSCOL regions, advisory services by CINARA staff and some of the members of the IRWGs in Colombia, and CINARA's participation in international advisory missions to Bolivia, Ecuador, Mexico, Nicaragua and Pakistan. Also, a number of publications were prepared in English and Spanish and widely disseminated.

7.5 Project funding

TRANSCOL received a total of NLF 4,655,155 (USD 2.9 million as at December 1995) from the Netherlands government. The national, regional and local contribution amounted to USD 3.2 million, including an investment in infrastructure of COP 2 billion

Box 11. The Pre-treatment project

This research project included:

- Comparative studies of different pre-treatment systems based on gravel filtration, which resulted in the development of MSF (Section 3.7);
- Cost comparisions of different MSF options;
- Development of tools and didactic material.

The interaction between the research team in this project and the full-scale implementation in TRANSCOL proved very useful to obtained feedback from the field. For example, the newly developed drainage system using corrugated PVC pipes (as explained in section 5.6) proved an important innovation that considerably facilitated cleaning of the gravel filters. Other aspects concerned the application of locally made valves and measuring tools that were jointly developed by practitioners and researchers.

The operation and monitoring of the MSF systems in the treatment station and the full-scale plants helped to develop training materials and eventually led to the idea of peer training (operators training operators). Without this parallel project, the effect of TRANSCOL, would have been considerably less and the MSF technology would not have been tested under extreme conditions. For the conditions in Colombia that were analyzed in the project, the combination of DyGF and UGF proved to be the best pre-treatment alternative prior to SSF (Galvis et al., 1998).

(USD 2 million) and another COP 1.2 billion (USD 1.2 million) in salaries, logistic support, travel and subsistence. This contribution came from different sources. The Ministry of Health agreed with CINARA to co-finance the programme and FINDETER[14] made credit available for the municipalities involved. The municipalities also made resources available that together with the inputs from community members, provided 34 percent of the construction cost. The key to this considerable contribution was a combination of interest from communities and authorities, continuous fund-raising support by CINARA and the regional teams, and a flexible programme approach that made it possible to adjust to changes in the sector. The distribution of the total programme expenditures is presented in Figure 17.

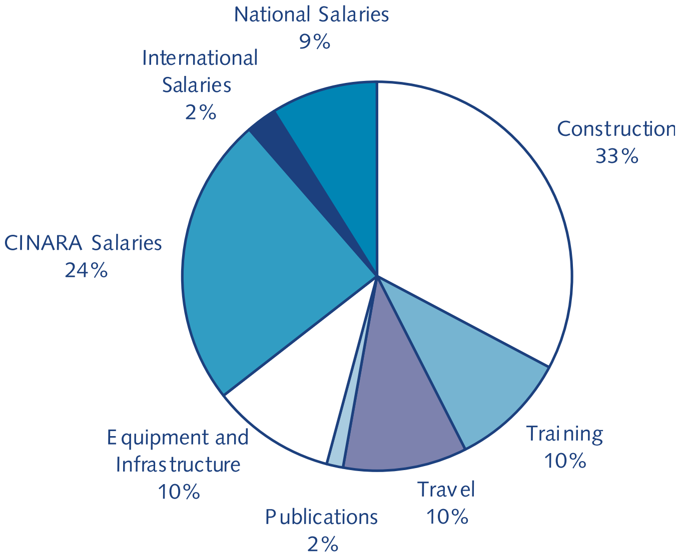

Figure 17. Distribution of project expenditures (US$ 6,121,000)

7.6 Project results

The project results summarized here are based on the final project report (CINARA-IRC, 1997), and take into account the views of the external evaluation of 1998 and the review made in 2005 when revisiting some communities. Results include both tangible and less tangible issues. The immediate tangible results include:

- Seventeen functioning MSF water supply systems in eight regions in Colombia, run by operators from the community trained by CINARA and members of the IRWG. These systems serve communities with between 200 and 3500 people;
- Advisory capacity established in CINARA and in members of the IRWGs in eight regions on the integration of MSF in water supply projects using a participatory

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[14] La Financiera de Desarrollo Territorial SA which provides credit facilities to municipalities in Colombia.

approach. This capacity supported the further implementation of MSF systems in Colombia (Table 16) and through CINARA also in Bolivia, Ecuador, Mexico and Honduras;
- Didactic material on MSF and participatory project implementation including formal publications, training manuals, videos and posters;
- Trained trainers, particularly in CINARA and to a lesser extent in the IRWGs;
- Sixteen operators trained to manage their MSF system;
- Some 600 staff members of different institutions, including 30 percent women, learned about the technology and the methodology;
- Over 1500 persons from the participating communities learned about MSF and their water supply.

The project also led to less tangible results, which include:
- An interest in inter-institutional collaboration, as it turned out that part of the work of the institutions was complementary, and some was overlapping. Unfortunately this collaboration was not sustained after the project ended.
- Establishment of a space for a different type of engineering, bringing a human-centred approach to development projects and technology transfer. Through CINARA and several of the IRWG members, these new concepts continued to be promoted through new projects (section 7.6) and post-graduate training at UNIVALLE with support from IHE[15].
- Increased attention to women's involvement, by, among other things, generating gender-specific data that showed that, on average, women accounted for 52 percent of the community members involved in planning and design (range 40 to 80 percent), 32 percent of those involved in construction (range 20 to 50 percent) and 40 percent of those concerned with operation, maintenance and management (range 10 to 60 percent) (CINARA-IRC, 1996b).
- Interaction between the research team of the pre-treatment project and the TRANSCOL team, which ensured that feedback was obtained from the field and new ideas could be introduced in the MSF systems.

The project contributed much to the development of CINARA as a centre in the university working on research, development and training (Box 12). Its development work makes it different from other sections in the university that are dealing with research and teaching more conventionally. The orientation towards development implies that it embraces a more people-centred approach to science, clearly emphasizing that the university needs to recognize communities as being responsible for their own development, which can benefit from the support of the university, as well as making a contribution to it. The project helped CINARA to strengthen its contacts with sector institutions at local, regional, national and international level. Several of these institutions for example contributed to the development of CINARA's research station in Puerto Mallarino.

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[15] Institute for Hydraulic and Environmental Engineering which now has become the UNESCO-IHE Institute for Water Education

Table 16. Short and long-term results in terms of number of MSF systems

Region	TRANSCOL	New systems, review 1996		MSF systems, review 2005[c]
		Construction[b]	Projected	
Boyaca	2	7	n.i.	> 40 (Not visited)[f]
Cauca	2	4	3	> 25[g]
Cordoba	2	7	n.i.	> 10 (Not visited)[f]
Costa Pacifica	2	2[d]	0	> 4 (Not visited)[f]
Nariño	2	4	3	> 6
Norte de Santander	2	3	7	> 3 (Not visited)[h]
Valle	0[a]	>10	n.i.	> 40
Quindio	2	3	n.i.	> 6
Tolima	3	3	20[e]	>7

a) Several MSF systems were constructed in Valle del Cauca with support from CINARA prior to TRANSCOL and served as a basis for technology transfer

b) Constructed or under construction according to the participants in the review workshop in March 1996 (CINARA-IRC, 1996b)

c) According to people interviewed in visits to five regions; systematic data are not available as a result of decentralization. The other four regions could not be visited for lack of resources

d) MSF has low potential in this region because of topography and economic conditions

e) Projected in theory as no financial resources were available

f) Information for regions that were not visited was collected by telephone interviews. It turned out that no clear registers were available, so figures are approximate

g) Part of these were built with CINARA support in a Regional Health Services project

h) Telephone communication with the health service indicated that preference is given to RSF by municipalities, but over 90 percent of the RSF have severe performance problems

n.i. No information

7.7 Reviewing MSF performance after ten years

In 2005, some ten years after TRANSCOL ended, the opportunity arose for me to revisit part of the project regions, working together with Mr. Andres Perez, a Colombian social scientist. Part of the information obtained in this revisit, which included interviews with staff from CINARA and visits to four regions to meet with persons involved in the IRWGs, community members and operators, has already been presented earlier in this chapter. Here I will discuss a few more findings, particularly in relation to performance of the systems.

MSF systems are working but can perform better

In 1996, it was concluded that the MSF systems built under TRANSCOL were operating and delivering water that for most of the time met WHO water quality guidelines. A similar picture arises from information collected in 2005 about seven of the 17 TRANSCOL systems. Six were operating reasonably well but with limitations (Table 17). The seventh, in Yaquanquer, is special, as it was by-passed (replaced by a direct

Box 12. CINARA grew and became an important support for the sector

CINARA was formally established as a foundation to be able to implement the TRANSCOL and pre-treatment projects. Its full-time programme staff increased from 15 to 47 between 1989 and 1996. During this period, five were nominated as teachers at the Valle University, in addition to the two that already had this position. The staff included sanitary engineers, architects, sociologists, social workers, psychologists, communication specialists, a historian, an economist, a chemist and a biologist. The size of the team continued at this level for another five years as CINARA continued to be involved in several large projects as well as in the post-graduate training with IHE. Because of the changing situation in Colombia, less donor support became available. Initially CINARA was able to substitute this loss of programmatic funding by income from national projects and advisory services in other countries in the region, but because of the lack of core-funding, for example, from sector institutions and limited interest in research in the sector, it was forced to reduce its programme staff to 28, including six teachers paid by the university. The team also counts on 12 support staff and 12 university students who assist on a part-time basis in different projects. Despite its smaller size, CINARA continues its important role as a support centre for the sector in Colombia and Latin America.

connection supplying untreated water) shortly after TRANSCOL ended. This was the result of a higher water demand than the MSF could treat, due to a very high water consumption, which, despite efforts of the IRWG, the community did not change at that time. However, the municipality is now making a big effort to put the MSF into operation again. It has completely renovated the plant and already replaced 2 km of the 6 km, 45-year-old distribution network of asbestos cement pipes, but financial resources are lacking for the rest. An engineer of the municipality wants to put the MSF back into operation after water meters are installed – a proposal still under debate in the community.

Unfortunately, no long-term water monitoring data are available, but, according to the operators, the visited systems produce water that is clear in appearance, which implies that it is low in turbidity. This also means that faecal coliforms are partially removed, but to what extent cannot be established without water quality testing. Spot samples in one of the plants, taken in January and March, were promising, with turbidity levels of 0.3 NTU and zero faecal coliforms in three samples. The fourth sample had 134 FCU/100ml, possibly as a result of recent cleaning, but clearly showing the need for safety chlorination, although this is often not guaranteed. In Suarez in Tolima, for example, the MSF is functioning, but the disinfection system is not, despite discussions about this between staff from the Regional Health Service and the municipality (Field note Perez, 2005).

Table 17. Overall performance of seven of the 17 MSF systems of TRANSCOL

Positive aspects	Negative aspects
Six out of seven were functioning; one was in process of being overhauled	Management of the systems is not sufficient, and does not receive adequate support
Overall structures were robust	Small cracks in concrete and leaking pipes show insufficient maintenance of structures
Water is produced that is low in turbidity	Bacteriological quality is improved but not always safe
Operators are available	Operators are often untrained and do not understand the biological nature of MSF
Operators, committed to their job, are putting in considerable efforts	Operators have “invented” inadequate maintenance procedures that over time reduce system performance
Control of water consumption has improved	Several systems still operate at too high a flow rate which is not measured due to defunct meters

Although virtually no water quality data exist for the MSF systems built in TRANSCOL, long-term data are available for MSF systems built in the same period in Valle region, which have been monitored by CINARA (Table 18). These data show that the MSF systems were able to deal with water qualities with average turbidity levels between 3 and 24 NTU, and peak loads between 15 and 300 NTU. Faecal coliform removal is impressive, confirming the potential of MSF to reduce the risk of transmission of waterborne disease. Good removal of colour is also obtained, reducing average colour levels between 5 and 30 TCU with peak values up to 200 TCU, to average levels that ranged between 3 and 4 TCU with peaks up to 30 TCU.

All systems produced water with a turbidity level below 1 NTU, with a frequency between 65 and 98 percent, and below 5 NTU in more than 98 percent of the samples. Faecal coliform counts were below 25 FCU/100 ml, with a frequency above 97 percent, and true colour below 15 TCU in more than 98 percent of the samples. With these water qualities, constant dose disinfection with chlorine, as suggested by WHO (1996), effectively becomes a safety barrier (Galvis and Visscher, 1998; Galvis, 1999). These data are very good, but in fact may not be fully representative for the TRANSCOL systems. The bi-monthly testing that was done by the CINARA team may have had a positive influence on results. During sampling, CINARA staff talked to the operators, reported their findings to the water committees and, if needed, provided advice on possible adjustments in operation and maintenance procedures. This attention may have influenced the performance and perhaps is also an important reason why the systems that were monitored look better and cleaner than the systems of TRANSCOL that were visited.

Table 18. Performance of different MSF systems in Valle region (1990 – 1998)

Name	l/s[1]	Turbidity (NTU)[2]		Faecal coliform Counts / 100ml[2]	
		In	Out	In	Out
El Retiro	15.1	14 (180)	0.6 (2.7)	5847 (69,500)	0.5 (8)
Cañasgordas	8.9	12.1 (75)	0.8 (4.1)	7000 (223,000)	1.5 (23)
La Rivera	3.8	5.9 (51)	0.6 (4.3)	3600 (23,100)	0.5 (28)
Javeriana	1.8	24.2 (300)	0.9 (12)	14,935 (204,000)	0.8 (25)
Shaloom	1	3.8 (22)	0.8 (2.9)	2895 (14,200)	4.3 (46)
Colombo	0.6	14.6 (122)	0.6 (6)	51,900 (677,000)	0.9 (82)
La Marina	7	6 (112)	1.1 (6.2)	803 (35,700)	1.8 (28)
Ceylan	9.4	2.8 (15)	0.4 (5.8)	330 (1920)	0.9 (12)
Restrepo	0.8	7.5 (55)	0.6 (2.8)	831 (15100)	0.7 (23)

1. Plant capacity in l/s (1 l/s provides 350 people with 250 litres per day)
2. Figures are given as mean value, with maximum value between brackets

Another strong argument that MSF is a good technology comes in data from the research station in Puerto Mallarino. These data show that properly maintained MSF systems can produce good results even from water that is of very poor quality in terms of turbidity and faecal coliform counts. This station (Figure 18) receives water from the Cauca River that shows considerable variations in quality between the dry and wet seasons. Over a research period of seven years, the registered turbidity level ranged from 15 to 1,880 NTU, true colour ranged from 24 to 344 TCU, and faecal coliform counts ranged from 7,300 to 396,000 FCU/100 ml. Even under these harsh conditions, the MSF units were able to produce water low in sanitary risk. The effluent value was below 1 NTU in 46 percent of the samples and reached a maximum of 5.5 NTU. Faecal coliform counts were below 25 FCU/100ml for 95 percent of the samples and the colour was below 15 TCU in 96 percent of the samples (Galvis and Visscher, 1998). This very good performance shows the power of pre-treatment, which, as indicated in chapter 5, was under-rated in the earlier SSF project.

Despite the good performance it is important to stress that MSF is not a panacea for all water treatment problems. Participants in the 1996 review workshop indicated that in one TRANSCOL plant colour removal was not always sufficient. A similar comment was received in one of the interviews in Tolima, where the engineer involved in TRANSCOL said that in a new project in Boima they pushed for MSF but, in retrospect, this was not the proper system because of the high colour of the water. Another comment in 1996 was that for the flat part of the Pacific Coast, rainwater harvesting is much more attractive than trying to treat surface water from polluted rivers which would require double pumping and therefore would be very costly.

Figure 18. The research station of CINARA in Puerto Mallarino, Cali

Operation and maintenance practices are a constraint

As shown in table 17, operation and maintenance is carried out on the systems visited, but not in a proper way and overall care for the systems is limited. Operators seem dedicated to their jobs, but lack training, supervision and advisory support. Several are new on the job and, at best, have learned the task from their predecessor. They have adjusted their operational procedures in a way that seems easier to them, but actually hampers the proper performance of the systems, causing them more work. In general, cleaning frequency is much higher than may be expected for the water quality the systems are treating. It should be about once every three months, whereas we found that in one case it was done every few days, probably because of the wrong cleaning procedure applied (Box 13).

Some have received well meant, but inadequate, advice from visiting engineers from, for example, the Health Service or the Coffee Growers Committee, with limited experience of MSF. This included the suggestion in el Convenio to interrupt the system one day per week for cleaning. This is acceptable to the community, as they know about it and take precautions. But this interruption is interfering with the treatment process and thus the water quality. Another example is that the engineer who accompanied the review visit to Paispamba indicated that it was essential to disinfect the sand before it is put in the filters. This is certainly not needed and is another indication that the biological character of MSF is not sufficiently appreciated.

Despite these limitations, it was instructive to see that the systems were still performing, even without adequate back-up support. This is quite different from the abandoned SSF systems from the past, such as those reported by Hespanol (1969) in Brazil. The 2005 visits confirm the finding of a review mission in 1998 that indicated that the effectiveness of MSF is good under the prevailing conditions of gravity supply and average turbidity levels below 40NTU (Samper and van Schaik, 1998).

However, the problems that do exist hamper the good performance of the systems and need to be remedied. Only some of these problems, such as poorly trained operators and lack of perception of the ecology involved, are directly related to the MSF system. Many others, as also indicated by Samper and van Schaik (1998), relate to more general problems, such as leakage from old distribution systems, high water use, and inadequate control of the catchment area. In San Felipe, for example, a sand road was illegally constructed in the catchment area (with support from the mayor). It causes a considerable increase in turbidity of the water reaching the MSF when it rains.

What comes out very clearly is the need for a comprehensive approach that really explores the overall problems and aims at establishing long-term solutions that go beyond water treatment by MSF.

Box 13. Variations on maintenance practice invented by untrained operators

In Puerto Alejandria the operator decided to clean the DyGF thoroughly. He took out all the gravel, washed it and placed it back, but instead of keeping the layers separated with a fine layer of gravel on top, as in the design specifications, he mixed the gravel. This effectively stopped the filter from performing its key function as an automatic switch-off valve, in the case of a turbidity peak.

The same operator, as well as several of his colleagues, revised the scraping procedure for the SSF, by immediately replacing sand on top of the filter after each scraping with washed sand from the previous scraping, instead of continuing the scrapings until the lowest acceptable depth of the sand bed and then re-sanding the filter (say every three to four years). Although this needs further review, it may be assumed that impurities will build up deeper in the filter, adding to the resistance of the filter and causing shorter filter runs (less time between scrapings). Much shorter filter runs are indeed being experienced and add considerably to the workload of the operator.

In Paispamba the new operator was not present at the time of the visit, but a contractor was working at the plant and the former operator pointed out that the contractor, who was doing the re-sanding of the SSF, did not properly wash the sand. He used the bottle test, putting washed sand with clean water in a bottle, shaking it vigorously and letting it rest. A thin layer of sediments was formed on top of the sand which showed that washing needed to be continued. This shows the importance of proper training and good supervision.

7.8 Learning in other projects

Learning did not stop at the end of TRANSCOL, but continued in several other projects implemented by CINARA, often in collaboration with IRC. I will mention a few experiences here that are particularly relevant for the further improvement of learning projects.

The school project

This project, which uses 'school' as a metaphor for the learning approach embedded in the project, took the concept of joint-learning projects emerging from TRANSCOL and applied it to identify water and sanitation problems in rural communities around Cali (CINARA-EMCALI, 1992). The new project established a working group similar to the IRWGs in TRANSCOL and with this group they initiated a more consolidated preparatory process than used in TRANSCOL as shown in Figure 19. The process started with an inventory (desk-study) of the information available in the different institutions about the area concerned. Subsequently all hamlets in the area were visited. Whereas the inventory showed a total of 168 hamlets with a population of almost 29,000, the visits revealed a different picture of 112 hamlets (several had merged or were absorbed by the city) with some 36,000 population. This information was systematically organized into a data base together with the main water supply and sanitation problems that were encountered. The problems were then clustered to identify and prioritize the most important types. Solutions were then proposed for these problems and, together with communities of selected locations, a learning project was established to review the problems in more detail and jointly agree on solutions, the way to implement the solutions, and the roles and contributions of the different actors in the process.

The very attractive element in this model is that, on the one hand, local solutions are developed systematically for the most pressing problems, while, on the other hand, a soft-systems approach is adopted by looking beyond the technical problems. Solutions can be developed without interrupting normal implementation processes, but can improve the 'mainstream' interventions by feeding the results from the learning projects quickly to the other people and organizations involved in the interventions, or even better, involve key people from these organizations (on a part-time basis) in the learning projects.

Restrepo (2001) argues that one of the strong points of the learning projects is that problems were prioritized jointly between the community and the institutions. She also mentions that the approach has been followed in other projects. That indeed is the case, but it appears that CINARA has been involved as the main driver in all of them. This holds an important lesson that an external 'facilitator' or facilitating organization is needed to orient the development of this process and, above all, to create the chemistry that allows the sector agencies to collaborate and work together with communities, respecting their right to have their own perspective on problems and to

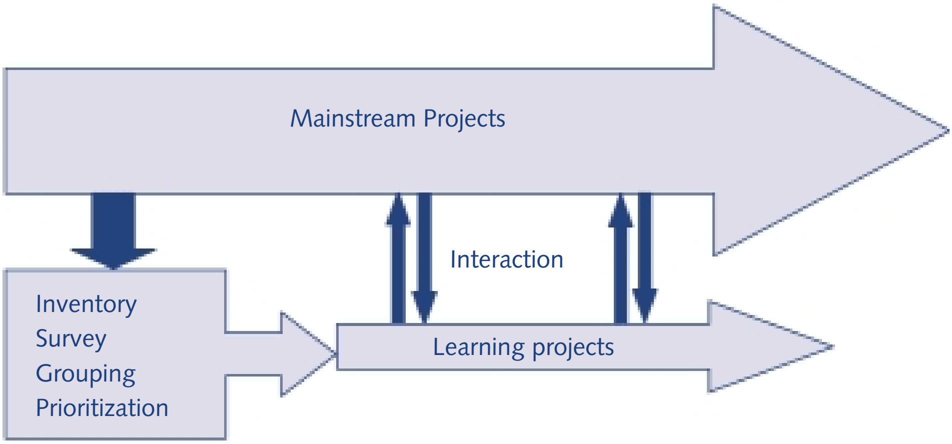

Figure 19. Parallel "learning projects" to improve sector investments (adapted from CINARA-EMCALI (1992)

make their own decisions, but helping them to understand the options and the consequences.

The sustainability project

Another relevant project is the national programme for the sustainability of water and sanitation systems with emphasis on management and community participation, which is extensively described by Restrepo (2001) on the basis of different project reports prepared by CINARA. This project was implemented in the late 1990s in three regions, with support from the Ministry of Social and Economic Development, the national financing agency FINDETER, the most important regional institutions and the selected communities. The process was facilitated by CINARA. In each region, one project community was selected as a learning project from a FINDETER list of project sites, after a review of prevailing problems. Projects were chosen that were in different stages of development, to maximize the learning experience.

The selected projects were:

- Mistrato (Risaralda); Project in planning and design stage (6000 population);
- El Bordo (Cauca); Project in construction stage (9000 population); and
- Ventaquemada (Boyaca); Project completed, system operating (1400 population).

A wide range of problems were identified in these projects, using the participatory assessment techniques that were applied in TRANSCOL. Problems include: inadequate designs; designers not listening to the local community, putting pipelines in areas that were indicated as having high risk of landslides; poor quality of construction; high water use and a lot of wastage; deficiencies in operational, administrative and managerial capacities; poor water quality; low sewerage coverage; and low effectiveness of earlier investments.

Solutions for the most pressing problems were jointly identified but only partly implemented as some did not match the available financial resources. This process was guided and facilitated by a strong CINARA team. Improvements included changes in the design and construction of the water and sanitation systems, adjustment of operational procedures, adoption of a participatory approach, establishment of legal management bodies, and training of community-based organizations and operators. According to the project reports cited by Restrepo (2001), results were positive and led to better functioning systems as well as to the incorporation of a large part of the documents used in the project into a national training programme that was being developed by the Ministry to strengthen the management capacities of small water service providers in Colombia.

Below I summarize some of the lessons learnt in the project, several of which are quite similar to the findings in TRANSCOL.

- The multi-disciplinary teamwork generates a high personal commitment of staff involved. It is suggested that this personal commitment leads to institutional commitment. This suggestion however is not supported by any evidence and I would argue that while today it could be claimed that long-term institutional commitment appears to exist in documentation in the Ministry of Environment (to which the Water Department of the Ministry of Social and Economic Development has been transferred), it is not felt in practice.
- Integrating the different disciplines needs considerable effort to help them to understand each other.
- Community involvement proved positive and facilitated reaching agreement on important issues, including the gradual introduction of water meters and the increase in tariffs after service provision improved.
- There is no support in Colombia to adopt an integrated gender-sensitive approach to water supply, sanitation and hygiene promotion.
- Selecting the ‘right’ technology is not sufficient, it is also necessary to guarantee an adequate design, a transparent tender process, good quality construction supported by community monitoring, and good management.

Participatory evaluations

Other activities that benefited from the thinking and materials developed in TRANSCOL included several participatory evaluations that have been carried out by CINARA and me in Ecuador and Bolivia and thereafter by CINARA in other places, including Nicaragua. These evaluations have applied several of the tools and techniques that were used in TRANSCOL and refined them in such a way that they can be applied more quickly, without jeopardizing participation of the communities. An important aspect is to ensure adequate feedback to the community to avoid evaluation becoming just a process of extracting information from the community that helps the evaluation team to learn. In all evaluations, a strong effort was made to ensure the interdisciplinary nature of the teams and to create political support, by arranging meetings with sector officials and the management of sector agencies before and after the evaluation.

7.9 Exploring the research questions

In this section I will review the case study of the TRANSCOL project against my main research questions. I have changed the name in the questions from SSF to MSF, because the findings from the research project on pre-treatment conclusively demonstrated that pre-treatment is virtually always necessary prior to SSF, and because the systems applied in Colombia were all MSF systems. In a similar way to section 5.7, I will use the framework of analysis presented in section 2.5 to discuss the emerging properties and conditions of the innovation process.

Q1. How successful was the introduction of MSF?

This question generates different answers at different levels.

Uptake at personal level

People involved in TRANSCOL have generated and acquainted themselves with considerable knowledge and experience about MSF. This includes the staff from CINARA, the IRC staff involved in the project and several members of the IRWGs. In different ways, they continue to promote the technology among others through the university programme, private consultancies, advisory support to the development of MSF systems in other regions and countries, and by publishing papers about it. An important feedback in the recent interviews was that TRANSCOL was a true ‘learning ground’ for those involved. This remark relates to the MSF technology, but even more to the interdisciplinary and inter-institutional character of the ‘social’ process and the work with the communities, as I will discuss later in this section. It clearly broadened the horizon of participants and encouraged them to look beyond the technology.

Uptake in the TRANSCOL communities

At community level, 17 MSF systems were established under TRANSCOL in Colombia in communities ranging from 160 to 3500 population. In fact, the project initially worked with two more communities, but funding constraints made it impossible to proceed with them. Fifteen of the MSF systems were quite successful in terms of their performance and the way maintenance tasks were carried out.

The performance of the systems is reasonably good. An external inspection report in 1998 indicates that two years after the project ended, 13 systems were functioning well; two had problems because there was no water in the storage tank due to failing rains; one was by-passed; and one had over 100 illegal connections above the plant, resulting in a strongly reduced flow (Samper and van Schaik, 1998). A similar picture arises from the 2005 review (Section 7.5) with six out of seven systems visited providing clear water, but data are lacking concerning the bacteriological quality of the treated water. It may be assumed that the water is not always safe and requires disinfection. The 2005 review showed the need for small repairs and for the addition of new sand, but also that in a number of systems considerable efforts are underway to reduce leakage by replacing the distribution system and by installing water meters to control consumption better and reduce wastage.

A point in favour of the technology is that performance limitations are mostly caused by deficiencies in operation and maintenance and by external factors that would have a negative impact on any treatment technology. Only in the case of one MSF system was colour removal not always sufficient. ‘External factors’ include inefficient water use, unavailability of advisory support for the operators and, in two systems, failing rains. Inefficient water use also had an effect on the other systems, as most of the MSF units were overloaded, causing shorter filter runs. Partly this is caused by lack of understanding among community members of how their actions interfere with the system. They do not ‘see’ the relationship of the ‘ecological processes’ in the MSF with erosion caused by their actions in the catchment area, or with leaking or open taps.

The way the operators carry out their operation and maintenance tasks is an important issue, as it affects the performance of the system. By the end of the project it had already been concluded that the capacity of operators to manage their systems needed to be improved. It was suggested that a regular training programme for operators was required to ensure this (Quiroga et al., 1997). Unfortunately this training programme did not materialize. The consequences were very clear in the revisit in 2005. Operators make important efforts to keep their system functioning, but have invented adjustments in operation and maintenance practices that have negative effects on the performance of the systems and their own work, as was shown in Box 13 in section 7.5. They clearly do not understand the water ecology involved in the system, nor the relationship between people’s behaviour and the system. In several communities, they experience considerable pressure from users who are more interested in water quantity than quality. It has not been established whether this is a majority of the population or just the most influential group with a vested interest, for example, in using water for small-scale irrigation or for coffee production.

The clearest example of lack of understanding of the biological process was found in San Felipe. Here the treatment plant has been extended with two extra SSF units, but one of these is kept as stand-by until another unit is taken out for cleaning. This has severe repercussions because a fresh filter needs several weeks before the “Schmutzdecke” is sufficiently formed to produce water that has a low bacteriological risk.

This limited understanding may not be so surprising, because many operators learned their job from oral instruction by operators they replaced. Without proper supervision this leaves a lot of room for misinterpretation, as reflected in the way they implement some maintenance procedures.

The situation is quite different in a number of MSF systems that are closer to Cali and still receive monitoring visits by CINARA staff. This back-up support and the training that operators receive seems to make a considerable difference.

Considerable scaling-out but not much scaling-up

Participants in the review workshop (CINARA-IRC, 1996b) indicated that some 10 MSF systems were already built in replication of the MSF systems in TRANSCOL, and another 16 were under construction (Table 16 in Section 7.5). Information from Valle region, the home base of CINARA, shows that another 10 MSFs were built there in the same period. This was a promising uptake of the technology, which was confirmed in the revisit in 2005, although that provided partial data from just four regions. Nevertheless, these data showed that the number of MSF systems was continuing to grow, with Cauca and Valle region together accounting for at least 65 MSFs, some of them supported by CINARA in collaboration with, for example, the Regional Health Service in Cauca.

Leeuwis (2005[16]) defined this type of replication as **'scaling-out'**, (i.e., the replication of a locally successful innovation). Initially this spread of MSF technology was strongly stimulated by staff from the Regional Health Services, who were leading the sector in most regions and were well represented in the IRWGs. Unfortunately, one year after the end of the project, their mandate changed as part of the decentralization process, from an implementing agency to the organization responsible for water quality surveillance. This significantly hampered the effectiveness of scaling-out of MSF, although some of the staff of the Health Services shifted to the private sector and continued to design water treatment systems. The effect of the "demonstration systems" (learning projects) has also been positive in that the MSF system in Suarez, which is considered one of the best water treatment systems in Tolima, was visited by all 45 municipalities from the region (Field notes Perez, 2005). This type of visit may be quite helpful, as shown in Box 14. In non-TRANSCOL regions, the uptake appears to have been much more limited, which would substantiate the need for a critical mass, for positive examples reasonably nearby, and for advisory support.
Another positive finding in 2005 was that MSF is now a fixed component in the teaching programme in universities in four of the five regions that were visited and lectures are given by staff members who participated in TRANSCOL. This is highly significant, as it prepares the new generation of engineers for widening the application of MSF in a practical way, also because field visits to MSF systems are often included in the curriculum.

But, what looks like a success story has important down-sides because the required **'scaling-up'** has not yet materialized. The overall situation still has a number of important limitations that hamper the wider spread and sustained performance of the MSF systems. These include:

- Virtual absence of operator training (except for some ad-hoc training by CINARA), despite the fact that the Ministry of Development and FINDETER financed the follow-

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[16] This definition of scaling-out was presented by Cees Leeuwis in the symposium of learning alliances for scaling-up innovative approaches in the water and sanitation sector in Delft in June 2005. In the same meeting he defined 'scaling-up' as replacing the existing socio-technical regimes, the organizational and institutional framework in which the technology is embedded. I follow these definitions of Leeuwis, and like the distinction between the two but I have found that others use the term scaling-up for the combination of what Leeuwis defines as scaling-out and scaling-up.

up project on sustainable water supply (section 7.6) and came to accept that technology was not the only problem, but that capacity building was also needed. They established a new training programme, which they called 'cultura empresarial' (management culture), that included part of the material developed by CINARA. However, implementation was only through short courses and emphasized the administrative tasks of the water provider and not of the operator.

- Limited availability of advisory support, particularly for the poorer communities. A good initiative is being taken in three regions, where an association of small water providers has been established with support from CINARA.
- Lack of understanding of the importance of the biological process, the water ecology and the crucial interaction between users and the performance of the system.
- Priority for water quantity over water quality, at the community level, as mentioned earlier, but also at the institutional level if we look, for example, at the water supply improvement programme that was established in 2003 to cope with rural water supply problems in Valle region. In a workshop with the management team of this project, in which the main institutions involved in the water sector in Valle region participated, it was proposed that the project should aim at reaching 70 percent coverage in five years, while guaranteeing water quality in only 15 percent of the communities.
- The interdisciplinary and inter-institutional approach was highly appreciated by CINARA and the IRWG members, but their agencies, sometimes because of political changes, did not change their approach, nor did the universities accept the social dimension of water supply interventions as an intrinsic part of their curricula. This lack of change at higher levels, which was also found in the SSF project and in the limited level of adoption of the VLOM concept (section 1.4), seems to be rather common, as indicated in Groot et al., (2002).

Box 14. Communities learn from other communities

In San Felipe in Tolima, people seem to be more aware that the water supply is for domestic use. Their system has water meters and is working quite well. It was the best kept plant among the five that were visited. It was clean but does need some repairs as it had several small cracks in the concrete and some poorly mended pipes. The MSF system in el Convenio, another TRANSCOl community in Tolima, was also operating, but the MSF has been bypassed for a considerable period of time because it could not produce the quantity of water the people wanted. Then the people from el Convenio became aware of the experience in San Felipe. After they paid a visit to San Felipe (peer sharing), they agreed on the usefulness of water meters. They then started to control consumption and were even willing to expand the plant. But when control was actually improved by installing water meters, the plant started to work well and it is now operating so well that it does not need to be extended.

Q2. How has facilitation of MSF introduction emerged?

In comparison with the SSF project, facilitation in TRANSCOL was different and more comprehensive. The approach focused on building rapport with the actors involved and on establishing a capacity to facilitate wider introduction of MSF. Management of the project was in the hands of IRC, but in practice was shared between myself, as the team leader of IRC, and the director of CINARA. It entailed a trust-based relationship with frank discussions and sharing of experience with the whole team. "CINARA staff appreciates IRC because they 'let you be!'. You can discuss and argue with them, but finally arrive at your own style. IRC recognises that the two cultures are different and have different rhythms" (Schulzberg, 1996).

Compared with the SSF project (chapter 5), the IRC approach was much more hands-on and much closer contact was kept, particularly by telephone. Also, a stronger emphasis was placed on progress monitoring and reporting, which helped the partners to keep track and to adjust where needed. It allowed me, in the same way as the facilitators in the SLIM Project (2004) [17] indicate: "to enter into the action by placing my knowledge in society in ways that serve to trigger reflection on what is at stake". The frank relationship and the trust among the leading partners made it possible for me, for example, to facilitate some of the team meetings of CINARA. It also meant that I could take a more interventionist approach by bringing in ideas and arguments to try and influence directions to be taken.

At another level, the relationship with IRC was also important as it added to the status of CINARA. "It is important that IRC is an internationally recognised institution – which, in turn, recognises and endorses CINARA" (Schulzberg, 1996), and it gave access to other experiences: "IRC has been able to transfer information, based on strong practical experience from Africa, Asia and Europe" (ibid). Equally, I would argue, IRC has benefited from its relationship with CINARA as the collaboration contributed to IRC's recognition in the international community as an organization with strong partners in the developing world. And it gave IRC access to a great deal of information and experience that it could share with others.

The most important group of facilitators in the project was the CINARA team and particularly its regional teams, each composed of one engineer and one social science professional and with a good gender balance. These interdisciplinary teams included a number of engineers who had already worked for some time in CINARA, and, alongside them, newcomers comprising social scientists, educators and engineers. "This new socio-technical team came from a tradition of single discipline study with a bias to undervaluing knowledge different to their own and a lack of knowledge about communities or groups of people who had never been involved in the formal education system" (Garcia 2005).

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[17] SLIM is a multi-country research project funded by the European Commission that involved researchers from France, Italy, the Netherlands, Sweden and the UK. SLIM stands for Social Learning for the Integrated Management and sustainable use of water at catchment scale.

Acquiring the skills necessary to become facilitators and to adopt the integrated vision of TRANSCOL was therefore not easy. "Recourse was made to psychologists to work with the team on self-knowledge, and the ability to understand others. Artists were also involved to develop creativity, mental and physical flexibility, and the enthusiasm necessary to face the challenge of working simultaneously in eight different regions of the country, with diverse cultural characteristics and many regional institutions. The capacities developed with this training meant that an environment favourable to learning at different levels was created, with great potential for strengthening capacities for interdisciplinary and inter-institutional work" (ibid).

Guided team learning continued throughout the project, through regular progress discussions and reflections. In the interviews in 2005, the team members remembered this process as very positive. It can be argued from the remarks of communities and staff in the IRWGs about CINARA staff that this training and learning paid off. The teams really managed to build a relationship of trust with the different actors in the process.

The preparatory training and orientation of the CINARA staff was very important and helped them to do a good job. They were not only facilitators, but often also the drivers of the projects and, to a certain extent, this may have limited the learning opportunities for the staff from the IRWGs. They could very easily 'hide' behind the CINARA staff and allow them to take the lead, which seems to be confirmed by the fact that community members in the 2005 interviews more frequently talked about the staff from CINARA than from the regional organizations.

Recently, the CINARA team reflected on the facilitation of people-centred participatory interventions and came to the conclusion that this requires the following key characteristics, to a greater or lesser extent (Garcia, 2005):

- Good awareness of own strengths and limitations;
- Able to put him/her self in the place of others (empathy);
- Capable of strengthening participants in autonomous decision making and taking action;
- Able to create an environment of trust among participants that allows them to freely express their feelings, thoughts, and opinions;
- Able to overcome the barriers that prevent horizontal relationships from emerging;
- Good listener, understanding the diversity in communication;
- In-depth knowledge of the socio-economic, cultural and political context in which the development process takes place;
- Capable of affecting the conscience and feelings of participants;
- Able to use simple language strengthened by metaphors and stories to illustrate his/her thoughts;
- Genuine interest in the people with whom he/she is working.

As well as the complex interactions among the different institutions and staff involved in the IRWGs and the communities, the training of caretakers also had to be facilitated. In TRANSCOL, this was done on the job by CINARA and by staff from the IRWG, after the MSF plant had been constructed, using training materials developed by CINARA. Practical guidance materials were left with the operators, who were pretty much on their own after the project ended. In Valle region, the training developed further towards guided training in action or 'learning by doing', as CINARA continued to facilitate MSF systems in this region and was faced with a turnover of operators in several systems. One CINARA staff member indicated that: "our training of operators has developed and now we very much use demonstration and action. In a training room, people can see the operation and maintenance practices on paper or on video, but do not experience it. Therefore we take them to an MSF plant to act, and in doing this they learn the routines. We started this approach when we found that people had difficulty in remembering concepts involved in MSF. Furthermore we use 'peer training' where operators train operators under our guidance".

Q3. Have the conditions been created to sustain the technology?

There is no single answer to whether conditions have been created under which MSFs perform properly and are being replicated. Several answers emerge, ranging from a prudent 'yes' to a 'no but progress has been made'.

In Valle region the answer is "yes", at least for the MSF systems that are being monitored by CINARA, which are performing well. For these systems, it is fair to argue that conditions have been created to sustain the technology, because the communities take care of their systems and have the financial means to access expert advice when needed, often from CINARA or former CINARA staff. Several communities with the means to do so have also built new systems on their own initiative.

In the seven TRANSCOL communities on which information was collected in 2005, and very likely also in the others in view of the data obtained in 1998, the answer is "partly". The MSFs are being operated and they do provide 'clear water' to the communities. Yet operation and maintenance of these systems is not adequate, back-up support is completely lacking, and the systems are often overloaded. So, it would be correct to say that the conditions to sustain the technology have not been created, but that progress has been made, or that only some of the necessary conditions have been created. Despite these limitations, I would still like to characterize the results as remarkable in that they have provided people with a vastly improved water supply. Nevertheless, additional action is needed, including the institutionalization of operator training and back-up support.

Another important dimension is that MSF is acknowledged as a feasible technology by the Ministry of Social and Economic Development and has been integrated as a respected technology in the university programmes in almost all regions that participated in TRANSCOL. This is very important for the future, because the engineering students of today are likely to have a large influence in decision making on technology selection in the future. However, it cannot be established from the available data how many young engineers are truly in favour of MSF, or whether sufficient attention is being paid to the crucial social and ecological dimensions.

Table 19 summarises how the project supported the development and dissemination of MSF, using the adapted knowledge system framework from Röling and Jiggins (1998), as discussed in section 2.5. The table makes clear that the project influenced an important part of the elements of the knowledge system but did not create the conditions to sustain the technology.

7.10 Conclusion

The overall picture that emerges from this case study is that the project strongly contributed to the development of MSF and to its introduction in eight regions in Colombia. The combination of the TRANSCOL and the Pre-treatment projects was very positive and allowed for a close interaction between researchers, practitioners and implementers. Most of the seventeen MSF systems that were built seem to be performing reasonably well, though they need improvements and repairs. Several have a 'demonstration function' in that they are visited by other communities, university students and one annually by school children. New MSF systems have been built in several locations. All of which allows me to draw the following conclusions:

MSF proved itself as a suitable water treatment technology

The fact that the TRANSCOL systems were still performing and the positive performance of the MSF systems in Valle region (Table 17 in Section 7.5) confirm the suitability of MSF as a water treatment technology for small and medium-size communities, provided adequate training and back-up support is given to operators. MSF is able to treat more contaminated water than SSF alone and, as indicated by the participants in the review meeting in 1996, is very competitive over RSF, particularly because it is simpler to operate, does not require chemicals and is therefore low in maintenance cost (Table 7 in Section 3.6 and Table 8 in Section 3.7). But, the project did not treat MSF at the level of complexity that it requires.

The treatment technology may be robust, but it still may be affected by human interference, for example by poor management of the catchment area resulting in erosion and higher turbidity levels, but also by uncontrolled or multiple use of water, which in many of the TRANSCOL systems led to overloading of the process. These problems may arise especially in smaller systems in developing countries, where catchment protection is weak, distribution systems are not of sufficient quality, and water consumption is not controlled.

Scaling-out occurred but was hampered by lack of scaling-up

A considerable number of MSF systems were built after TRANSCOL, which shows that scaling-out happened. The better performing systems often provided water to the

Table 19. Analysis of the supporting knowledge system framework

Elements	MSF water supply treatment	Comments
Stakeholders involved	Regional government, management and staff from implementing agencies, university teachers, community members and operators.	It appears that at CINARA and in several universities a critical mass for MSF was reached; Good involvement of staff from institutions and of community members during the project was not sustained.
Sound practices for dealing with MSF systems	MSF was further developed in the pre-treatment project. Videos and training manuals stress the importance of the biological process and deal with the broader tasks of operators and small water providers. A learning project approach was followed, stimulating interaction between agency staff and communities, thus developing the foundation for implementation and O&M of MSF systems.	Including sound practices in guidance material, training manuals and videos and working with them proved not to be sufficient, as operators and IRWG staff lacked insight in the water ecology involved in MSF. Systems were overloaded because of leaking distribution networks and communities not changing their water-use patterns. The approach to community participation was innovative and sound as it stressed the community's responsibility in its own development.
Learning to support the MSF practice	Staff from CINARA, and to a somewhat lesser extent staff from the IRWGs, learned in training workshops and by applying this learning in practice. Contractors received some training and guidance. Community members learned in creative workshops and operators were trained on the job in a relatively short period of time.	Researchers from the parallel pre-treatment project had exchange with TRANSCOL staff. IRWG members however only came to the research station once and were not involved in MSF research, which reduced their learning opportunities. However, they were exposed to discussions with CINARA staff. The training was people-oriented and mostly participative in nature, clearly adopting a learning philosophy.
Facilitation to support the learning	The facilitation of the process by CINARA was hands on, using guidance material developed by themselves in consultation with IRC and their own senior advisors. The facilitation role of the staff from the IRWG was less prominent, as they could 'hide' behind the CINARA staff. The philosophy was very much human-centred and participatory.	CINARA staff has not been able to transfer the crucial importance of the water-ecology side of MSF treatment to the IRWGs, partly because they themselves did not take a sufficiently broad view by not including catchment management and efficient water use. They were successful in introducing MSF systems in the communities, as well as in facilitating a learning approach in the

Continued over

Table 19. Continued

Elements	MSF water supply treatment	Comments
	Few efforts were made to establish national training programmes for MSF operators.	projects. Their approach to working with the community was positively valued by the community and the IRWGs, but thereafter not adopted by sector institutions, despite the participatory evaluation workshop in 1996 that strongly supported this type of approach.
Institutional support system	Policy makers and the management of the implementing agencies was initially involved and approved the approach, but this involvement was not sustained and did not lead to institutional change.	Workshops and IRWGs proved not to be sufficient to influence the institutions to adopt a more community-based approach. A more strategic (politically supported) scaling-up approach is needed with sustainable safe water supply as a common objective.
Conducive policy context	The project had some impact on the policy context. Project material was included in the training material of the Ministry of Economic Development, but it primarily focused on administrative management.	It can be argued that political change is needed, agreeing on the necessity of good quality water which can only be achieved by a comprehensive multi-disciplinary approach. This change would also have an impact on university education.

‘better-off’, the communities with more resources, better education, and a higher interest in water quality. Their distribution systems are in better shape and they can seek and finance advice when needed. A considerable number of communities benefited, but many others did not because scaling-up – the development of a supportive institutional framework – did not occur. It could be argued that development of CINARA provides for some kind of scaling-up in Valle region, but a stronger arrangement is needed that guarantees continuous training and back-up support either through a government-supported programme or through public private partnerships.

It was hoped that the IRWGs would help to establish institutional support, and indeed the groups proved to be an effective mechanism for creating commitment among staff of relevant agencies for MSF, the community-involvement strategy, and the inter-disciplinary and inter-institutional approach, thus creating an environment that encouraged scaling-up. However, it proved difficult to keep the groups together. After an initial period of enthusiasm, attendance at the meetings started to dwindle. The voluntary nature of the participation led some staff experiencing pressure in their own organizations to give priority to their normal routine work, because the management did not attach sufficient value to the learning projects. This seems to confirm “the social science understanding that most policy makers and scientists, usually influenced by economics, tend to ignore learning processes and their facilitation" (Röling and Jiggins, 1998 p 292). They view it as a technical problem. The end of TRANSCOL also meant the end of the IRWGs – a great shame, as institutional commitment, a key driver (in this case CINARA), and financial resources are needed to sustain the effort.

A further complication was decentralization of the sector, which makes municipalities responsible for water supply, although many do not have the qualified staff to take this forward, and very few have staff that gained experience with MSF as few of their staff members participated in TRANSCOL, or learned about MSF in university.

The resulting picture shows similarities with the observations of Colin (1999) about the introduction of new hand pumps based on the VLOM concept, discussed in section 1.4, but for different reasons than expressed in section 5.8. Following his line of thinking, it can be argued that, based on the positive results of the MSF technology, it should have heralded a new era of water quality improvement in rural water supply schemes. Sadly, this still is not the case for a number of reasons.

- The MSF technology has an important potential but it was introduced before the time was "ripe", as water quality still has low priority.
- Operation and maintenance problems exist because operators lack training and understanding of the MSF process and do not have back-up support.
- Considerable costs are involved in installing water treatment, as it often also requires repairs and/or replacement of the water distribution system.
- Lack of understanding that community water supply is not a technical concept, but has a strong social dimension, and that including MSF implies adding a water-ecology dimension.

Particularly the last point seems to remain an important obstacle, as it would require a change in thinking that appears to exist, to some extent, on paper in the training materials of the ministry, but not in the practices of the engineers. They still seem to view it as a technical problem that needs a technical solution and some training. So the project has not really been able to ensure the scaling-up of the technology and the methodology.

Operators lack support and invent poor maintenance procedures

Training of operators included the use of manuals that made specific reference to the biological nature of the MSF process. The thinking behind this matches the suggestion by Röling and Jiggins (1998) that ecologically sound agriculture makes special demands on learning and facilitation. Looking at the results in 2005, the effort has not proved sufficient because operators continue to see the system as a mechanical filter. Operators often work hard on their systems, but many have introduced changes to operation and maintenance procedures that are counterproductive. Also they lack adequate back-up support from people who know MSF, because the number of change agents is still too low and few are visiting the systems.

The learning project strategy emerged

The learning project approach has been developed and further consolidated into Joint Learning Projects (JLPs) and has been applied by the CINARA team in other projects. This entails elements of social learning (Jiggins, 2003; SLIM Project, 2004), as I will discuss in more detail in chapter 8. Participatory methods in multi-stakeholder processes that were tried in the project have been the basis for participatory evaluations by the CINARA team in different countries in the region, often in collaboration with IRC. On the other hand, the scope for learning appears to be more limited in recent projects, as implementing agencies seem again to be focussing much more on quantitative targets (number of constructed facilities) than on more integrated interventions that are essential for the adequate functioning and the sustainability of water supply systems.

CINARA grew in its role as a sector support organization

The joint learning projects, in combination with the structured learning events in Cali, worked well, particularly for the CINARA staff, who mastered both the introduction of MSF and the facilitation of participatory processes. Members of the IRWGs also learnt a lot, though they had less opportunity to learn than the CINARA staff, and, more importantly, fewer opportunities to apply it later, when the role of their institutions changed.

CINARA grew as a team and in status. TRANSCOL and the parallel research project on pre-treatment technologies provided the opportunity and the resources for CINARA to grow, experiment with the technology and the methodology, build up its information and documentation centre and establish a strong national and international network. This made an important contribution to the development of CINARA as a water-sector support centre, with national and international recognition, working in Colombia and other countries in the region.

Universities incorporate the technical dimension of MSF

Universities have adopted MSF technology, but not the methodology. In four of the five project regions visited in 2005, MSF has become part of the curriculum of universities in the region, allowing engineering students to learn about the technology. The teachers were all involved in TRANSCOL and some have carried out research activities on MSF in their universities. This makes the university an important factor in technology transfer, though unfortunately not (yet) of the broader social science and environmental components. This relates to the fact that universities arrange teaching in disciplinary departments, whereas teaching a beta/gamma approach requires inter-disciplinarity. It appears that this limitation has deeper roots; the management of the universities has not really grasped that successful technological change has an important social dimension and needs to be viewed as involving different disciplines.

Reflection on the fairness of my conclusions

The question to pose at the end of this section is: How realistic are my conclusions and my perception of the project? With respect to the performance of the systems, I am confident that my conclusions are fair. I have been able to obtain a good impression of the situation in several of the TRANSCOL systems and have used hard data that match the basic requirements for positivist research. Although these were from non-TRANSCOL MSF systems, they were treating comparable water sources. My other findings are of a more constructivist nature. Hence the relevance of these findings needs to be checked against the quality checks suggested by Guba and Lincoln (1994). By using project documents produced by different authors and triangulating these with my own field experience and by seeking feedback from my co-interviewer and from people that were interviewed, I feel that it is fair to say that my findings are **credible**, in that they match the reality of the actors in the different situations presented in this chapter.

In terms of **fairness,** I was able to seek confirmation from some of the key actors, even though quite some time has passed since the end of the project. Furthermore, I have based my observations on results reported in the participatory 'end-of-project' review workshop in 1996 and evaluation reports that at the time of their development have been shared with different actors involved in the project, for comments and adjustments. Also, my review is quite critical and does not show a rosy picture emerging from the project. Results are better than from the SSF project, but it certainly could be argued that, because of my involvement as project manager, it would be in my interest if a nicer picture had emerged. So I trust that I have been able to give fair treatment to the project information and results, the more so because my findings have some parallels with Colin's (1999) observations as to why VLOM hand pumps have not yet become mainstream.

This leaves me with the question about the **authenticity**, which is easier to answer than in the case of the SSF project. The learning-project approach has already proved very stimulating and has empowered a considerable number of people to learn, to act and to develop the approach further. Also, I have had good discussions with the CINARA team and have shared and discussed this document with several of the actors involved in the interviews. I can only hope that these discussions will strengthen them to proceed in their important endeavour to improve the lives of the many people that still lack access to good quality water supply in Colombia and elsewhere.

8. Emerging lessons and concepts

> *"Normally, we do not so much look at things as overlook them." Allan Watts*

In this chapter I revisit the concepts underlying the TRANSCOL experience. I argue that the insight gained contributes to emergent theory about a more comprehensive approach to water project interventions, technology transfer and diffusion, the role of institutions and communities, and facilitation of the process.

I show that a new skill set is needed to improve sector performance and facilitate the adoption of innovations. I argue that the experience confirms the criticism of the technology-transfer model of Rogers. Some of his thinking still applies, as do the ideas incorporated in the chain-linked model of Kline, but neither seem to match the technology transfer that takes place in the water sector, perhaps because it is a public sector in which competition is lacking and interventions are not judged against their long-term performance. This places a very important responsibility on governments to ensure that users are given a better say in their water supply and better access to adequate information that will make decision-making processes more transparent. It also challenges universities and other technical training institutes to ensure that future sector professionals are able to understand the broader implications involved in water supply provision.

8.1 A learning alliance made up of different platforms

The TRANSCOL project has all the characteristics of a *Learning Alliance*, which, at its simplest, is a series of linked platforms at different institutional levels (national, district, community, etc.) created to bring together a range of stakeholders interested in innovation and in the creation of new knowledge in an area of common interest" (Moriarty et al., 2005). A key characteristic of the project was that it provided social learning on multiple scales (Jiggins, 2003). The area of interest was the dissemination of MSF in Colombia. CINARA with its advisors, and in close collaboration with IRC, was the platform with decision-making authority over the project. CINARA worked in collaboration with national institutions that co-financed the learning projects. For each of the regions, CINARA established a team of two facilitators, one with a technical and the other with a socio-economic background. These teams facilitated the second-level platform, the IRWGs that were established in each region, comprising the main institutions involved in water supply (policy, regulation, research, training and implementation). The teams, together with key staff from the IRWGs, facilitated the third-level platforms – at the community level in each of the participating communities. In general, the third-level platforms were the water committees, extended by adding interested individuals.

Sustaining the core team of the learning alliance was relatively easy while financial resources were available from the Dutch government and while a shared objective was established that was supported by the management of CINARA and IRC.

Sustaining the IRWGs (the alliances at the regional level) proved much more difficult, as different degrees of importance were attributed to water quality improvement and to working in a participatory way with the community and other institutions. Also, for the IRWG members, project activities were competing with other tasks. The IRWGs worked well during the project, but did not make a lasting impact, partly because insufficient organizational and political commitment was obtained, but also because of the changing roles of the institutions in the sector. Responsibility shifted to the municipalities, which were not prepared for it in terms of staff and capacity.

A related issue may be the project's 'narrow' focus on the introduction of water treatment. It did not make an inventory of the most pressing problems in the sector as was done in the school project. It did not explore what the leaders of the institutions perceived as most important problems and then prioritize these and establish learning projects to develop the most suitable solutions. Such an approach might have generated broader political support, but not necessarily for the introduction of water treatment. However, if political leaders had been involved more closely and had prioritized MSF treatment, there would have been a better possibility that the necessary orgware – the support capacity needed for small water providers and operators – would have been established in the project regions.

At the community level, after an initial period of inertia, quite a number people became involved, but not everyone, because the interest in water quality improvement was not fully shared. Many people were more concerned with water quantity. This is an important point for reflection, as it appears that the 'shared' interest was perhaps less shared than everyone thought, or at least was subject to different interpretations. I would expect this to be the case for most learning alliances. Interests are social constructs, based on people's perceptions, as further discussed in section 8.2. Despite these differences, the learning projects helped to strengthen the community, to establish a reasonably functioning, legally registered, administrative body, and to train operators.

It seems though that this training was too short and that back-up support was too limited to really ensure that operators appreciated the water ecology involved in MSF. On the other hand, the approach did lead to some communities introducing water meters to control water consumption, which, in turn, served as an example for others. Unfortunately, working with the community did not result in the elimination of political interference. At a later stage in some communities, operators were replaced with untrained new ones belonging to the party of the new political leader. This implies that more work is required at community level, to enhance understanding of the importance of water quality, and to give the community a stronger say in decision making.

Sustaining the vertical linkages among the different platforms in the alliance was an important element of TRANSCOL. This was very much supported by its flexibility to adjust both its strategy and its implementation schedule. Initially the project was formulated for three years, but in consultation with the Netherlands government, the leading funding organization, it was agreed that a more flexible approach could be taken. This made it easier to look for additional support from local resources, which could be found more easily for the construction of water systems than for other project activities. When this became apparent, the Netherlands Government agreed to shift funds originally earmarked for construction to training and facilitation, allowing more frequent interventions by the teams from CINARA over a longer period of time. Their inputs as facilitators greatly contributed to the positive impact of TRANSCOL. The downside is that the level of resources needed for the sector to implement more comprehensive approaches and to facilitate learning are not yet made available by national or regional governments.

The flexibility of the process also allowed for elements of redesign and learning which, according to Leeuwis (2004 p. 12), are essential in the scaling-up of tailor-made innovations to different contexts and people. After the project came to an end, vertical linkages continued to operate, particularly between the regional health service and communities, but only for a short time because the mandate of the RHS changed.

8.2 Soft-system thinking with a stakeholder perspective

The approach in TRANSCOL moved away from hard-system thinking driven by engineers, to soft-system thinking better able to deal with the complex inter-relationship involving the technology, the environment, the users and other potential stakeholders, who may have very different perceptions about problems and solutions. In this context, it is important to refer to actor network theory (ANT) developed in the 1980s by different researchers including Latour and Callon. ANT is based on the systems way of thinking. Latour (1996) suggests that it is useful for studying fast-changing and fuzzy issues where boundaries are not clear. Contrary to engineering beliefs, I would argue that water supply systems are indeed fuzzy and very complex issues.

In ANT, actors (or rather actants) are human or non-human entities such as machines, MSF systems, bacteria, social structures, information, environments, etc. An actant can literally be anything, provided it can be the source of an action (Latour 1996). Networks are complex entities constructed by two or more actors connected through various links or communication channels. Actors influence other actors by shaping their attributes and properties (the process of inscription). The properties and attributes of any particular actor or network are a result of a complex inscription process by human and non-human actors. Human actors are able to inscribe onto non-human actors, and vice-versa (Akrich and Latour, 1997).

This theory matches well with the complexity of the different domains involved in MSF water treatment that I discuss in section 8.3, and it reflects the interaction between the technology and the human actors – the stakeholders. The stakeholders influence each other, the technology and the set of rules and regulations. In turn, the technology interacts with the stakeholders and the rules and regulations, and this interaction may even be stronger in smaller water supply systems in the developing world when compared with large urban water supply systems, where the influence of individual behaviour on the system is much smaller.

Cana (2004) makes a remark that I feel appeals to engineers: "The systems way of thinking emerges as a very insightful and powerful tool, especially because it helps you to study a problem by identifying the boundaries around it, its scope, what happens within the boundaries, and how the issues with the problem at hand interface with the environment (i.e. with outside of the relevantly defined boundary)". When looking at the experience in the TRANSCOL project we see in fact that the project operated within different boundaries (Figure 20).

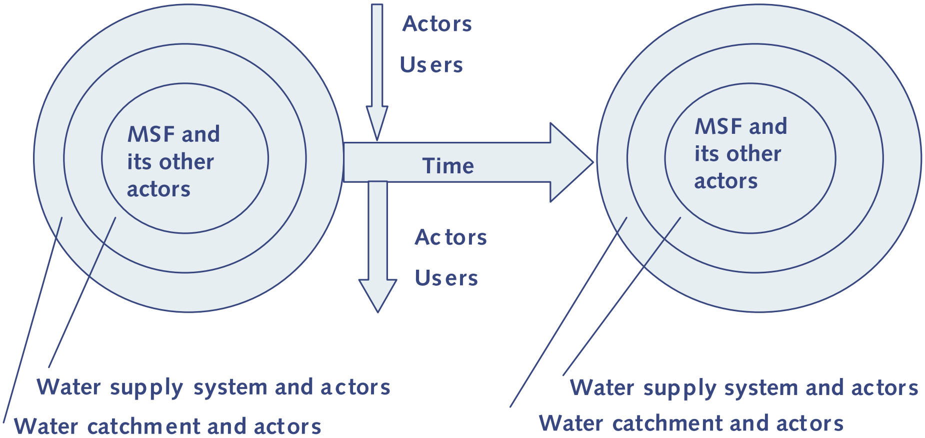

Figure 20. Reflection of the different boundaries used in TRANSCOL

Initially the focus was mostly on the MSF system itself and its direct actors, but during the project the boundary needed to be broadened to include the water supply system as a whole and subsequently also the catchment area. So this experience was more in line with the suggestion of Latour (1996) that a network as defined in ANT has no boundary. "The only question one may ask is whether or not a connection is established between two elements". If we had put our analysis in this light at the beginning of the project, we could have worked with a different mindset that would have helped us to be more inclusive from the start about the different actants, instead of working within assumed boundaries.

When reflecting on the revisit in 2005, it becomes clear that ANT needs a time-bound perspective as, over time, actors (including users) change (the system is aging, new rules are developed, etc.) and new actors (new users, new operators, etc.) come in, while others (old operators, old distribution systems, etc.) leave or are removed. This time element is essential to understanding the complex interaction among the water supply system, the other non-human actors, and the stakeholders involved. For example, changes in the catchment area (man-made or as a result of natural phenomena) may influence the water quality and hence the treatment process, which in turn may influence the users. An operator may be replaced by a 'politically correct' newcomer with little experience, etc. This underscores the importance of managing such changes to ensure the sustainability of the system.

Stakeholder categories in TRANSCOL

Jiggins (2003 p. 17) indicates that "stakeholders are those who have a 'stake', a real, material interest, from their perspective, in the situation or resource under consideration. . . The nature of the 'stake' which any person or group holds serves to construct the stakeholder as an actor with a particular interest". A person or group becomes a stakeholder by participation in stake-holding processes, actively promoting and defending their stake. Looking at the different interests (Table 20), it is obvious that stakeholders do not all share the same view about what is desired. As a consequence, conflicts may arise, as was experienced in TRANSCOL (overloading of systems, deterioration of catchment area, changing of operators, etc.). This points to the need for the type of stakeholder processes described by Jiggins (2003), which include "debate, negotiation, dialogue, joint research, and also the development of a 'platform' or social space where stakeholders interact".

The learning projects in TRANSCOL provided such 'facilitated' social spaces at the different levels on which some of the 'stakes' were discussed. Interestingly, attitudes of stakeholders changed over time. At the beginning, the institutional actors still had a paternalistic approach, which was actually reinforced by the communities – who called them 'doctor'. This gradually changed, through the participatory processes, towards a much more mature way of negotiating. This is in line with the suggestion of Borrini-Feyerabend et al., (2000) that the best approach to managing negotiations among institutional actors is one of learning by doing (adaptive management).

With hindsight, the project was not systematic enough in exploring all the problems and differences of interests. On the other hand, a more systematic approach might have put some of the MSF systems in jeopardy, because several communities may have opted out of the project, as they favoured quantity rather than quality. As it is, some have learned to accept water regulation (water meters) and are getting both quantity and quality while contributing to the spreading of MSF.

Decision making

With many stakeholders involved, MSF became a collective innovation that requires a broad understanding, concerted action, and ideally shared decision-making. In TRANSCOL, the decision to implement MSF was taken by community leaders, IRWG members and CINARA staff, with the last having a comparative advantage in being more familiar with the technology. So in fact CINARA staff had the strongest voice and were able to 'persuade' the IRWG members, the local leaders and the community to accept the proposition. This decision-making situation was very common at that time. For other water supply projects, decisions were mainly taken by engineers linked to government organizations, because they had access to the financial resources. This is changing as

Table 20. Stakeholder categories in TRANSCOL and their main interests

Stakeholders	Stakes (main interests)
Users	Guaranteed water supply at low cost, with only part of them being interested in water quality; some were involved in multiple water use in the catchment area (grazing cattle, crops, etc.) or used water from the system for other purposes (washing coffee beans, small-scale irrigation, etc.). These interests may differ considerably between men and women, rich and poor, etc.
Municipalities	In the process of becoming formally responsible for water supply provision; keen to defend their political interests in contracting works and staff.
Contractors	Rate of return in construction; normally not made responsible for good performance and long-term sustainability of systems; designs are often provided 'free-of-charge' in return for the construction contract.
Operators	Ensuring that their system functions with least efforts and limited complaints particularly from those that support them in the community.
Regional Health Services	Improvements in regional programmes to enhance water coverage, with an interest in water quality improvement (some regional programmes were carried out by other organizations, including, for example, the coffee growers committee with a particular interest in water quantity).
National and regional government	Enhance water coverage with an eye for the political dimension and emphasis on water quantity and not water quality; improved regulations and management of systems with increasing cost recovery from users.
Universities	Gain understanding about MSF technology.
CINARA	Establish an approach to disseminate MSF as an appropriate technology to improve the conditions of the rural population in Colombia and learn about its implications in view of its perception of the mandate of the university as being research and training for development.
IRC	Contribute to the wider development and dissemination of MSF in line with its role as an international resource centre for the sector.

more funds are being transferred to the municipalities, although agencies still manage to obtain separate funding, as for example in Valle region, where a recent programme was implemented that covered 65 percent of investment cost if the municipalities would provide 35 percent.

Decision-making power did not change much during implementation. CINARA had the lead as facilitators with a 'stake' that the MSF system would be built. Yet it seems fair to say that these facilitators did not abuse their position, as communities remained interested, kept attending meetings and continued to collaborate. Several community members indicated in the 2005 review visit that it is "our system". Gradually, the facilitators introduced decision-making elements in the process with the communities, providing them with the necessary information and guiding the discussions, for example about tariff setting. In more recent projects, CINARA has changed its approach and is placing much more emphasis on leadership training and shared decision-making based on insight into the perceptions of problems and solutions. This better matches what is needed in practice. Adding MSF to a properly managed and controlled water supply system is not so complex and may only require a good design, a good operator and a discussion with the users about tariffs. But management and control were not well established in the systems that were included in TRANSCOL and the existing distribution systems were not in good shape. This makes decision-making much more complex, because users need to change their behaviour and their water use, which adds a clear dimension of common-property[18] management and concerted action and decision making. With hindsight, we should have given this much more attention, but we underestimated the complexity and impact of this dimension.

8.3 The attributes of MSF

The experience in Colombia shows that MSF is a promising technology for water treatment which has the potential to be appropriate for conditions in developing countries, but its attributes need to be taken into account to ensure a proper match with the context. Rogers (1995) often uses the words ‘innovation’ and ‘technology’ as synonyms and suggests that a technology usually has two components, the hardware (the tool) and the software (the information base) for the tool. Even if we broaden the definition of software to include the inter-relationships between people and technology, this definition still seems too narrow. TRANSCOL showed that to achieve sustainable performance of MSF technology it is necessary to include the ‘orgware’[19], the organizational base to introduce and sustain the technology, and the ‘ecoware’[20], the relationship between the technology, the ecology and the environment. This is in line with the suggestion of Leeuwis (2004) that innovation is a “new pattern of coordination between people, technical accessories and natural phenomena”. He stresses that “innovations not only consist of new technical arrangements, but also of new socio-organizational arrangements, such as, new rules, perceptions, agreements and social relationships, always involving multiple actors”. I will elaborate on the attributes in the four domains that I distinguish as they became apparent in TRANSCOL.

The technical domain, the ‘hardware’

The perceived attributes in this domain make MSF an attractive option for community water treatment. It is more interesting than SSF, as it is equally robust but has higher treatment efficiency, is able to treat water with higher turbidity and coliform levels than SSF alone, and is better able to accommodate abrupt changes in water quality occurring,

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[18] A common property is a property for which user rights are attached to a specified user group (Edwards and Steins, 1998 in Steins, 1999).

[19] In my perception ‘orgware’ is the total of organisational concepts, regulations, methods, and measures for the introduction and operation of technology or as stated in TNT news June 2005 the institutional settings and rules for the generation of technological knowledge and for the use of technologies (http://www.iiasa.ac.at/Research/TNT/WEB/Page10120/page10120.html).

[20] The term ecoware includes for me the processes involved from the catchment area through to use, reuse and disposal.

for example, after it rains. It has also a considerable advantage over RSF, as it does not require chemicals, does not involve mechanical equipment and is easier to operate and maintain. But it takes more time to construct, whereas RSF package plants can be delivered on a truck.

In many locations, MSF can be built with local materials, although in some of the TRANSCOL locations in Nariño, availability of sand proved difficult and involved transporting it over rather long distances. Several technical 'inventions' have been developed in the project that facilitate operation and maintenance and so increase the attractiveness of MSF. They include fast drainage valves for gravel filters and a movable overflow-cum-drainage outlet.

The social domain, the 'software'

This domain concerns the relationship between the technology and stakeholders (Table 21). From the table it is clear that there are many different relationships that have important implications for the uptake of the technology and its performance. The relationship between MSF and users is more complex in developing countries because both control of the catchment area and regulation of water use involve important aspects of common property management, as will be discussed under 'orgware'.

Introduction of MSF will often require a change of the 'frames' (the worldviews of actors at all levels), establishment of new relationships among stakeholders, changes in their 'culture', and new regulations. Human actors need to understand the importance of good quality water and its relationship with their activities in the catchment area, the water source and their water use. They need to gain understanding of the complex interactions among human and non-human actors as presented in ANT. For example, in all TRANSCOL systems, introduction of MSF implied a forced reduction in water consumption, to keep the cost of water treatment at a reasonable level. A higher consumption requires a larger system and so involves higher cost. In some cases, water provision was reduced from 400 – 500 litres per person per day (l/p/d) to less than 200 l/p/d, partly through leakage control, but also through requiring change in the 'water culture'.

This domain also includes the knowledge needed to develop and sustain a technology, which for MSF was well established at the level of CINARA, who had benefited directly from the parallel research in the Pre-treatment project. This was not the case for the staff of the IRWGs or the operators, who had to gain insight and experience during the process.

The organizational domain, the 'orgware'

This is an important domain that concerns the institutional settings and rules for the generation and use of technology. An institutional framework is needed to ensure that rules and regulations are available to guide the management of the catchment, the water source(s), and the water supply (the 'common property', even though the users may not own it).

Table 21. Relationship between selected stakeholders and MSF in TRANSCOL

Category	Relationship
Decision makers	They appreciated TRANSCOL to some extent as it delivered good quality MSF systems (value for money), but they gave higher priority to coverage than to quality.
Planners and designers	They learned about the technology in TRANSCOL. Increasingly, MSF is also becoming part of university curricula and available in text books. They seem to have difficulties in appreciating the biological nature of MSF. Few go back to systems in the years after their design is built.
Contractors	It was their first experience with MSF construction, but many components are standard construction practice. Difficulties were observed particularly with cleaning of filter media and quality of construction.
Operators	They learned the job on the plant, but gradually adjusted maintenance practices, partly because several were replaced over time with inexperienced newcomers. They are crucial for sustained performance but see MSF as a mechanical system and do not appreciate its biological nature.
Users	Their water-use behaviour may lead to overloading of the MSF. The importance of water quality still seems underestimated by many users; hence they may put pressure on operators to provide more water.

In our review we found a number of MSF systems that were well organized and these were showing good performance. In many others the organizational setting was not adequate. In theory, municipalities are responsible for the organization of water supply provision and this is clearly established in the law. In practice, however, they lack the knowledge, capacity and skills to support the operators of MSF systems (and also of other types of water supply systems – even those without treatment). As a consequence, the organizational setting and the available back-up support in most MSF systems does not match the requirements of the technology.

A CINARA colleague expressed this very nicely: “We see a separation between the technology and the politicians who take decisions, change operators, putting in people that are not trained, etc. This separation between the political (decision-making level) and the technology is bad for the technology. New political leaders take decisions without being properly informed. They receive information, driven by personal gains and not by the merits of the technology and so allow the application of technologies and procedures that are not adequate”.

Operator training was carried out in TRANSCOL, but it was not institutionalized in the regions, nor was performance monitoring of systems and operators carried out in most systems. In several non-TRANSCOL systems, however, the situation was different. These systems received continuous support from CINARA, for which the communities were paying. These systems look better; maintenance practices are followed; and performance is good. Clearly the context for these systems differs from many of the TRANSCOL communities (and the majority of the communities in Colombia). They are better organized, monitor their systems, have well-trained operators who are supervized, make efforts to control water use and can afford to seek advice from CINARA as needed (some frequently receive visitors accompanied by CINARA staff).

The environmental domain, the ‘ecoware’

MSF is a biological treatment process involving a complex water ecology that needs to be dealt with carefully. It is essential to smooth the progress of the treatment process by ensuring that a continuous water flow is maintained to supply oxygen and food to the bio-film in which treatment is taking place. A related issue is the possible influence of turbidity peaks. They should not reach the SSF, as this may not only cause premature blocking but may also cover part of the active bio-film. This requires proper care for the pre-treatment units that are part of the MSF. Any interruption of flow should be as brief as possible to reduce the decay of micro-organisms. Interruptions will always lead to a temporary breakthrough of potentially disease-causing organisms, making disinfection an important safety barrier against disease transmission. If disinfection is not provided, the solution is to run the water of the SSF units to waste for approximately two days, depending on the local environmental conditions, before putting the water into supply. The important task of ensuring proper conditions for biological treatment will be more easily carried out if operators understand the biological nature of the process. The 2005 review suggests that this was often not the case.

The environmental domain extends beyond the MSF system. It starts in the catchment area, where adequate protection is essential to avoid erosion and contamination of the water to be treated. When problems in the catchment area are caused by the actual users of the water system, it is often easier to create a better understanding of the impact on the treatment and encourage them to change their behaviour. This domain also extends to the distribution system[21]. Virtually every water distribution system is prone to the formation of biofilms, regardless of the purity of the water, type of pipe material, or the presence of a disinfectant. Growth of bacteria on surfaces can occur in the distribution system or in household plumbing (WSTB, 2005). MSF seems to result in lower biofilm formation because of its high removal efficiency of organic matter, but regular monitoring and occasional cleaning (flushing) of the distribution network are still needed.

Although the environmental dimension was limited in TRANSCOL, the software and orgware dimension was strengthened by moving towards dialogue and learning, and by bringing in stronger linkages with the users, thus adhering to what Röling had already noted in 1988 as: “the fastest gain in extension effectiveness being measures to

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[21] Experimental studies are ongoing, for example in the USA, to understand the physical, chemical, and biological activities that occur in drinking water distribution systems (US Environmental Protection Agency; http://www.epa.gov/ORD/NRMRL/wswrd/distrib.htm

strengthen the flow of information from and about target clients to the intervening party". The TRANSCOL team recognized that research, extension, education and users form a system.

The lesson that can be learnt is that an important change is needed in the 'software', the 'orgware' and the 'ecoware' in the water sector in Colombia to guarantee that not only the better-off can benefit from good water supply. It is not just scaling-up of MSF that is needed, but also scaling-up of a software approach to community-based sustainable water supply. Based on my experience and the general understanding in literature, this lesson requires political will and goes well beyond Colombia. Indeed, it seems to apply to all developing countries.

Putting the MSF experience in context

Looking at the relative success[22] of different MSF systems in Colombia, a picture emerges that some are performing well, whereas others are working but with a number of limitations. At the risk of some over-generalization, I have made a comparison of these systems (Table 22).

The results show that, while MSF is a simple technique, in the sense that it only requires a few concrete boxes with some pipes, valves, gravel and sand, it is in fact a very complex technology (the technique embedded in context), because of its software, orgware and ecoware implications. It deals with a complex biological process of partially invisible water quality improvement (which may often not be especially attractive to the users). Also it may represent conflicting interests among stakeholders using the water catchment area, the water source and the treated water.

Dealing properly with MSF means combining the positivist approach to technology transfer that ensures that a suitable technology is selected for a specific location with maintenance requirements that can be met, with a more constructivist approach that accepts that multiple and sometimes conflicting social realities exist that are the products of human intellects, but that may change as their constructors become more informed and sophisticated (Guba & Lincoln, 1994, cited by Hamilton, 1995).

8.4 Technology transfer and diffusion of innovation

From the experience with SSF and MSF, and also with VLOM pumps, a picture emerges that technological innovation in community water supply seems to be driven primarily by universities and large donor projects. Some innovations may come from manufacturers, but primarily as a spin-off from research for commercial applications in large systems in developed countries. This is most likely to be because there is not a 'market' in

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[22] MSF has gained a lot of recognition as can be seen from the journal Semana no 1208 of July 2005, Bogota, Colombia, where it was listed as one of ten Colombian inventions that were mentioned as an inheritance for humanity. It was portrayed as a combination of two knwon technologies brought together by the work of CINARA.

Table 22. Comparative analysis of 30 MSF systems in Colombia

Issue	Satisfactorily performing MSF (12)	MSF performing with limitations (18)
MSF design and structure	Adequate	Adequate
Maintenance of structures	Adequate	Not up to standard
Distribution system	Reasonable quality	Often in need of repairs
Control of consumption	Metered	Often not metered
Interest in water quality	High	Only partial
Operators	Trained	Less or ‘self’ trained
Management	Active	Passive
Monitoring	Yes	No
Access to advice	Good	Very limited
Catchment protection[1]	Sometimes	Sometimes

1. The situation differs very much. Some systems are connected to a single small catchment which in some cases is well protected (nature reserve); other systems take water from rivers and streams that connect to different catchments, which can be more or less protected depending on the level of activity of environmental control agencies

community water supply treatment, perhaps with the exception of selling compact RSF systems and disinfection equipment.

In agriculture, the role of research seems to be more prominent and to involve more actors. Farmers have been the inventors of many new products with a potential commercial or environmental value. This makes the dialogue between science, industry and farmers very important for the development and diffusion of innovations in this sector. This understanding, which is presented by many authors (Leeuwis, 2004; Röling 1988; etc.), has led to the fair criticism of Rogers’ linear technology transfer model that the situation in agriculture is more complex. The positive scaling-out and limited scaling-up of MSF discussed in section 7.7 shows that the situation in the water supply sector is also very complex.

On the basis of the case studies, it can be argued that there is no single diffusion model for MSF technology. In fact, two models can be used to explain part of the experience:

- A diffusion model
- An entrepreneur-driven chain-linked model

The diffusion model

MSF diffusion did and does take place and was particularly successful in communities where the ‘framework conditions’ in terms of software, orgware and ecoware were adequate. MSF systems are operating in quite good condition in a growing number of locations in Valle region. Often the communities in these locations are the better-off, who are interested in good water quality, and several communities include people with close contacts with Valle University. Others obtained support from engineers that worked in TRANSCOL or used the project's published results. These communities were able to establish the conditions under which MSF performs well, e.g., trained operators, controlled consumption, quality monitoring and access to back-up support when needed.

Under these conditions, it can be argued that diffusion may follow the model of Rogers (1995) in that the MSF technology was developed by science, handed over to extension workers (engineers in this case) and adopted by water committees. This suggestion seems to match the view of Chambers and Jiggins (1987, p. 36) when criticising the TOT (transfer-of-technology) model: "rates of return to successful agricultural research are high where the beneficiaries are the better off. . . Socially the better-off share class and professional attitudes and values with the scientists, with whom they quite readily communicate". As shown in the case of MSF they can then create the conditions under which the technology can work.

This was very much the case in el Retiro (Box 6 in Section 7.4), where several teachers from the University had their residences. In this community, the water source is a river connected to a well-regulated catchment area. This water is suited for MSF treatment. The community has a strong water committee with the capacity to properly finance, control and manage operation of the treatment plant, control consumption, and access back-up support when needed. Under these conditions, systematic decision making favoured MSF, as decision makers were well aware of its positive attributes and were interested in water quality. In fact the MSF system replaced an earlier RSF system that was not performing very well and involved much higher operating costs than the current MSF.

But the TRANSCOL experience also shows that in most cases these conditions are not met, making the diffusion of MSF a much more complex problem. The question then arises as to whether the problem can be solved by adapting the technology to match the societal conditions, which was the drive behind the development of hand pumps that can be maintained at village level (VLOM). Yet the relative failure of the VLOM approach (Colin,1999) shows that technological innovation was not able to solve the complexity of the problem. So, the only option is to adapt society to the technology (scaling-up), by effectively facilitating adjustment of the software, orgware and ecoware, and if needed the hardware (as was done in the case of VLOM pumps), to ensure the best possible match of these four domains. In many Colombian communities where MSF systems have been built, there is still a mismatch between the technology and society which, if not taken care of, eventually may impede further diffusion of MSF. On the positive side, we find that several communities are making efforts to improve their systems, possibly as a result of increased awareness about the importance of water quality through information from television, radio and newspapers, among others. On the downside, we see that operation and maintenance problems have grown over time, due to inadequate management and, if not remedied, this may encourage operators to abandon their MSF. Under these conditions, diffusion cannot be predicted with the Rogers model.

The entrepreneurial 'chain-linked model'

The previous section clarifies only part of what happened with MSF scaling-out during and after TRANSCOL. To understand this better, we need to look at the leading actors in the development and diffusion process, for which 'entrepreneurial change agents' seems an appropriate term. It can be argued that the development of MSF by staff from CINARA and IRC followed a kind of chain-linked model, as developed by researchers of commercial innovations. Mahdjoubi (1997), in his description of the model (Figure 21) developed by Kline and Rosenberg (1986), indicates that: "the general process starts with a market-finding phase (a perceived opportunity) followed by design, production, marketing and distribution, and use phases". The development of MSF followed this model and benefited from the dialogue involving researchers in the Pre-treatment project, practitioners in TRANSCOL and the operators, which led to some adjustments and fine-tuning in the technology. This feedback loop is an important component of the chain-linked model, but is not included in Rogers' diffusion model. "The Chain-linked model differs from the linear diffusion model in a number of ways: there are multiple paths from which innovations may arise and many forms of feedback. Research is not normally considered to be the initiating step (in fact, research occurs in and contributes to all phases in the innovation process), and the primary source of innovation is now held to be stored knowledge and technological paradigms" (ibid). The feedback from the market may lead to adjustments in the innovation, but what seems to be lacking from the model looking at the MSF experience is that marketing may not be sufficient if the context does not permit the sustained performance of the innovation. Under those conditions, contextual change ('scaling-up') is needed, which often will go beyond the possibilities and interests of the entrepreneur, as it would require the involvement of the government and other stakeholders.

In the case of MSF, the CINARA and IRC staff identified a potential market and started to talk with staff in national and regional government agencies in Colombia. The staff shared their views about the need for a water quality improvement technology suited for the large number of small community water supply systems in their country. The positive response from these agencies and the positive findings from the SSF project and the pilot research triggered support from the Netherlands government. This allowed CINARA and IRC to continue with the 'entrepreneurial dream' to further develop and disseminate MSF technology, not for financial gain – although the project sustained the salary of quite a number of the actors – but because they believed in MSF and were concerned about the need for good quality community water supply to reduce the incidence of waterborne disease.

The dissemination process continued through the learning projects in TRANSCOL, in which change agents learned about the technology and methodology. Participation was

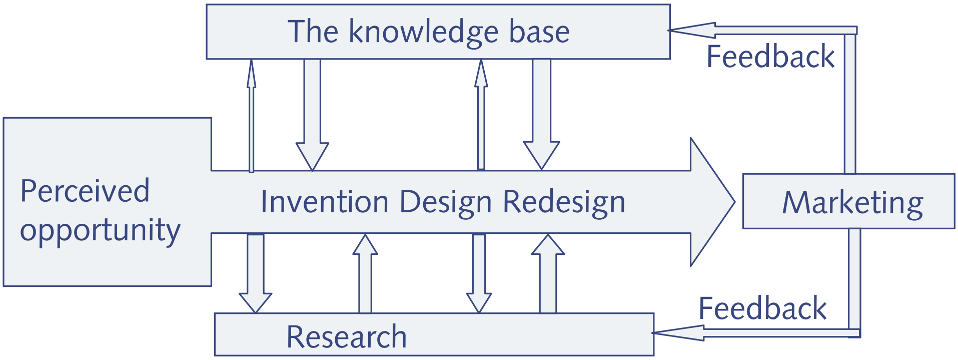


Figure 21. The chain-linked model of Kline and Rosenberg (1986)

made easy for the communities in TRANSCOL, because CINARA and the IRWGs facilitated the process and managed to obtain considerable co-financing. That made adoption of MSF an opportunity that could be obtained with relatively limited efforts on the communities' side – just participation in workshops and accepting a higher water tariff. This was still an institution-driven approach that happened to match the interest of a number of regional organizations and at least part of the members of the community. It can be argued that this cannot be considered true diffusion, as it is still a kind of 'one-organization show', even if it is always in collaboration with others.

After TRANSCOL the situation changes

After TRANSCOL, diffusion took a new turn in Colombia, stimulated partly by CINARA staff but also by others and mostly those who had been involved in TRANSCOL. Conditions were now different in that costs, including those of CINARA, had to be financed through normal sector programmes and/or directly by the recipient communities. This made it more difficult to follow the comprehensive approach that had been applied in TRANSCOL, which implied that MSF moved gradually from an integrated domain back to an engineering domain. At the same time, MSF became an integral part of the curriculum of several universities. Unfortunately these curricula also favour engineering aspects and only to a very limited extent include the crucial aspects of software, orgware and ecoware.

This may imply that scaling-out of MSF will continue, as it will become part of the solutions young engineers have 'on the shelf'. But this is likely to have a limited effect if scaling-up is not taken much more seriously in the sector and in universities. CINARA and IRC keep striving for that to happen. CINARA is continuing its entrepreneurial approach, which has led to the development of MSF learning projects in Ecuador, Mexico, Bolivia and most recently in Honduras and in Caldas, a region in Colombia. These activities are financed by national or regional governments and development banks. This is strong evidence that interest in the technology is growing. In a way the approach of CINARA can be compared with some industries that are promoting the sales of RSF package plants, but with two differences: (i) The MSF design is in the public domain so is not patented and anybody can use it; and (ii) CINARA keeps promoting its introduction through learning projects to stimulate further diffusion and not for financial gain.

Taking an Actor Network perspective

We can also look at the introduction of MSF in TRANSCOL from an ANT perspective. Initially ANT was developed for the analysis of scientific innovation. It is an approach that thinks of the technological and sociological development together (Stalder, 1997). In his study about how Frederic Joliot, the nephew of Marie Curie, engaged France in an important research programme to build a nuclear reactor, Latour (1999) argues that Joliot was faced with different challenges. He had to get the reactor to work, convince colleagues, interest the military, politicians and industrialists, give the public a positive image and at the same time understand what is going on with these neutrons that have to become so important to the parties. This is clearly a problem that involves human and non-human actants, which have to be 'convinced' through using different skills and discourses. Following this line of thinking, the challenge of introducing MSF can be seen as a similar problem with multiple actants.

Four different operations can be identified in the process to meet the challenge (Callon, 1986).

- *Problematization*, the operation of identifying a problem (in the case of TRANSCOL, the prevailing water quality problem in many communities that could be solved with MSF), and then identifying other actors and their interests;
- *Interessement*, the operation to interest other entities. This in fact was a very important and complex part of the project, and included issues such as discussion with donors, politicians, researchers, communities, but also building pilot systems, creating conditions for bacteria to perform better by pre-treatment, etc.
- *Enrolment*, the moment that another actor accepts the interests defined by the focal actor, which happened at different levels and at different moments in the regional meetings, the research on pre-treatment, etc.
- *Mobilization*, the transformation of enrolment into active support, which in the case of the project can be exemplified with the work of the IRWGs, the community groups, the MSF systems, etc.

The project achieved considerable mobilization, including sustained interest in MSF from universities and sustained performance of systems, but not for changing the 'framework conditions' (scaling-up) needed to sustain wide-scale water quality improvement. In retrospect, it can be concluded that it was a mistake that changing the framework conditions was not in itself included as an aim in the project, as this very much hampered the wider application of MSF (which was an aim of the project). An advantage of taking an ANT perspective is that it forces you to think about the influence of both human actors and non-human actants such as the prevailing rules and regulations, the political setting, environmental change, etc. These indeed had an impact on the dissemination of the technology that is not reflected in the linear model of Rogers, nor in the chain-linked model of Kline and Rosenberg. In the conservative water sector, it requires a real champion and a learning process to make things happen. As I will discuss in the next section, learning projects were an essential tool in the process – the 'boundary objects' that allowed the learning process to take place.

8.5 Learning projects and facilitation

The emphasis changed from information sharing and demonstration, to joint learning in learning projects. This change is based on ideas about adult education and experiential learning, and is characterized by the shift implied in social learning from multiple to collective or distributed cognition (Röling, 2002). This change seems to be well in line with the oral nature of information sharing that is common in Colombia. It matches the need for understanding and concerted action implied in 'collective innovation'. Installation of a 'new common good' requires a contribution from the users as well as controls to avoid the phenomenon of 'free riders' (people using the public good without contributing to it). In water supply, the free-riding has an important social dimension, as access to water is seen as a basic human right. Special measures may therefore be required to ensure access for users who cannot afford to contribute, e.g., extremely poor households. These measures need to be part of the learning process and the stakeholder dialogue.

Learning can be considered as "a process of knowing based on experience and practice. In this perspective, knowing is inseparable from a subject capable of speech and action" (SLIM project, 2004). The learning projects demonstrated that different levels of learning are needed in community water supply to ensure that a collective innovation can be effective. They confirm the assumption of Groot et al. (2002) that: "reflection on action, and preferably in action, is essential for social learning to occur". Looking at the results from the review in 2005 with the benefit of hindsight, it seems that learning needs to be a much more continuous process and to be established in such a way that it can address and influence problems at different levels, because some problems, such as water quality monitoring, usually cannot be solved at the level of an individual community.

The emergence of learning projects was a very relevant aspect of the project. Two different types of LPs seem to emerge from this experience (Figures 22 and 23).

- **Technology Development Learning Projects** (TDLPs) bringing different stakeholder groups together to jointly develop and learn about a new technology or approach (social learning and learning through applied research). This reflects the approach that was followed in TRANSCOL, because the MSF technology was further developed during the project and newcomers to the technology learned about it. Choice of project locations depends in this case on the presence of the problem to be solved, the possibility to implement research and the accessibility of the location to ensure that sector staff and other stakeholders can see the result.

- **Mainstream Optimizing Learning Projects** (MOLPs) to increase effectiveness of sector interventions by adjusting existing approaches and by identifying solutions to specific problems jointly with sector staff and communities. This is similar to a TDLP, but instead of developing a single technology, it looks at a range of sector problems. The approach creates a 'test ground' in parallel with mainstream projects. This type of project was used by CINARA in the School Project in Cali. Its basis is a joint inventory of water supply interventions and problems in a given area (for example, a region or a district) in which a water supply programme is being planned or implemented. The most important problems are identified and communities are selected jointly with agency and university staff, to develop and test solutions to these problems. Sector staff is involved in these MOLPs on a part-time basis, while working in parallel in other projects, where they can try to apply what they have learned. In this way an innovation and reflection process is added to a mainstream implementation programme. Project locations will depend primarily on the occurrence of the problems to be solved.

When results are positive, some locations may be transferred into training and transfer learning projects (TTLPs), spaces to support technology-transfer training adopting a 'learning-by-doing' approach, because apprenticeships are considered as perhaps the most effective way of knowledge sharing. If possible, project locations should be chosen in such a way that training and demonstration is facilitated, which implies easy access, good facilitation and a supportive community. CINARA is developing the concept of 'community learning centres' around this type of project, where the community takes active part in, or even leads, the training of other communities.

The intuitive decision to focus on MSF as a socio-technical object in the learning projects shows a very interesting parallel with the positive experience with water management by movable weirs used to control water levels in the Netherlands presented by Jiggins (2002 p.5). She indicates that the decision taken "to focus on action around socio-technical objects such as the weirs, and metered use of overhead sprinklers was informed by an understanding that in change management it is better to:

- begin the action than wait for perfect advice, or for the actions required by others;
- develop your own experience and data;
- be recognised as an informed voice when negotiating meaning and value".

She reports that the weirs, which were under farmers' control, provided learning opportunities that were valued by all stakeholders and pulled distinct stakeholders into new relationships. The learning projects in TRANSCOL offered a very similar experience. They provided a concrete issue for different types of dialogues and action, with adjustments being made in the course of time and an emphasis on informed choice. At the same time, Jiggins mentions that there is ambiguity in the policy and the application of weirs in the different areas of the Netherlands that participated in the project (ibid), which seems to indicate a need for scaling-up similar to the one identified for MSF in Colombia.

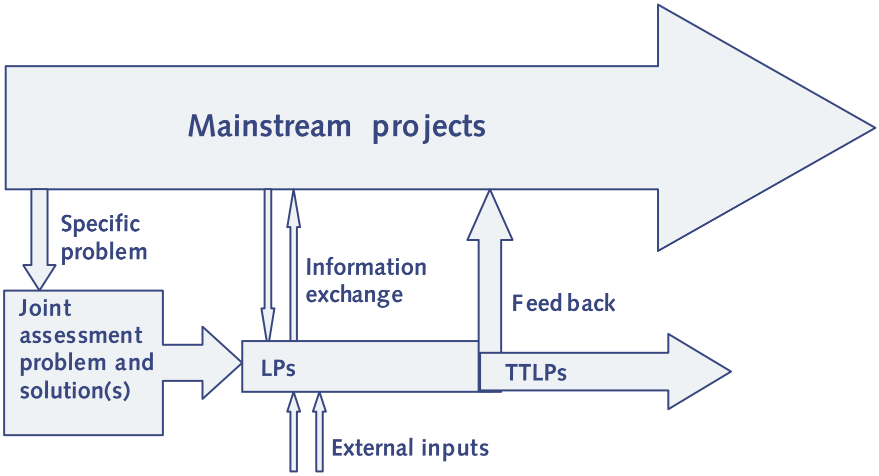


Figure 22. Technology Development Learning Projects (TDLPs)

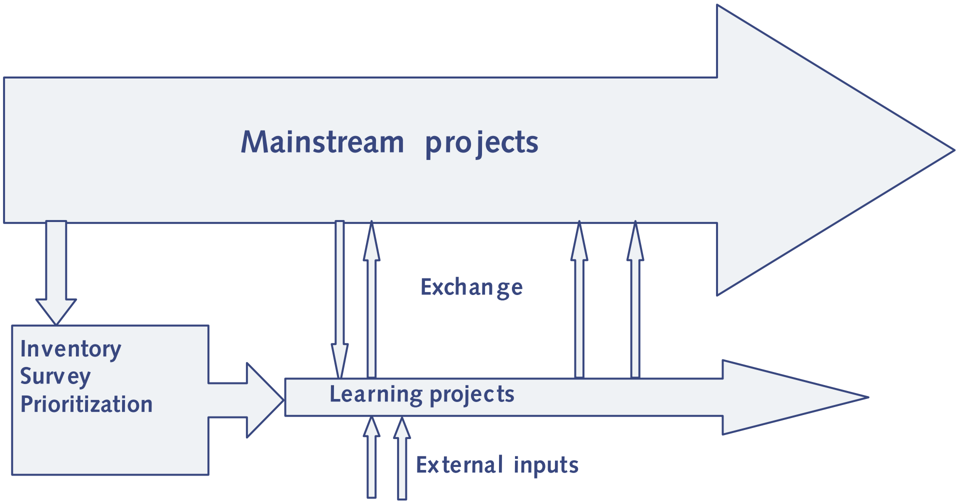


Figure 23. Mainstream Optimizing Learning Projects (MOLPs)

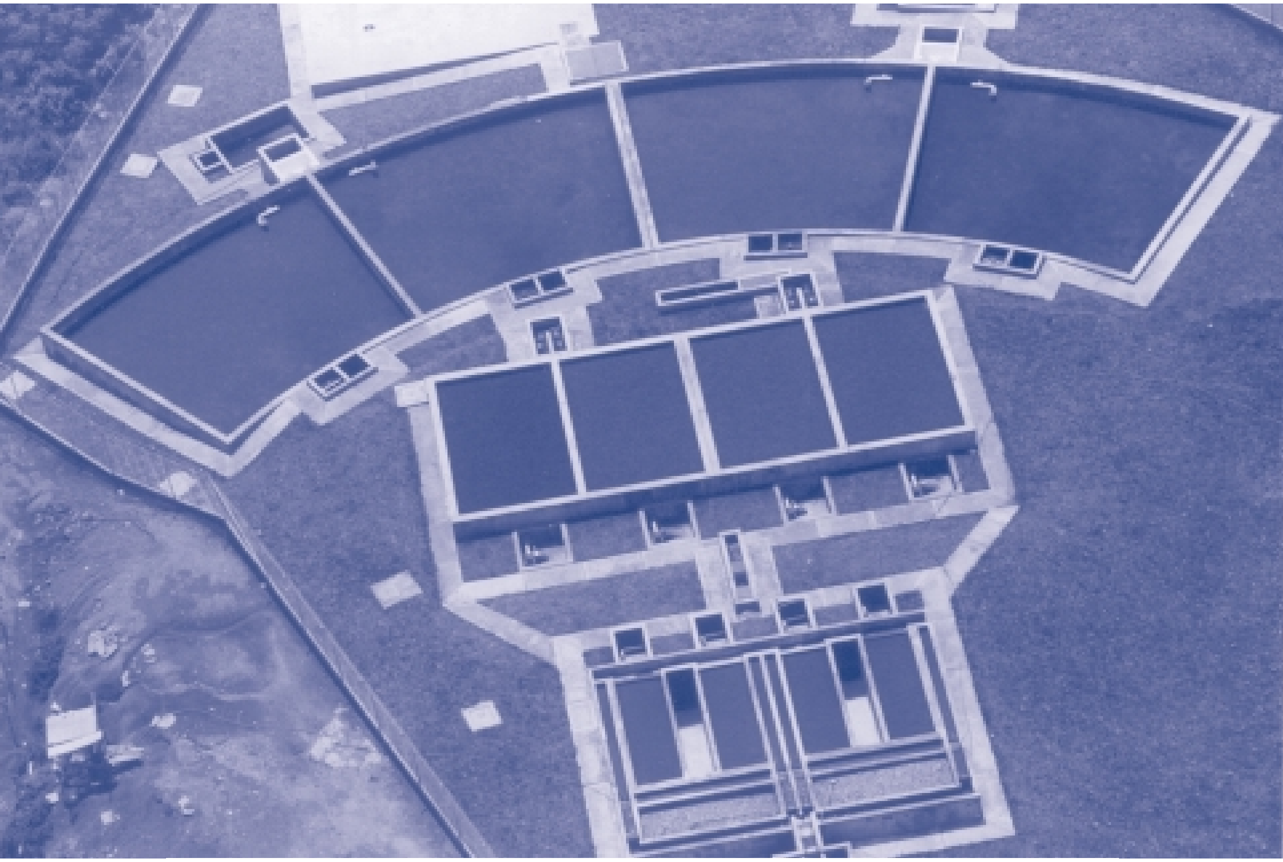
The MSF learning projects match well the definition of a ‘boundary object’, which stems from the larger theoretical body of ANT. Boundary objects are abstract or concrete objects which ‘inhabit’ several intersecting social worlds. They “have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation” (Star and Griesemer, 1989 p 393). To fulfil their function, boundary objects, or what Vinck and Jeantet (1995) call intermediary objects, should have all or part of the following properties (Mauret et al., 2003):

- Common point of reference for conversations;
- Support and reveal different representations of the reality, meanings, points of views;
- Means of translation between individuals or groups belonging to different communities of knowledge. Even if a full translation seems utopic, the structure of a boundary object is shared enough to work together;
- Means of coordination and alignment;
- Working arrangements, adjusted as needed and not imposed by one community or by outside standards;
- Plastic enough to be transformable (an "open" object and not a "closed" object) during the interaction process;
- Trace of the collaborative process (successive proposals of transformation, successive states of the final output, comments, etc);
- Help to manage uncertainties (through development of trust, increase of knowledge, larger number of solutions found and evaluated, etc).

According to Harvey and Chrisman (1998), boundary objects do not provide a common understanding or consensus between participants. They do not create a common language or a perfect translation. Instead, boundary objects serve a dual function: at the same time as they serve to distinguish differences, they also supply a common point of reference. However in the case of the MSF LPs, it can be argued that an element of common understanding was strived for as well as, perhaps not a common language, but at least a language that the community could understand. These projects resulted in a different relationship among actors and particularly increased understanding between staff with a technical background and those with a social background. Also the 'pedestal' of the agency staff visiting the communities was removed and changed into a much more horizontal relationship.

Looking at the review results in 2005, it seems that the learning projects indeed had an impact when they were implemented and some of the actors were changed for life. MSF systems are still operating be it with certain limitations whereas it is still common in the sector that water treatment systems fall into disrepair rather soon after they have been built. So I would argue that our results are positive but, because of limitations in scaling-up, part of the effect gradually faded away in terms of the interaction needed to manage the collective dimension of the MSF water supply. As Leeuwis (2004) indicates, this collective dimension requires new forms of interaction, organization and agreement among multiple actors. During the learning projects, agreements were establishment with different actors, but only for the duration of the project. Thereafter the actors were left to their own devices. In later projects, CINARA has strengthened its interventions, emphasizing leadership training at the community level, but unfortunately financing agencies still allow for rather limited interventions to keep the short-term costs down. This is an important problem, because learning projects, facilitating interagency collaboration, and social learning require upfront investment in interaction, while aiming for long-term results. The problem remains however, that donor agencies and government still seem to pay lip service to long-term sustainability and still opt for short-term results and cost savings.

The complexity of community water supply, the community-based approach, and the mediation needed within and between communities and agencies pose special demands on the facilitation of development processes, and require special characteristics on the part of the facilitator, which I have already highlighted in section 7.7. Facilitation has to be change-oriented, as it needs to touch the culture, beliefs, skills and relationships of people. Therefore the training in TRANSCOL included sessions guided by psychologists and creative workshops, to put people in a different context and open them up. The leadership training that CINARA now applies with participants from the associations of water service providers, for example, goes even further. It includes participants reflecting on their self-image and how they are seen by others. Participants also discuss gender issues, linking them to personal situations. Separate meetings are held with male and female participants. The creative workshops really helped to change people and stimulate dialogue in a complex society, in which bullets are sometimes considered easier than words for solving a problem. In my view, this experience from CINARA matches the philosophy of Freire (1970) and actually takes it further. Agencies (trainers) can learn a lot from communities (students), and communities can learn a lot from agencies, but both can also learn from sharing among themselves. The keys to these processes are trust, reciprocity, self-confidence, genuine leadership and often good facilitation.



Multi-stage filtration plant in Mondomo (photo CINARA).

9. Conclusion and looking ahead

"People want to change, but not to be changed." Peter Senge

The conclusions in this chapter are based on the rich experience reviewed in the case studies and in some of the follow-up activities from CINARA. This experience has directly contributed to improving the water supply situation in a number of communities, but more importantly created opportunities for communities and sector staff to learn about a soft-system approach to community water supply treatment, initially focussing on SSF but later on MSF, a technology that can be applied more widely. The conceptual thinking underlying this experience has changed over the years, based on insights emerging from the projects, but also influenced by a change in overall thinking in the sector. This chapter draws the most salient experience together in a number of conclusions that are guided by my research questions and touch clearly on the beta-gamma character of my study. Hopefully, these conclusions will stimulate further discussion and critical thinking about water supply interventions, because much is at stake and considerable change is needed if we aspire to come even close to achieving the Millennium Development Goals (MDGs). As discussed in the first chapter, the number of people that have no access to safe water supply is considerably higher than official statistics suggest, because good water quality is not guaranteed in most systems due to lack of catchment protection and absence or non-performance of water treatment. Also a new threat is emerging from global climate change and is already influencing water availability and water run-off patterns in many places.

In the second part of this chapter, I present FLAIR (Facilitating of Learning, Application, Implementation, and Reflection) which draws on the experience and brings the elements together to meet the second purpose of my research, the search for an effective approach to introduce water treatment in community water supply in developing countries. This approach proposes facilitation of learning as a key strategy to introduce change and has wider application to improve sector performance. The concept of FLAIR emphasizes the need for facilitation to establish the collective innovation that is implied by the introduction of water treatment. The concept integrates many ideas that may help to make sector interventions more effective and efficient, while building on experience in other sectors in which a larger body of research exists.

It is important to keep in mind that the experience gained in TRANSCOL is encouraging, but might have been even more positive had it not been partly constrained by the difficult situation in several of the project communities because of security problems in Colombia, particularly in rural areas. This has led to people leaving their communities (brain drain, fewer users to share the cost, etc.), placing a strain on the sustained management of the systems. Other communities grew excessively because of the influx of displaced people, putting pressure on a quick expansion of water treatment systems, which is more readily accomplished by (less sustainable) chemical water treatment. Also, some community members may have been afraid to participate actively in the project because of its participatory approach, which could be associated with socialist movements and so may involve a personal risk of forcing people to flee their community or worse.

9.1 Main conclusions

The most salient conclusions from this study relate to seven main areas which I will summarize in this section.

The water sector in developing countries needs a new paradigm

A number of salient factors characterize the water sector in developing countries and have been confirmed by my case studies. These factors include:

- Financing of most water supplies comes from public funding, through government contributions, donor grants or soft international loans. This seems to reduce interest in 'innovation' and in the long-term sustainability of investments. Research funding for the water sector is scarce and often involves donor funding channelled through research institutions in donor countries;
- Construction of new systems has priority at the political level over operation and maintenance; and water quantity often has priority over water quality;
- Decision makers may have considerable vested interests. It is suggested that 20 to 60 percent of resources could be saved if transparency was optimal and corruption eliminated (Shordt, 2005);
- Users are at the receiving end and have no direct say in investments, whereas ultimately they pay the price through taxes or, increasingly, tariffs. As a result, increased efficiency through innovation is not a priority;
- Users, often without realising it, interfere with their water system. They may face a kind of 'Prisoner's Dilemma' in managing their common property. When water does not flow from the tap, for example, because of (temporary) low pressure, they may leave their tap open when leaving home. Their bucket may fill up and probably overflow, but as a consequence others living at higher elevations may not receive water. If they keep the tap closed, no water may be available when they come home. The added complication is that if people open their tap only when they need water, the users at higher elevations still may not receive water because of high leakage and low pressure in many distribution systems;
- Hard-system thinking still seems to guide decision making in the water supply sector, which is primarily driven by engineers. This type of thinking however fails to establish sustainable solutions. Engineers seem to hinder a switch to soft-system thinking and learning. Chambers and Jiggins (1987 p. 39) indicate about engineers that "their education and training are shaped in the TOT (transfer-of-technology) model. The hierarchical learning of schools and universities implants the idea of learning from above and teaching to below. By the time they leave universities, engineers have been deeply conditioned to believe that …their knowledge is superior". Thus engineering education (university curriculum) needs to change to ensure that the professionalism of engineers incorporates a social component and/or that social scientists obtain more key positions in the sector.

These factors are important causes for poor sector performance. What is really needed is a new paradigm for the sector. This is perhaps the most important conclusion from this study, because it touches upon the lives of so many people in need of better water supply (and sanitation) conditions. To support these people in gaining access to better services, governments, universities, and sector staff need to recognize and understand that water supply problems cannot be solved through hard-system thinking. It needs a soft-system approach that recognizes that:

- Multiple views exist about problems and solutions among the stakeholders involved;
- Decisions need to be guided by aiming at long-term sustainable service provision and not just short-term construction targets;
- Social learning is essential to understand the local problems in their context, equally valuing communities', practitioners' and scientific knowledge;
- Facilitation of the process will often be essential in view of its complexity and the potential for conflicts of interests among stakeholders;
- Multiple scales need to be considered, not only at the service level, but also at the level of framework conditions.

Sector improvements will often imply 'collective innovation', which can only materialize based on broad understanding and concerted action of the actors involved. This requires an inter-institutional and interdisciplinary approach. My case studies confirm the need for what Jiggins (2002) calls "shared learning across political and administrative hierarchies, resource management jurisdictions, and divergent disciplines and domains of experience for which 'social spaces for learning' need to be created".

The required learning in the sector has to ensure that sector staff and communities become able to master the four logics that are required to create the basis for sustainable water supply solutions:

- The technical logic, "*the hardware*", that is needed to ensure that the proper type of system is being built based on an adequate selection of the technology that must be able to cope with the water quality and quantity problems at hand;
- The social logic, "the software", which deals with the inter-relationships involving the technology, the water supply system, the operators, the users and possibly other stakeholders. This is a complex dimension because stakeholders have different frames and interests, and may, for example, not be aware of their interactions with the system. Innovation involves new perceptions and new relationships among multiple actors (Leeuwis, 2003);
- The organizational logic, "the orgware", the organizational base to introduce and sustain the technology and the water supply system, which includes institutions, management, supervision, training and ensuring back-up support when needed. Innovation involves new rules and regulations and new agreements (ibid);
- The ecological logic, "the ecoware", the relationship between the technology, the ecology and the environment. This concerns the whole water supply system from the

source to wastewater discharge, as the latter may contaminate water bodies downstream. For surface water supply sources, the system includes:

- Water catchment management and protection, which is needed to ensure water quantity and the first step in ensuring water quality. A growing body of literature shows that insufficient attention about the complexity of this management and protection puts water supply systems at risk of failure;
- (Biological) water treatment and disinfection to ensure a 'safe' water supply, but considerably adding to the complexity of the system;
- Managing water distribution systems in which biological and chemical processes may have an effect on water quality;
- Organizing wastewater discharge and treatment to reduce down-stream pollution.

Multi-Stage Filtration proves to be a promising water treatment technology

My case study shows that MSF is a robust water treatment technology that can perform well under the given conditions in Colombia, providing that framework conditions are in place, and ensure that operators understand the technology, the biological nature of the system, and the interaction with users, and receive adequate training and back-up support. CINARA's more recent experience suggests that MSF also has potential for other countries in the region and, based on its attributes, elsewhere in the world, again providing that framework conditions are in place. It has promising potential to help improve the water quality of many people in rural communities and small towns that depend on surface water sources. MSF has particularly good potential for gravity water supply, where the continuous flow necessary for the biological process is more easily guaranteed than in pumped systems, which in many developing countries operate intermittently. Operation and maintenance is equally simple as for SSF, but MSF is less vulnerable and can treat water with higher levels of contamination. It has the advantage over RSF that it is cheaper for smaller systems and does not require pumping to clean the filters, or chemicals (except for disinfection). After MSF, a lower disinfection dose is required than after RSF.

The cost of MSF systems will be largely determined by the water quality risk associated with the water source, the geomorphologic and geographical conditions, and locally available materials. Even so, based on the data from Colombia, indicative figures can be given for systems that provide some 150 l/p/d. The construction cost of such MSF systems range from US$ 27 to 46 per person, representing some 25 to 40 percent of the overall cost of the water supply systems. This implies a considerable investment but, according to Hutton and Haller (2004), the economic benefits of this investment far outweigh these costs and lead to accelerated growth. Operation and maintenance costs of MSF systems (excluding back-up support) may range from some US$ 0.7 to 2.2 per year (US$ cent 1.3 to 4.1 per person per week). These data cannot be generalized for other locations, but it may be expected that the order of magnitude will be similar.
It should be kept in mind that MSF is not a panacea; it is not a solution to all water quality problems. Water with a high colour or excessive pollution, for example, may need other types of treatment. Sound technology selection is essential to ensure that the

proper treatment objectives are achieved in relation to the available water source and user requirements.

Scaling-out takes place but is constrained by lack of scaling-up

Scaling-out and scaling-up are two aspects related to my first and third research question: How successful was the introduction of water treatment by SSF and MSF? And, have the conditions been created to sustain the technology? The answer is that results are mixed and initially were most positive in India, but the additional efforts in Colombia proved even much more productive and revealing, resulting in scaling-out of MSF. Yet neither in India nor in Colombia, are general conditions in place to sustain the technology, except for its application in better-off communities, which properly manage and control their water supply systems and have the resources to obtain back-up support when needed.

Scaling-out of SSF took place after the SSF project ended, particularly in India once the revised design criteria were included in the CPHEEO manual and the Indian Standards. However, in other aspects, scaling-up, the adjustment in the organizational conditions, did not take place, thereby hampering scaling-out. Lack of a critical assessment of the situation also hampered continued innovation, which I expect would have resulted in a much stronger emphasis on pre-treatment in India, as considerable operational problems in SSF systems were reported in a workshop several years after the SSF project ended (IRC-SSF, 1994). Scaling-out of MSF in Colombia is positive, but equally shows difficulties in scaling-up. Diffusion did take place and was particularly successful in communities in which the conditions in terms of software, orgware and ecoware were adequate to sustain the technology and the water supply system. Often these communities are the better-off, who are interested in good water quality and they include inhabitants with close contacts with sector and university staff. Hence, in this type of communities, who are able to sustain the necessary conditions, MSF can be installed and perform very well.

But the case studies show that in many cases these framework conditions are not met, or do not match the complexity involved in the diffusion of MSF. This finding is in line with the difficulties experienced with the diffusion of VLOM hand pumps, where the technical innovation was also not sufficient to solve the complexity of the problem. Hence the only option is to adapt society to the technology (scaling-up) by effectively facilitating the adjustment of the software, orgware and ecoware, and if needed the hardware, (as was done in the case of VLOM pumps) to ensure the best possible match between these four domains.

Diffusion driven by entrepreneurs from IRC, CINARA and IRWGs

The case studies reflect thinking that was still very much based on the diffusion theory of Rogers (1995). The findings though show that, as expressed by many others (Chambers and Jiggins, 1987; Röling, 1998; Crul, 2003 and Leeuwis, 2004), this theory is not sufficient to explain the diffusion of complex innovations. In fact, the development of MSF actually better matches the chain-linked model of Kline, in which CINARA and IRC acted as entrepreneurs who saw an opportunity to develop a water treatment technology particularly suitable for community water supply in developing countries. Technology research continued during project implementation and led to further MSF improvement. During the project, CINARA staff had a strong say in decision making and were able to convince community leaders to adopt MSF.

Dissemination continued after the project through CINARA entrepreneurs as well as through members of the IRWGs. This led to diffusion of MSF systems in Colombia and also in other countries.

MSF performance results were positive in communities where conditions matched the technology, and under such conditions Rogers' diffusion model still seems to apply. However, in most communities, systems are operating with limitations, not so much as a result of inadequacy of the technology, but because of the conditions under which it is applied. To remedy this, interventions of a constructivist and holistic nature are needed, at both community and institutional level, because several support services that are needed to sustain MSF go beyond the level of individual communities (training, water quality monitoring, technical advice, etc.). This is an important deviation from Rogers' model and also of the chain-linked model, where a marketing phase is mentioned but no reference is made to the need to change the context, (the framework conditions) to ensure that the technology can be sustained. Yet this is an essential element to support MSF diffusion, because otherwise maintenance problems may cause operators to abandon their systems and that in turn will have a very negative impact on continued diffusion.

Universities and governments need to take more responsibility

An important factor in future scaling-out is that MSF has been included in the curricula of several universities and in international textbooks. This may lead young engineers to apply MSF, but entails a considerable risk of failure if they only learn about the technology and do not master the other dimensions. An interdisciplinary approach is needed, but that does not seem to suit the current organizational set-up of universities, which is generally based on mono-disciplinary departments.

A related issue is that governments and communities do not presently push for long-term solutions, or for programmes in which designers of water supply systems would be held responsible for the long-term results in meeting treatment and performance objectives. Putting such an orientation in place would force engineers, who are the main channel for the introduction of innovations, to adopt a soft-system approach and either involve social scientists in their work or try to develop these skills themselves, perhaps calling upon the universities from which they graduated to adapt too.

Learning project approach has potential

The learning project approach as developed in TRANSCOL has a great potential for technology transfer and for contributing to sector improvements. It creates multiple spaces for social learning on the multiple scales needed to develop, test, and learn about the complexity of community water supply. Learning projects create an environment for a combination of single, double and triple-loop learning, which, as suggested by different authors (Swieringa and Wierdsma, 1992 and Groot et al., 2002), is necessary to deal with complex issues. This type of learning has been shown now to help sector staff and other actors to better appreciate and come to grips with the complex inter-disciplinary nature of the water sector.

The learning project approach has very much to do with my second research question: How has facilitation of the introduction of the MSF water treatment technology emerged? Facilitation is an essential component of the learning projects and, I would argue, of any effort to build or improve community water supplies in developing countries. A learning project is a 'boundary object', an object which inhabits several social worlds, which supplies common points of reference and clarifies differences, thus creating a space for learning. Boundary objects are part of the broader Actor Network Theory, a theory that helped me to enhance my understanding of the complexity of sector interventions and the interaction among human and non-human actants in relation to the introduction and diffusion of MSF through the learning projects.

Reflecting on the experience, two types of learning projects emerged and have been discussed in more detail in section 8.5:

- **Technology Development Learning Projects** (TDLP) bringing different stakeholder groups together to jointly develop and learn about a new technology or approach (social learning and learning through applied research).

- **Mainstream Optimizing Learning Projects** (MOLP) increase the effectiveness of sector interventions by adjusting existing approaches and identify solutions to specific problems jointly with sector staff and communities, by establishing a few LPs implemented in parallel with mainstream projects.

Both types of LPs, when they succeed, can be transformed into training locations to help sector staff to learn to adopt a new approach or technology that has already been tested (learning by doing). Easy access to the location is therefore an important condition. These locations may, as is now being promoted by CINARA, develop into 'community learning centres', where experience can be gained in different technologies and methodologies.

I am very enthusiastic about LPs, which I believe can really make a difference in the sector. Good facilitation is perhaps the most important ingredient, because there are different perceptions of and interests in water supply problems and solutions that need to be mediated to help establish sustained action. This requires an independent subsidized advisory body to promote change, provide information support and be available for a second opinion (review designs, plans and agreements). Yet I have to recognize that sector agencies still do not seem convinced. They seem to be willing to spend only relatively small amounts on this type of learning and the new LPs of CINARA face resource constraints.

CINARA grew into an important development-oriented centre

CINARA was the driving force behind the introduction of MSF treatment and the LP approach in Colombia. Through the financial contribution from the Netherlands government, it became the 'subsidized advisory body' mentioned in the previous paragraph. It established the facilitation skills and learned a great deal in the process. Learning continued after TRANSCOL in subsequent projects and activities. With a staff of 26 sector professionals, including six teachers from Valle University, CINARA is in a good position to further its goal as a research centre in the university with a clear development orientation and an important resource function for the sector.

9.2 FLAIR, a different 'mindset'

Reflecting on the experience covered in this publication and the discussions with my colleagues from IRC and CINARA, it is clear to me that change is needed in the approach to community water supply: change which involves the hardware to some extent, but more importantly the software, the orgware and the ecoware. This brings me to my second purpose of enquiry, i.e. to contribute to the development of an effective approach to introducing water treatment in community water supply. In view of the complexity of any water project, it is essential to adopt a soft-system approach to ensure that stakeholders 'buy into' the innovation and the change that is implied in introducing water treatment or other improvements in the water supply. Interventions need to be developed along with the stakeholders. In that way, a shared understanding is developed of initially different interpretations of the problem and its solutions, based on consolidated information and a desire for collective action to implement the agreed solution(s).

Facilitation is the most important aspect of this process. Its importance is increasing all the time because of the growing 'water crises' that will inevitably lead to an increase in 'water conflicts'. This requires resource allocations that may appear to reduce the available resources for hardware interventions, but the poor performance of many development projects clearly shows the need for a different approach.
FLAIR has the potential to meet this challenge for change. I am using the acronym **FLAIR** to label the comprehensive approach needed to make interventions sustainable. FLAIR stands for Facilitating of Learning, Application, Implementation and Reflection (Box 15). It is a 'mindset' based on ANT. It recognizes interactions among and between human and non-human actants. It views the water supply system as a boundary object which is the playing field, or theatre of interaction, in which the different stakeholders meet. In view of the different interests that usually are involved, good facilitation is required to explore and make sense of the interactions and to jointly establish and implement solutions. With facilitation being the heart of FLAIR, the crucial question becomes who can take this on board. Initially, facilitation needs a skilled 'development facilitator', with a skill mix

Box 15. The key elements of FLAIR

The key elements represented in the Acronym are:

- **Facilitation** which is necessary because community water supply systems involve different stakeholders with different world views and often conflicting interests;
- **Learning** because problems and solutions are much less straightforward than often realized and many opportunities exist to improve the efficiency and effectiveness of interventions;
- **Application** of the learning, putting ideas into practice and seeing how they work out and can be further improved;
- **Implementation at scale** of new approaches, methodologies and technologies after they have proved their value;
- **Reflection** needs to be institutionalized as a continuous process. It is essential to stay alert about implementation and innovation, and to review and reflect on results in order to maximize learning and improve both theory and practice. It is crucial to go back to earlier interventions, as I have done in this publication, to learn about what works and what does not.

that goes beyond the ability to implement some participatory techniques (Box 16). It needs dedication, understanding of the situation, empathy and the ability to mediate among the different interest groups (see also 7.7). Furthermore, facilitators need to ensure that the different stages of the process and the agreements are properly documented, to keep track of developments and stimulate innovation and reflection. Reviewing the experience with TRANSCOL and some recent projects of CINARA, it appears that part of the facilitation, perhaps even a large part, can be trusted to community members. Peer processes start to develop, in which leaders of communities that have been involved in learning processes with CINARA staff help other communities to initiate action and take things forward. This can create the necessary snowball effect in which communities benefit from the experience of other communities and operators from other operators, etc., through the powerful concept of peer learning. With some guidance, communities thus may become a powerful resource base for the implementation of FLAIR. CINARA is implementing FLAIR-based approaches and is giving this type of guidance but only to a limited extent as the resources to take this up in a big way are not being allocated because of the continuing construction focus of sector agencies and governments.

This will need to change to give FLAIR-based approaches a chance to guide the learning in ‘normal projects’ (see section 9.3) as well as in specific learning projects (section 9.4).

Box 16. Tools to be used in FLAIR

Useful participatory tools include the following:

- Participatory mapping of the system and the catchment area (review the water source). Taking an amateur video and screening it for discussion with a wider group in the community can be very helpful to encourage discussion and the development of insights.
- Sanitary survey of catchment and water supply system including water-use analysis.
- Water quality testing using a portable test kit and a microscope.
- Stakeholder analysis, particularly exploring their interests (VENN diagram).
- Recollecting the water supply history.
- Assessment of willingness to pay.
- Transect walk looking also at the sanitation situation.
- ‘Summary reporting to share information and consolidate agreements with the community and other stakeholders.

9.3 Improving community water supply projects with FLAIR

Improvement of the water supply in a community is a complex process that needs to be facilitated. Often, some or all stakeholders will need to learn to come to grips with a ‘new world view’ as a precondition for the introduction of ‘new’ technologies and methodologies and their sustained performance. This process needs to be facilitated as indicated in section 9.2 and needs to look at the framework conditions as well as the system itself, while involving all the different stakeholders.

A complicating factor is that the number of skilled facilitators available in the sector is limited and perhaps most of the professionals working in the sector have a strong technical bias. They therefore first need to come to grips with some of the most important new concepts involved in sustainable water supply. Current experience in several countries in Latin America shows that sector staff and community members are not well aware of the thinking involved in the concepts of hardware, software, orgware and ecoware. They have particular limitations in grasping the three most important concepts for sustained community water supply treatment:

- Sustainable financing with an equity perspective, which promotes community financing of at least operation and maintenance costs, takes a gender perspective and distinguishes between poorer and better-off sections of the community. Often sector staff and even community members do not realize the differences within communities or, for example, the difficult situation of poor female-headed households, which may require differential tariffs and possibilities for in-kind contributions;
- Efficient water use with an equity perspective, which looks at the efficiency of the water supply system in terms of leakages and consumption patterns and stimulates the equitable sharing of available water resources. A difficulty is that in many rural

communities the water delivered through the supply system is also used for other purposes such as gardening, raising cattle and small-scale industrial activities. This multi-use, if not detected and dealt with, will create major problems later, as it implies that more water needs to be treated and that could lead to poor performance or larger and more costly systems;
- Water quality, which may be perceived very differently among the different actors. As clearly shown in this study, it cannot be assumed that all people value water quality improvement in the same way and this needs to be discussed upfront before any water quality improvement measures are taken.

In general it will first be necessary to establish a shared understanding about these concepts among the main sector staff, before they can effectively contribute to the introduction of 'innovations'. In this preparatory work, it is also essential to discuss their basic role as 'external agents', which is not building white elephants but helping community members to find sustainable solutions that match their reality. For the process to work, recipient communities also need to understand the concepts listed above, which means that facilitators not only need to understand the concepts but also to be able to share them with others.

When a reasonable knowledge base has been established, sector staff will be more effective in helping to improve community water supply. This can be further enhanced if they follow a structured approach when aiming to improve the water system in one or a few communities. This approach may entail the following steps:

1. Rapid participatory situational assessment, including:
    - Analysis of the water supply system and context, with special attention to water source problems (catchment management, water quality problems and efficient water use, including possible multiple water use);
    - Assessment of management, operational and financial capacity;
    - Assessment of the water 'culture', the perceptions of the community about their system, the water quality, and the cost involved, etc.
    - Exploration of gender-specific community values and desires;
    - Review of the presence of different political factions and power groups;
    - Assessment of potential back-up support, including training possibilities (institutional analysis).
2. Create community understanding of the problems by involving them in the review using participatory techniques (Box 15) and information-sharing tools (multi-media, video, locally-made information posters) to enhance their understanding of the key concepts involved in sustainable water supply systems;
3. Establish and obtain broad agreement on solutions from all political factions and power groups, agreeing on the expected result and the implications (including operation and maintenance), possibly including visits to other communities in which solutions are already in place (peer information sharing);
4. Design the technical solutions as well as the software, the orgware and the ecoware, which often will include development and implementation of a learning strategy,

including leadership training. If solutions have not been tried before in a given area, it would be essential to first establish a TDLP along the lines outlined in section 9.4;
5. Arrange for formal approval of the design and agreement on financing. If formal approval of the design is not embedded in the legislation, at least it should be explored to obtain a second opinion of an independent organization, to ensure that the chosen technologies and design and the related cost are appropriate and adhere to proper standards;
6. Establish clear tender procedures to avoid interventions of stakeholders with vested interests;
7. Implement the project including the software, orgware and ecoware in construction, training, etc. Training may benefit from other LPs that have been implemented earlier in a given area;
8. Formalize the management and back-up arrangements (if needed include training of persons that will provide the back-up support);
9. Establish monitoring and surveillance process and evaluate users' satisfaction.

Using FLAIR in individual projects will increase the learning in these projects and will enhance their possibility for success, but often will not be sufficient to introduce a new technology, or to change the framework conditions, or to improve the sector as a whole in a country. In such a situation, a FLAIR-based LP approach is needed, as outlined in the next section.

9.4 Improving sector performance with FLAIR

To introduce a new technology or methodology or to improve the water sector in a more structured way, a FLAIR-based LP approach offers many opportunities. This approach creates insight into the needs and desires of stakeholders and helps them to gain insight into problems and to participate in solutions. This is achieved by changing some 'mainstream projects', e.g., projects that are part of the normal implementation process, into LPs that are being implemented in parallel with mainstream projects. It does not imply however that learning stops in the mainstream projects, as in fact no two projects are the same and all need to take learning seriously.

The 'special' LPs require the same basic understanding by sector staff mentioned in section 9.3, but differ in that they become theatres of innovation – the learning space in which key actors can experiment, learn about new approaches and technologies and subsequently feed this learning back to mainstream implementation. The essence is to involve the stakeholders, including particularly the political and management levels, in meaningful discourse about problems and solutions and about *scaling-out* and *scaling-up* innovations that contribute to solving 'their problem', taking their '*stakes*' into account. It is important that stakeholders and particularly those at the community level, understand that the relevance of their involvement in this particular project goes beyond the solution of their own problem and may make important contributions to the health and well being of other communities.

As indicated in section 8.5, it is possible to distinguish between TDLPs, which are projects that introduce a specific technology or methodology and MOLPs which look at broader sector improvements by prioritizing key problems in the sector and identifying and implementing solutions to these problems. As the approach to both types of projects is not so different, I have combined the discussion about the main phases that can be identified in the development of these projects and the organization of the stakeholders, the 'learning alliance'.

Phase 1: Getting started, creating interest and commitment

- Identify the area of intervention and formulate its boundaries; this may concern issues such as the desire to improve community water supply in a region through a MOLP, or to introduce MSF in a district, or a country through a TDLP.
- Identify the stakeholders involved in the 'problem area'. In the water sector this will concern multiple stakeholders at multiple levels. Identify a champion who will facilitate the process. This can be, for example, a university. In any case it is important to include one or more universities involved in sector and development-related issues as a stakeholder, because it can be very useful in the process and is the breeding ground for new sector staff;
- Establish a first encounter of stakeholder representatives to formulate the problem more precisely and obtain an overview of the 'stakes'. Depending on the size of the problem in terms of number and level of stakeholders, meetings may be needed at different levels, as was the case in TRANSCOL. To stimulate interaction among stakeholders, representatives of different levels may attend each others' meetings;
- Obtain political and institutional support as well as resources to proceed with the process. Changing organizational conditions (scaling-up) is virtually impossible without this support;
- Formalize the 'learning alliance', the multi-stakeholder learning effort, as well as the responsibility for leadership and facilitation. Often it will be necessary to create a core team to take things forward.

Phase 2: Seeking insight and overview, looking from different perspectives

- Establish a clear definition of the problem, clarifying the different perceptions and claims of stakeholders and taking a comprehensive view of the water supply system from the source to wastewater discharge. If many competing views exist, it might be more feasible and necessary to create a higher level objective which is less controversial (e.g. improve the health of children instead of improve water quality) and to start a practical process during which stakeholders can act and do something instead of just talking;
- Establish the knowledge base by bringing relevant information and relevant people together. This may include fact-finding in selected communities using the participatory techniques indicated in Box 15 in section 9.2;
- In the case of a TDLP, specify and describe the problem and the potential solution(s). In the case of a MOLP, cluster and prioritize problems and possible solutions, which may include difficulties related to scaling-out but also aspects that relate to scaling-up,

with the latter usually being more complex and requiring stakeholders at different levels to change.

Phase 3: Developing parallel learning projects

- Develop LPs to learn more about the problems and test solutions closely, involving all relevant stakeholders. These projects will usually follow the approach indicated in section 9.3. It is important to make sure that all dimensions (hardware, software, orgware and ecoware) are dealt with. Consider carefully which stakeholders are to be included in the projects and which just have to be aware of what is going on but do not need to get closely involved;
- Train facilitators for the LPs, as some of them may come from sector organizations or universities and may not have much experience with facilitation of participatory multi-stakeholder processes. Some of the key requirements for these facilitators are indicated in section 7.7;
- Build interaction among different levels of stakeholders and with other projects, for example, by involving sector staff on a part-time basis in the learning projects in parallel with their inputs in other projects, or by arranging field visits involving both agency staff and communities;
- Implement the solutions that were agreed upon;
- Monitor and document progress, as this will strengthen the learning process and will serve as a basis for future action and knowledge sharing;
- Reflect with the stakeholders on the effectiveness and efficiency of the new approaches and the obtained results;
- Consolidate the established innovations and the required changes to support scaling-out and scaling-up, which includes development of tools and information for wider application in training and advisory activities;
- Promote wider application.

The FLAIR-based LP approach draws on the experience in the SSF project and particularly in TRANSCOL and subsequent projects of CINARA, as well as on the experience of others as reflected in the literature that I have reviewed. It goes further than TRANSCOL in that it suggests that considerable emphasis needs to be placed on:

- Institutional commitment to create better opportunities for scaling-up;
- Carefully preparing staff by ensuring that they have a basic understanding of the main concepts involved in sustainable water supply;
- Making a comprehensive participatory analysis of the problem in context, e.g., looking at the total water system, and not just a part of it as was done in TRANSCOL, and carefully mapping the different interests (stakes) of stakeholders;
- Establishing a stronger link with ongoing (mainstream) projects, thus allowing other sector staff to learn about the innovations quickly.

I believe that these additions enhance the possibility that innovations can be scaled-up and scaled-out in the sector and will help to achieve the sector improvement that is urgently needed to meet the MDGs for water supply in terms of quantity and quality.

This cannot be achieved without a much closer collaboration of stakeholders in a process that builds on mutual respect and dialogue, valuing institutional (academic) and community knowledge and concerted action.

It requires a change in thinking about the need for an ecologically sound and sustainable water supply service in which water quality and the social process are taken seriously. This necessary change can well be compared with the shift from conventional to ecologically sound agriculture, which often implies a shift from strategic manoeuvring to consensual decision making, based on negotiated accommodation of interests and on social learning of new shared perspectives (Röling and Jiggins, 1998). It requires, as Leeuwis (2004) calls it, new forms of coordinated action and cooperation characteristic of the management of collective natural resources. Change also needs to be supported by enhancing the interdisciplinary character of university programmes, because of their importance as a channel for technology and methodology transfer in the water sector.

Above all it needs FLAIR, it needs facilitating of learning, application, implementation and reflection. It needs FLAIR-based learning projects to help make sector interventions more efficient and effective, to really learn about what works. It also needs a FLAIR-based approach to normal projects to facilitate the soft-systems approach, taking into account that water supply systems are about hardware, software, orgware and ecoware. Initially the facilitation will require more financial resources than conventional projects, but the rate of return will be considerable as the risk of poor performing systems will be greatly reduced and decision making will be much more transparent. This will bring considerable cost savings over the lifetime of the systems. Also, innovation will find its way into the sector much more quickly and open up possibilities for community learning and sharing with other communities. Other sector actors, including universities, will be able to play a much more active role in the learning projects.

History has taught that unless facilitation of learning is embraced sector interventions will not become sustainable. FLAIR is the mindset that can help to bring this about, that can create the movement in which sector staff becomes more efficient and effective and encourage communities to help other communities.

References

Formal literature

Akrich, M. and Latour, B. (1997). A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies. In Bijker W.E. and Law, J. (eds). Shaping technology/building society: studies in sociotechnical change. (pp. 259-264). Cambridge, MA: The MIT Press.

Aramini, J., McLean, M., Wilson, J., Holt, J., Copes, R., Allen, B. and Sears, W. (2000). Drinking water quality and health care utilization for gastrointestinal illness in Greater Vancouver. Ottawa: Public Health Agency of Canada.

Arboleda, J. (1993). Teoría y práctica de la purificación del agua. Bogotá: Asociación Colombiana de Ingeniería Sanitaria y Ambiental (ACODAL).

Arlosoroff, S. et al. (1987). Community water supply: the handpump option. Washington: World Bank.

Baker, M.N. (1981). The quest for pure water. Denver: American Water Works Association.

Bellamy, W.D., Silverman, G.P. and Hendricks, D.W. (1985). Filtration of Giardia cysts and other substances. Vol 2. Slow sand filtration. Cincinnatti, OH: U.S. Environmental Protection Agency.

Bennis, W. (1989). Las cuatros claves del liderazgo eficaz. Bogota: Editorial Norma.

Borrini-Feyerabend, G., Farvar, M.T., Nguinguiri, J.C. and Ndangang, V.A. (2000). Co-management of natural resources : organising, negotiating and learning-by-doing. Heidelberg: GTZ and IUCN, Kasparek Verlag.

Cairncross, S. (1992). Sanitation and water supply: practical lessons from the Decade. Washington: UNDP-World Bank Water and Sanitation Programme.

Cairncross, S. and Feachem, R.G. (1983). Environmental health engineering in the tropics: an introductory text. Chichester: John Wiley & Sons.

Callon, M. (1986). Some elements of a sociology of translation: domestication of the scallops and the fisherman of St Brieuc Bay. In: Law, J. (ed.) (1986). Power, action and belief : a new sociology of knowledge? London: Routledge & Kegan Paul Books

Cernea, M. (ed.). (1991). Putting people first: sociological variables in rural development. 2nd rev.ed. Oxford: Oxford University Press.

Chambers, R. (1985). Shortcut methods for gathering social information for rural development projects. In Cernea, M. (ed.) Putting people first : sociological variables in rural development. (pp. 399-415). New York: Oxford University Press.

Chambers, R. (1993). Challenging the professions. London: Intermediate Technology Publications.

Chambers, R and Jiggins, J. (1987). Agricultural research for resource poor farmers. Part I. Transfer-of-technology and farming systems research. Part II. A parsimonious paradigm. Agricultural administration and extension, 27, 35-52 (Part I) and 27, 109-128 (Part II).

Chan, M.S. (1997). The global burden of intestinal nematode infections – fifty years on. Parasitology today, 13(11), 438–443.

Checkland, P.B. (1989). Soft systems methodology. In Rosenhaead, J. (ed.). Rational analysis for a problematic world. (pp. 71-100). Chichester: John Wiley & Sons.

Colin, J. (1999). VLOM for rural water supply; lessons from experience. Loughborough: WEDC.

Craun, G.F, Regli, S., Clark, R.M., Bull, R.J., Doull, J., Grabow, W., Marsh, G.M., Okun, D.A., Sobsey, M.D. and Symons, J.M.. (1994). Balancing chemical and microbial risks of drinking water disinfection. Part II. Managing the risks. J Water SRT – Aqua 43, 5: 207-218.

Crul, M. (2003). Ecodesign in Central America, Delft: Delft University of Technology.

Di Bernardo, L. (1993). Métodos e técnicas de tratamento de água. (pp. 1-498). Rio de Janeiro: ABES-Asociação Brasileira de Engenharia Sanitaria e Ambiental.

Ellis, K.V. (1985). Slow sand filtration. CRC Critical reviews in environmental control, 15, 4: 315 – 354.

Foster, S., Gouvea da Silva, R.B., Ventura, M. and Hirata, R. (1987). Ground water: an undervalued resource in need of protection. Lima: Cepis.

Freire, P. (1970). Pedagogy of the oppressed. New York: Continuum.

Furlow, B. (2005). To your good health. New scientist, 3 December 2005.

Galvis, G. (1993). Pre-treatment alternatives for drinking water supply systems. (Occasional paper series; no. 22), Delft: IRC International Water and Sanitation Centre.

Galvis, G. (1999). Development and evaluation of multistage filtration plants : an innovative, robust and efficient water treatment technology. Guilford: CEHE, University of Surrey.

Galvis, G., Garcia, M., Visscher, J.T., Quiroga, E., Duque, M. and Restrepo, T. (1997). Searching for sustainable solutions. In Visscher, J.T. (ed.). Technology transfer in the water supply and sanitation sector : a learning experience from Colombia. (pp. 31-51). Delft: IRC International Water and Sanitation Centre and Cali: CINARA.

Galvis, G., Latorre, J., and Visscher, J.T. (1998). Multi-stage filtration : an innovative water treatment technology. Delft: IRC International Water and Sanitation Centre and Cali: CINARA.

Galvis G.; Visscher, J.T. and Fernandez, B. (1994). Overcoming water quality limitations with the multi-barrier concept: a case study from Colombia. In: Slow sand filtration. (pp. 47-60). Denver, CO: American Water Works Association.

Garcia, M., Visscher, J.T. and Quiroga, E. (1996). La formación de actores del sector en el marco de proyectos de aprendizaje en equipo en Colombia. Paper presented at the Conferencia Internacional de Mejoramiento de Calidad de Agua, APRA 30-May 4, 1996. Cali: CINARA/Universidad del Valle.

Giampietro, M. (2003). Beta-Gamma science for sustainable agriculture taking the implications of complexity seriously. Wageningen: Wageningen University.

Glaser, B.G., and Strauss, A.L. (1967). The discovery of grounded theory : strategies for qualitative research. Chicago: Aldine.

Glennie, C. (1979). The rural piped water programme in Malawi: a case study in community participation. London: University of London, Department of Civil Engineering.

Groot, A., Dijk, N. van, Jiggins, J. and Maarleveld, M. (2002). Three challenges in the facilitation of system-wide change. In Leeuwis, C. and Pyburn, R. (eds). Wheelbarrows full of frogs : social learning in rural resource management. (pp. 199-214). Assen, The Netherlands: Royal van Gorcum.

Gross, B., Wijk, C. van and Mukherjee, N. (2001). Linking sustainability with demand, gender and poverty: a study in community-managed water supply projects in 15 countries. Washington, DC: World Bank Water and Sanitation Program.

Harvey, F. and Chrisman, N.R. (1998). Boundary objects and the social construction of GIS technology. Environment and planning A, 30(9), 1683-1694.

Hespanhol, J. (1969). Investigação sobre o comportamento e aplicabilidades de filtros lentos no Brazil. São Paulo: Universidade de São Paulo.

Hommes, E.W. (1983). Overdracht van technology. Enschede: Technische Hogeschool Twente.

Huisman, L., (1982). Slow sand filtration. Delft: Delft University of Technology.

Huisman, L., Wood, W.E. (1974). Slow sand filtration. Geneva: WHO.

Hutton, G. and Haller, L. (2004). Evaluation of the costs and benefits of water and sanitation improvements at global level. Geneva: World Health Organization.

IRC (1979). Community education and participation in the slow sand filtration project : report of an international meeting. (IRC bulletin; no. 14). Delft: IRC International Water and Sanitation Centre.

Jiggins, J. (2002). Managing change in water conservation through multi-stakeholder learning processes: an interdisciplinary dialogue : agriculture and ecosystem management. Milton Keynes: Open University.

Jiggins, J. (2003). Water management in the central Benelux area. Wageningen: Wageningen University.

Kline, S.J. and Rosenberg N. (1986). An overview of innovation. In Landau, R. and Rosenberg, N. (eds). The positive sum strategy: harnessing technology for economic growth. (pp. 275-305). Washington: National Academic Press.

Korten, D.C and Klauss, R. (eds). (1984). People-centred development: contributions toward theory and planning frameworks. West Hartford, CT: Kumarian Press.

Latour, B. (1996). On actor-network theory : a few clarifications. Soziale welt 47, 4, 367, 369-381.

Latour, B. (1999). Pandora's hope : essays on the reality of science studies. Cambridge: Harvard University Press.

Lenton, R., Wright, A.M. and Lewis, K. (2005). Health, dignity and development, what will it take?: achieving the millennium development goals. Sterling, VA, Earthscan.

Leeuwis, C. (2003). Van strijdtonelen en luchtkastelen. Inaugurale rede. Wageningen: Wageningen University

Leeuwis, C. (2004). Communication for rural innovation: rethinking agricultural extension. 3rd ed. Malden, MA: Blackwell Science.

Lewicki, R., Gray, B. and Elliot, M. (eds). (2003). Making sense of intractable environmental conflicts: concepts and cases. Washington, DC: Island Press.

Long, N. and Ploeg, J.D. van der (1990). Demythologizing planned intervention: an actor perspective. Sociologia Ruralis, 29 (3/4), 226-249.

Lloyd, B. and Helmer, R. (1991). Surveillance of drinking water quality in rural areas. Harlow: Longman.

Mahdjoubi, D. (1997). Non-linear models of technological innovation. Austin, TX: University of Texas.

Mathers, C.D., Bernard, C., Moesgaard Iburg, K., Inoue, M., Fat, D.M., Shibuya, K., Stein, C., Tomijima, N. and Xu, H. (2003). Global burden of Disease in 2002: data sources, methods and results. (Global Programme on Evidence for Health Policy Discussion Paper; no. 54). Geneva: World Health Organization.

Maurel, P., Cernessona, F., Ferranda, N., Craps, M. and Valkering, P. (2003). Some methodological concepts to analyse the role of ic-tools in social learning processes. Montpellier: Cemagref/ENGREF.

Max-Neef, M., Elizalde, A. and Hoppenhayn, M. (1986). Desarrollo a escala humana : una opción para el futuro. Uppsala: Dag Hammarskjöld Foundation.

McJunkin, F.E. (1982). Water and human health. Washington, DC: USAID.

Ministerio de Salud (1992). El agua un recurso invaluable. (Colección salud, ambiente y desarrollo). Santafé de Bogotá: Ministerio de Salud.

Murray, C. J. L. and Lopez, A.D. (eds). (1996). The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. (Global burden of disease and injury series). Cambridge: Harvard University Press.

Narayan, D. (1995). The contribution of people's participation : evidence from 121 rural water supply projects. (Environmentally sustainable development occasional paper series; no. 1). Washington, DC: World Bank.

Nyerere, J. K. (1973). Freedom and development, Dar es Salaam: Oxford University Press.

Packham, R., Rogers, R. and Bawden, R. (1989). Our faculty goes experiential. In Warner Weil, S. and McGill, I. (eds). Making sense of experiential learning: diversity in theory and practice. (pp. 129-149). Stony Stratford: Open University Press.

Pittock, B. (2003). Climate change: an australian guide to the science and potential impacts. Canberra: Australian Greenhouse Office.

Pijnenburg, B. (2002). Community based natural resource management as dogma: a case from Mozambique. In Leeuwis, C. and Pyburn, R. (eds). Wheelbarrows full of frogs: social learning in rural resource management. (pp. 289-301). Assen: Royal van Gorcum.

Restrepo, I. (2001). Team Learning Projects (TLPs) as a strategy to contribute to the sustainability of WSS services. Leeds: University of Leeds, School of Engineering.

Robertson, L.H. (1980). The development of self help gravity-piped water projects in Malawi in rural water supply in developing countries: proceedings of a workshop on training held in Zomba Malawi. Ottawa: IDRC.

Rogers, E.M. (1995). Diffusion of innovations. 4th ed. London: The Free Press, Macmillan Publishers.

Röling, N.G. (1988). Extension science, information systems in agricultural development. Cambridge: Cambridge University Press.

Röling, N.G. (1995). Naar een interactieve landbouwwetenschap. Innaugurele rede, 21 september 1995. Wageningen, Wageningen University.

Röling, N.G. (2002). Beyond the aggregation of individual preferences : moving from multiple to distributed cognition in resource dilemmas. In Leeuwis, C. and Pyburn, R. (eds). Wheelbarrows full of frogs: social learning in rural resource management. (pp. 25-49). Assen, The Netherlands: Royal van Gorcum.

Röling, N.G. and Jiggins, J. (1998). The ecological knowledge system. In Röling, N.G. and Wagemakers, M.A.E. (eds). Facilitating sustainable agriculture: participatory learning and adaptive management in times of environmental uncertainty. (pp. 283-311). Cambridge: Cambridge University Press.

Röling, N.G. and Wagemakers, M.A.E. (eds). (1998). Facilitating sustainable agriculture; participatory learning and adaptive management in times of environmental uncertainty. Cambridge: Cambridge University Press.

Russel, D.B. and Ison, R.L. (1991). The research-development relationships in rangelands : an opportunity for contextual science. IV Congrès International des Terres de Parcours, Montpellier, France. Strasbourg: Council of Europe.

Salazar, L.G. (1980). Agua potable para la zona rural Colombiana. ACODAL, 96, 9-24

Schouten, T., Moriarty, P. and Fonseca, C. (2003). Scaling up community management : challenges and opportunities. In Harvey, P. (ed.) (2004). Towards the millennium development goals : actions for water and environmental sanitation: proceedings of the 29th WEDC conference, Abuja, Nigeria, 2003. (pp. 288-291). Loughborough: WEDC, Loughborough University of Technology.

Senge, P. (1990). The fifth discipline. New York: Doubleday.

Smet, J. and Wijk, C. van (2002). Small community water supplies: technology, people and partnership. Delft: IRC International Water and Sanitation Centre.

Snowdon, D. J. (2002). Just in Time management. Part 1. Recognizing common KM errors and the progress they inhibit. KM review, 5(5), 14-17.

Stake, R.E. (1995). The art of case study research. London: SAGE Publications

Star, S.L, and Griesemer, J.R. (1989). Institutional ecology, 'translations' and boundary objects : amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. Social studies of science, 19, 387-420.

Straus, A. and Corbin, J. (1994). Grounded theory methodology : an overview. In Denzin, N.K. and Lincoln, Y.S. (1994). Handbook of qualitative research. Thousand Oaks, CA: Sage.

Swieringa, J. and Wierdsma, A. (1992). Becoming a learning organization : beyond the learning curve. Reading, MA: Addison-Wesley.

UNESCO (1987). CASTAFRICA II: Science, technology and endogenous development in Africa : trends, problems and prospects. Paris: UNESCO.

Vinck, D. and Jeantet, A. (1995). Mediating and commissioning objects in the sociotechnical process of product design : a conceptual approach. In MacLean D., Saviotti, P. and Vinck, D. (eds). Management and new technology: design, networks and strategy. (Social science series). Brussels: COST.

Visscher, J.T. and Veenstra, S. (1984). Slow sand filtration caretakers manual. Delft: IRC International Water and Sanitation Centre.

Visscher, J.T., Paramasivam, R., Raman, A. and Heijnen, H.A. (1987). Slow sand filtration for community water supply. Delft: IRC International Water and Sanitation Centre.

Visscher, J.T., Quiroga, E., Garcia, M., Madera, C.A. and Benavides, A. (1996a). En la búsqueda de un mejor nivel de servicio: evaluación participativa de 40 sistemas de agua y saneamiento en la Republica de Ecuador, (Serie documentos técnicos ocasionales; no. 30). Cali: CINARA, Delft: IRC International Water and Sanitation Centre and Quito: CARE Ecuador.

Visscher, J.T., Quiroga, E., García, M. and Galvis G. (1997). From technology transfer to technology sharing. In Visscher, J.T. (ed.). Technology transfer in the water supply and sanitation sector: a learning experience from Colombia. Delft: IRC International Water and Sanitation Centre and Cali: CINARA

Warner, D.B. (1990). New roles for monitoring and evaluation in water supply and sanitation. Geneva: World Health Organization.

Wegelin, M. (1986). Horizontal flow roughing filtration (HRF) design, construction and operation manual. Duebendorf. IRCWD.

Wegelin, M. (1988). Roughing gravel filters for suspended solids removal. In Graham, N.J.D. (ed.). Slow sand filtration: recent development in water treatment technology. (pp. 103-122).(Series in water and waste technology). London: Ellis Horwood.

Weggeman, M. (2000). Kennismanagement: de praktijk. Schiedam: Scriptum.

WHO (1983). Minimum evaluation procedure (MEP) for water supply and sanitation projects. Geneva: World Health Organization.

WHO (1984). The international drinking water supply and sanitation decade: review of national baseline data (as at 31 December 1980). Geneva: World Health Organization.

WHO (1997). Guidelines for drinking-water quality. Vol. 3. Surveillance and control of community supplies. Geneva: World Health Organization.

WHO (2000). The world health report: making a difference. Geneva: World Health Organization.

WHO (2004). Guidelines for drinking water quality. 3rd ed. Geneva: World Health Organization.

WHO (2005) Children's environmental health (CEH). Geneva: World Health Organization.

WHO/UNICEF Joint Monitoring Programme (2000). Global water supply and sanitation assessment 2000. Geneva: World Health Organization and New York: UNICEF.

Wijk, C.A. van (2001). The best of two worlds: methodology for participatory assessment of community water services. (Technical paper series; no 38). Delft: IRC International Water and Sanitation Centre.

Wilkens A. (1990). Development aid in the 1990s: Swedish experience and perspectives. Stockholm: SIDA

Woodhill, J. and Röling, N.G. (1998). The second wing of the eagle : the human dimension in learning our way to more sustainable futures. In Röling, N.G. and Wagemakers, M.A.E. (eds) (1998). Facilitating sustainable agriculture; participatory learning and adaptive management in times of environmental uncertainty. (pp. 46-71). Cambridge: Cambridge University Press.

WSTB (2005). Public water supply distribution systems: assessing and reducing risks: first report of the Committee on Public Water Supply Distribution Systems of the Water Science and Technology Board. Washington: National Academies Press.

Yin, R. K. (1989). Case study research: design and methods. Newbury Park, CA: Sage.

Grey literature

Alzate, H.A.A., (2000). Validación de un modelo de análisis de costos en sistemas de potabilización de agua. Cali: Universidad del Valle.

Appleton, B. (1994). Water a priority for life, a quarter of a century of caring for water supply and sanitation. Delft: IRC International Water and Sanitation Centre.

Cana, M. (2004). Theories informing my research. http://www.kmentor.com/socio-tech-info/archives/000601.html. Accessed 15 August 2005.

CINARA-EMCALI (1992). Informe ejecutivo, proyecto de studio a nivel de inventario y prediagnostico de los sistemas de abastecimeinto y remocion de agua de las comunidades rurales y urbano marginales del municipio de Cali. Cali: CINARA

CINARA and IRC (1996a). Proyecto integrado de investigación y demostración de métodos de pretratamiento para sistemas de abastecimiento de agua. Cali: CINARA and Delft: IRC International Water and Sanitation Centre.

CINARA and IRC (1996b). Programa de transferencia de tecnología en sistemas de abastecimiento de agua en la Republica de Colombia: informe del taller de recuperación de experiencias, Cali, Marzo 6-8 de 1996. Cali: CINARA and Delft: IRC International Water and Sanitation Centre.

CINARA and IRC (1997). Programa de transferencia de tecnologia en sistemas de abastecimiento de agua en la republica de Colombia: informe final. Cali: CINARA and Delft: IRC International Water and Sanitation Centre.

Cruz, C.H., Galvis, G., Visscher, J.T., Di Bernardo, L. and Alaerts, G. (1998). Optimización de sistemas de potabilización con filtración rápida : la filtración gruesa dinámica y la clarificación con filtración gruesa ascendente, una alternativa factible. In Garcia V., M., Galvis C., G. and Gijzen, H. (eds). Agua 98: conferencia internacional agua y sostenibilidad, Santiago de Cali, Colombia, Junio 1 al 3 de 1998: [memorias]. Cali: CINARA.

CWS-WHO (1986). Study group on technology for water supply and sanitation. Geneva: Community Water Supply and Sanitation Unit of the Division of Environmental Health of World Health Organization.

Galvis, G. and Visscher, J.T. (1998). Multi-stage filtration a life saving technology. Paper presented at the First International Symposium Technology, Operations and Economics of Providing Safe Drinking Water in Small Systems, May 10-13, 1998, Washington, DC, USA.

Garcia, M. (2005). The importance of the facilitator in building learning alliances: reflections on the experience of the CINARA Institute. Paper presented at the Symposium on Learing Alliances for scaling up innovative approaches in the water and sanitation sector, June 7-9, 2005, Delft, the Netherlands.

INS-IRC (1984). Evaluacion del impacto de un servicio de agua tratada en una zona rural, Alto de los Idolos, Huila, Colombia. Delft: IRC International Water and Sanitation Centre.

IRC-SSF (1976). Outline of the programme for the second phase of the slow sand filtration project. Delft: IRC International Water and Sanitation Centre.

IRC-SSF (1977). General project description as part of the agreement for participation in the SSF project. Delft: IRC International Water and Sanitation Centre.

IRC-SSF (1980). Status reports on the SSF project in Colombia, Sudan, India, Jamaica, Kenya and Thailand. Delft: IRC International Water and Sanitation Centre.

IRC-SSF (1991). Technology transfer in the SSF project: report of an International Evaluation Workshop, The Hague, September 1991. Delft: IRC International Water and Sanitation Centre.

IRC-SSF (1994). Workshop on SSF in Ongole, Andhra Pradesh, May 31 – June 2, 1994. Delft: IRC International Water and Sanitation Centre.

Lord Selborne (2000). The ethics of freshwater use : a survey. Paris: UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST)

Lloyd, B., Pardon, M., and Wheeler, D. (1986). The development, evaluation and field trials of a small scale, multi-stage, modular filtration system for the treatment of rural water supplies. Lima: DelAgua.

Lloyd, B., Pardon, M., and Bartram, J. (1987). The development and evaluation of water surveillance and improvement programme for Peru. Paper presented at the International Conference on Resource Mobilization for Drinking Water Supply in developing Countries, Puerto Rico.PMC-Thailand, 1981 : Monitoring and evaluation of village demonstration plants SSF research project. Bangkok: Project Management Committee.

Max-Neef, M. (1987). Postludo al libro “ Economia Descalza”. Magazin dominical, 226.

Moriarty, P., Fonseca, C. Smits, S. and Schouten, T. (2005). Learning Alliances for scaling up innovative approaches in the water and sanitation sector: background paper for the symposium. Delft: IRC International Water and Sanitation Centre.

NSA (2000). Comparitive religion compilation: the Arayan faith before Krishna. Mbabane: National Spiritual Asembly of the Baha’is of Swaziland (NSAB).

PWA (1984). Evaluation of the existing conditions of SSF in Thailand. Bangkok: Provincial Waterworks Authority

Quiroga, E., Garcia, M., Sanchez, L.D., Madera, C., Garavito, J., and Visscher, J.T. (1997). Evaluación participativa de 15 sistemas de agua y saneamiento en la República de Bolivia. La Paz: IRC International Water and Sanitation Centre, PNUD-BM and Cinara.

Röling, N.G. (1994). Platforms for resource use negotiation proposal for collaborative action research to design conducive policy contexts and participatory methodologies for facilitating sustainable resource use. (unpublished document).

Röling, N.G., and Salomon, M. (1995). Integrated extension. Paper for the International Workweek organised by ETC in Kericho, Kenya, 30 October through 4th November, 1995. To be published in the report of the Workweek. Leusden: ETC Foundation.

Samper, O. and Schaik, H. van (1998). TRANSCOL: short inspection report on request of the Ministry of Foreign Affairs, The Hague, The Netherlands.

Sanchez, L.D. and Quiroga, E. (1996). Diagnostico participativo sobre tecnologías de agua y saneamiento en Bolivia. Documento presentado en el informe nacional sobre transferencia de tecnología, Bogota, Noviembre 6-7 de 1996.

Sarriegi Domínguez, J.M. (2002). El conocimiento tácito lo que los ordenadores aun no pueden gestionar. Pamplona: Universidad de Navarra..

Schulzberg, G., Sawyer, R. and Yansheng, M. (1996). External evaluation of IRC Intenational Water and Sanitation Centre.

Shordt, K, (2005). Transparent as water: supporting honesty in the water service sector. Delft: IRC International Water and Sanitation Centre.

Sinclair, P. (2004). Scaling-up rural water supply coverage in Uganda : can the ambitious targets be achieved? Delft: IRC International Water and Sanitation Centre.

SLIM Project (2004). The role of learning processes in integrated catchment management and the sustainable use of water. (SLIM policy briefing; no. 6). Milton Keynes: The Open University.

Soleman, M.A.A. (1976). Slow sand filtration project: review of activities and results of phase 1. Delft: IRC International Water and Sanitation Centre

Stalder, F. (1997). Text on Latour and his ANT. http://amsterdam.nettime.org/Lists-Archives/nettime-l-9709/msg00012.html. Accessed 15 August 2005.

Sundaresan, B.B. and Paramasivam, R. (1982). Slow sand filtration: research and demonstration project – India : final report. Nagpur: NEERI.

UNDP (1977). The debate on the selection of technologies for development. (TCDC case study; no. 6). New York: UNDP.

UNICEF (2000). Learning from experience: evaluation of UNICEF's Water and Sanitation Programme in India, 1966-1998. New York: UNICEF, Evaluation Office, Division of Evaluation, Policy and Planning.

UNIVALLE (1987). Transferencia organizada de tecnologia simplificada para el tratamiento de agua en sistemas de abastecimiento. Cali: Universidad del Valle.

Vaa, M. (1990). Choice of technology in development organisations in water and sanitation projects, 6th General Conference of the European Association of Development Research and Training Institutes, 27-30 June, Oslo, Norway. Bonn: EADI.

Visscher, J.T., Quiroga, E., García, M., Benavides, A., Valencia, A. and Segura, A. (1996b). Informe del taller de recuperación de experiencias, Cali, Marzo 6-8, 1996. Cali: CINARA and IRC International Water and Sanitation Centre.

White, A. (1984). Community education and participation in the slow sand filtration project: notes on the project. (unpublished notes developed for IRC).

Woersem, B.L.M. van and Manuel, A.R. (2001). IRC International Water and Sanitation Centre, assessment of its role and place within the sector: report of the appraisal team 1996-2000: report on request of the Ministry of Foreign Affairs, The Hague, The Netherlands.

Summary

For more than a quarter of a century, IRC has been supporting the development of Slow Sand Filtration (SSF) and more recently, together with CINARA, the pioneering of Multi-Stage Filtration (MSF) – a combination of Gravel Filtration and SSF that has been shown to have great potential as an effective water treatment system for community water supply. This study examines experiences in introducing SSF and MSF technologies in a number of countries and reviews key components of the “learning project approach” developed in Colombia. It seeks to answer three questions about the replication of these two technologies:

- Was the introduction of SSF and MSF successful?
- Has an effective facilitation process emerged for the introduction of the technologies?
- Have the conditions been created to sustain the technologies?

Based on the findings, it proposes an expansion of the learning project approach into a comprehensive new methodology for participatory technology development and replication to be known as: Facilitating of Learning, Application, Implementation and Reflection – FLAIR.

Material for the study has come from the SSF project (1975-1986) and the TRANSCOL project between 1989 and 1996. It has been supplemented by revisiting several MSF systems in Colombia in 2005, nine years after the TRANSCOL project ended. The authors' involvement in these projects started in 1982.

The study presents salient aspects of the SSF and MSF technology including a number of innovations that have been developed over time in the two projects and in a related research project. It shows that results with SSF have been moderately positive, wherever a good quality water source was available. MSF treatment has similar implementation characteristics to SSF but is able to treat water of much poorer quality, and the results were better. The study shows that MSF can perform very well and is well suited to community water supply treatment, provided that the contextual situation is supportive.

The author reconstructs the initial conceptual framework of the SSF project and describes different transfer channels that were used. He stresses the potential of the concept of using project management committees in each country, and draws lessons from the fact that results did not live up to expectation. The SSF project was moderately successful in only three of the six project countries. He argues that the thinking underlying the project was in line with the conventional technology transfer paradigm of that era. Based on a detailed review of the project, the findings support the criticism of this model – confirming that technology transfer is not a unilateral process, but much more complex. The project did not treat the SSF technology at this level of complexity. SSF truly is a complex system and its successful functioning involves interactions between the biological processes and the human operators.

A change in thinking came about at the end of the SSF project and became the basis for the TRANSCOL project, the second case study presented. An essential change was that the project team was much more convinced that it was necessary to move towards a dialogue approach, to understand better the different perceptions those involved may have about the attributes of the technology and the problems at hand. A learning approach was adopted with a constructivist perspective, recognising that different 'world views' exist.

The detailed analysis of this project shows that results are more promising, particularly where a supportive framework exists, which primarily seems to be the case in better-off communities with better access to resources and to advisory support. This analysis also shows that the TRANSCOL project has the characteristics of a learning alliance – a series of nested platforms at different institutional levels (national, district, community, etc.) created with the aim of bringing together a range of stakeholders interested in innovation. This learning alliance provided opportunities for social learning on multiple scales.

The author concludes that the *chain-linked* model better matches the approach to the development and promotion of MSF in TRANSCOL than the conventional technology transfer model, but that much better understanding is obtained when using an *Actor Network Theory* (ANT) perspective. The MSF systems have the characteristics of what are called boundary objects, abstract or concrete objects which 'inhabit' several intersecting social worlds and can provide a common point of reference. ANT helps to enhance understanding of the interaction between the human actors, the water supply system and the environment. A positive finding is that scaling-out (i.e. the wider application of a locally successful innovation) of MSF technology has occurred in Colombia and that activities are also now being initiated by the TRANSCOL coordinating agency, CINARA, in other countries. Yet the necessary scaling-up (i.e. replacement of the existing organizational and institutional framework in which the technology is embedded) to sustain the MSF systems has not yet taken place.

Water supply sector staff still has a hardware bias, whereas the sector needs a soft-systems approach, because a multitude of perceptions about problems and potential solutions exist among the different stakeholders. Sector staff and communities need to be able to understand not just the "hardware", but also: the "software", which deals with the interrelation between the technology, the water supply system, the operators, the users and possibly other stakeholders; the "orgware", the organizational base and rules and regulations involved; and the "ecoware", the relationship between the technology, the ecology and the environment.

The author concludes the study by proposing a FLAIR-based approach, adapting the concept of learning projects developed in TRANSCOL, to create appreciation of the needs and desires of stakeholders and help them to gain insight into problems and to participate in solutions. Process facilitation, using participatory tools, is the corner stone for every water project and for innovation in the sector. This requires that sector staff come to grips with key concepts such as, soft-system thinking, sustainable and equitable financing, efficient water use, and water quality, and either learn about process facilitation or involve process facilitators. In addition, a FLAIR-based approach sets out to introduce new concepts or to enhance sector performance in a broader sense. This converts some mainstream projects into ‘parallel learning projects’. These become theatres of innovation –learning spaces in which key actors can experiment and learn about new approaches, strategies and technologies and subsequently feed this learning back to mainstream implementation. The essence is to involve the stakeholders, particularly including the political and management levels, in meaningful discourse about problems and solutions and about *scaling-out* and *scaling-up* of innovations that contribute to solving ‘their’ problem, taking their ‘*stakes*’ into account.

The FLAIR-based approach and the overall findings of this study present an important challenge for all sector actors, and especially for governments and universities to stimulate the required change in thinking about the need for an ecologically sound and sustainable water supply service in which water quality and the social process are taken seriously. It also opens the possibility for communities to help fellow communities, thus creating the leverage needed to truly enhance sector performance.

Resumen

Durante más de veinticinco años, el IRC ha apoyado el desarrollo de la tecnología de tratamiento de agua, denominada Filtración Lenta en Arena (FLA) y más recientemente con CINARA ha liderado el proceso de desarrollo de otro sistema, la Filtración en Múltiples Etapas (FiME) – una combinación de filtración con gravas y FLA que tiene mucho potencial como un sistema efectivo de tratamiento para el abastecimiento de agua potable.

Este estudio examina las experiencias ligadas a la introducción de las tecnologías de FLA y FiME en varios países y revisa los componentes claves del “enfoque de proyectos de aprendizaje” desarrollado en Colombia. Igualmente busca dar respuesta a tres preguntas relacionadas con la replicación de las dos tecnologías:

- ¿Fue exitosa la introducción de FLA y FiME?
- ¿Surgió un proceso facilitador efectivo para introducir las tecnologías?
- ¿Se han creado las condiciones para sostener las tecnologías?

Con base en los hallazgos, se propone la expansión del enfoque de proyectos de aprendizaje hacia una nueva metodología comprensiva para el desarrollo participativo en la implementación de proyectos en el sector, denominada FLAIR (Facilitating of Learning, Aplication, Implementation and Reflection), en español ‘facilitación para el aprendizaje, aplicación, implementación y reflexión’.

Los insumos para el estudio provienen de los proyectos FLA (1975-1986) y TRANSCOL (1989-1996), y de una serie de visitas a varios sistemas de FiME en Colombia realizadas en el 2005, nueve años después de finalizar el proyecto TRANSCOL. El autor estuvo involucrado con los proyectos mencionados desde 1982.

El estudio presenta aspectos claves de las tecnologías FLA y FiME, incluyendo una selección de las innovaciones que se han desarrollado a lo largo del tiempo en los dos proyectos y en otro proyecto de investigación afín. Demuestra que los resultados con FLA han sido positivos, siempre y cuando una fuente de agua de buena calidad esté disponible. El tratamiento con FiME presenta características parecidas a las de FLA pero tiene la capacidad de tratar agua de menor calidad con mejores resultados. El estudio demuestra que FiME funciona muy bien y es apropiada para el tratamiento comunitario de agua, pero requiere el respaldo del contexto institucional.

El autor reconstruye el primer marco conceptual del proyecto FLA y describe los diferentes canales de transferencia que fueron utilizados. Hace énfasis en el potencial de crear comités de manejo de proyecto en cada país y saca lecciones de la diferencia entre los resultados esperados y los alcanzados. El proyecto FLA solo tuvo un éxito moderado en tres de los países en los que se implementó debido principalmente a que su marco conceptual estaba fundamentado en el paradigma convencional de transferencia de

tecnología vigente en esa época. Los hallazgos sustentan la crítica del modelo y confirman que la transferencia de tecnología no es un proceso unilateral sino que es mucho más complejo. El autor argumenta que el proyecto no manejó la tecnología de FLA con el nivel de complejidad que se requería. La FLA es un sistema muy complejo y su funcionamiento exitoso exige la interacción entre los procesos biológicos, los operadores y los usuarios.

Se abordan también en esta investigación, los cambios ocurridos en las formas de pensamiento en el sector de agua y saneamiento y que constituyeron la base del proyecto TRANSCOL, el segundo estudio de caso que se presenta. Un cambio fundamental fue que el equipo del proyecto estaba convencido de la necesidad de avanzar hacia un enfoque de diálogo, para entender mejor las diferentes percepciones que los diferentes actores involucrados podrían tener con respecto a la tecnología y a los problemas inmediatos. Un enfoque de aprendizaje con una perspectiva constructivista fue adoptado, reconociendo que los actores pueden tener 'visiones del mundo' distintas. El análisis detallado del proyecto demuestra que los resultados son más prometedores, particularmente cuando existe un marco de apoyo; esto se ha observado principalmente en las comunidades más ricas con mejor acceso a recursos y a soporte externo. El análisis también demuestra que el proyecto TRANSCOL tiene la característica de una alianza de aprendizaje – una serie de plataformas ubicadas en diferentes niveles institucionales (nacional, departamental, comunitario) - creadas con el objetivo de unir diferentes actores interesados en la innovación. Esta alianza de aprendizaje brindó oportunidades para el aprendizaje social en múltiples escalas.

El autor concluye que el desarrollo y la promoción de FiME en TRANSCOL guardan más armonía con el modelo 'Chain-linked' (*vinculado en cadena)* que con el modelo convencional de transferencia de tecnología. Además concluye que con la aplicación de la *Teoría de Actor-Red* (Actor Network Theory –ANT) es posible profundizar más en el entendimiento de la transferencia de la tecnología FiME. Los sistemas de FiME tienen las características de 'objetos fronteras' (boundary objects), objetos abstractos o concretos que 'habitan' varios mundos sociales distintos y que pueden ser puntos comunes de referencia. La ANT ayuda a entender la interacción entre los actores humanos, el sistema de abastecimiento de agua y el medio ambiente.

Uno de los hallazgos positivos de esta investigación es que **la "escalada**" (la aplicación más extensiva de una innovación que ha tenido éxito local) de la tecnología FiME ha ocurrido en Colombia y que CINARA, la agencia coordinadora de TRANSCOL, ha iniciado el proceso en otros países. No obstante, el **"aumento a escala"** (el desarrollo del marco organizacional e institucional en el cual la tecnología está arraigada) para sostener los sistemas de FiME todavía no ha ocurrido.

Esto último está dado básicamente por el hecho de que el personal del sector de abastecimiento de agua todavía tiene un sesgo hacia la *infraestructura;* mientras lo que se necesita es adoptar un enfoque de 'sistemas suaves' (soft systems approach), porque entre los diferentes actores existe una multitud de percepciones acerca de los problemas y de las soluciones potenciales. El personal del sector y las comunidades necesitan entender cuatros elementos claves en la implementación de proyectos, i) la tecnología (hardware); ii) el 'software' que incluye la interrelación entre la tecnología, el sistema de abastecimiento de agua, los operadores, los usuarios y posiblemente otros actores; iii) el 'orgware', que incluye la base organizacional y las normas involucrados; y iv) el 'ecoware', la relación entre la tecnología, la ecología y el medio ambiente.

El autor concluye el estudio proponiendo un enfoque con base en FLAIR, adaptando el concepto de proyectos de aprendizaje desarrollado en TRANSCOL, de tal manera que permita a los actores participar en las soluciones con base en sus necesidades y deseos. La facilitación del proceso utilizando herramientas participativas es fundamental para cada proyecto. Esto requiere que el personal del sector entienda conceptos claves como los que subyacen al enfoque 'soft system thinking', al financiamiento sostenible y equitativo, al uso eficiente del agua, a la calidad del agua y aprenda a ser facilitador o emplee facilitadores en los proyectos. Adicionalmente, el enfoque de FLAIR, desde un principio, trata de introducir conceptos nuevos o mejorar el desempeño del sector en un sentido más amplio. Este último objetivo se puede lograr convirtiendo algunos proyectos en proyectos de aprendizaje paralelos, que se vuelvan 'teatros de innovación', espacios para el aprendizaje en los cuales los actores claves pueden experimentar y aprender más sobre enfoques, estrategias y tecnologías nuevas y luego alimentar la aplicación. La esencia es involucrar a los actores, sobretodo los del nivel administrativo y político, en un diálogo importante acerca de los problemas y las soluciones y de la necesidad del "aumento a escala" de las innovaciones que pueden contribuir a resolver 'sus' problemas, teniendo en cuenta sus intereses.

El enfoque de FLAIR y los resultados generales de este estudio representan un reto importante para todos los actores del sector, y fundamentalmente para los gobiernos y las universidades. Se busca generar el cambio necesario en las formas de pensar, de tal manera que se identifique la necesidad de concebir un servicio de abastecimiento de agua sostenible en el cual la calidad del agua y el proceso social sean valorados seriamente. Este enfoque también permitirá a las comunidades que han adquirido un mejor nivel de servicio, apoyar a las comunidades vecinas y de esta manera crear un movimiento que realmente mejore el alcance del sector.

Samenvatting

Al meer dan een kwart eeuw ondersteunt het IRC International Water and Sanitation Centre de ontwikkeling van langzame zandfiltratie (LZF) en meer recent, samen met CINARA in Colombia, die van meervoudige filtratie (MF), een combinatie van filtratie door grindlagen en LZF, waarvan inmiddels is vastgesteld dat het een waterzuiveringstechnologie is met een zeer grote potentie voor kleine en middelgrote drinkwatersystemen. Deze studie onderzoekt de ervaring met het introduceren van LZF en MF in een aantal landen en analyseert de belangrijkste componenten van de in Colombia ontwikkelde aanpak met leerprojecten. De studie beoogt antwoord te geven op drie vragen betreffende de repliceerbaarheid van deze technologieën:

- Was de introductie van LZF en MF succesvol?
- Is er een effectieve begeleidingsmethodiek ontwikkeld voor deze introductie?
- Zijn de omstandigheden gecreëerd om deze technologieën duurzaam te laten werken?

Op basis van de resultaten wordt een uitbreiding van de leerprojectaanpak voorgesteld tot een veelomvattende methode voor het gezamenlijk ontwikkelen en introduceren van technologie. Deze methode wordt aangeduid met de Engelse term FLAIR, Facilitation of Learning, Application, Implementation and Reflection.

Het studiemateriaal is afkomstig uit het LZF project (1975-1986) en het TRANSCOL-project (1989-1996). Dit materiaal is verrijkt met informatie afkomstig uit bezoeken aan een aantal MF-systemen in Colombia in 2005, negen jaar na afloop van het TRANSCOL-project. De betrokkenheid van de auteur bij deze projecten begon in 1982.

De studie toont een aantal karakteristieke eigenschappen van LZF en MF-systemen, waaronder een aantal innovaties die in de bovengenoemde projecten en een gerelateerd onderzoeksproject zijn ontwikkeld. Het laat zien dat de ervaringen met LZF gematigd positief waren, op die plaatsen waar een waterbron van goede kwaliteit aanwezig was. MF heeft met LZF vergelijkbare eigenschappen, maar kan water van aanzienlijk slechtere kwaliteit zuiveren met betere resultaten. De studie toont aan dat MF goed functioneert en zeer geschikt is voor gemeenschapswatervoorziening mits er een goede ondersteunende organisatorische context aanwezig is.

De auteur reconstrueert het initiële conceptuele raamwerk van het LZF-project en beschrijft de verschillende kennisoverdrachtkanalen die werden gebruikt. Daarbij worden de mogelijkheden van het gebruik van nationale projectcommissies benadrukt en worden er lessen getrokken uit de bevinding dat de resultaten niet naar verwachting waren. Het LZF-project was namelijk slechts in drie van de zes projectlanden enigszins succesvol. Er wordt vastgesteld dat het gedachtegoed dat ten grondslag lag aan het project overeenkomt met het conventionele technologieoverdrachtmodel uit die tijd. De studieresultaten bevestigen de kritiek op dit model dat technologieoverdracht geen eenrichtingsproces is maar veel complexer. De auteur stelt dat het project de LZF-

technologie onderschat heeft in haar complexiteit die mede veroorzaakt wordt door de interactie tussen het biologisch zuiveringsproces en de mensen die bij het proces betrokken zijn.

Tegen het eind van het LZF-project ontstond er een verandering in het denken die vervolgens de basis vormde voor het TRANSCOL-project, de tweede casus die wordt gepresenteerd. Een essentiële verandering was dat het projectteam veel meer overtuigd was van de noodzaak tot dialoog, om beter inzicht te krijgen in de diversiteit in percepties van de verschillende actoren betreffende de waterproblemen en de technologie. Daarom werd er een leermodel gebruikt met een constructivistisch perspectief, wat erkent dat er verschillende wereldbeelden naast elkaar bestaan. De gedetailleerde analyse van het TRANSCOL-project toont een veel positiever resultaat dan het LZF-project, met name daar waar goede ondersteuning aanwezig is. Dit laatste bleek vooral in de rijkere gemeenschappen het geval, omdat deze meer middelen hebben en betere toegang tot advies.

De projectanalyse toont ook aan dat TRANSCOL de karakteristieken van een leeralliantie heeft. Deze alliantie wordt gedefinieerd als een serie van gekoppelde platformen op verschillende institutionele niveaus (nationaal, district, dorpsgemeenschap, etc.), opgezet met de bedoeling om verschillende geïnteresseerde belanghebbenden in vernieuwing bij elkaar te brengen. De leeralliantie bood de mogelijkheid van ‘social learning’ op verschillende schaal.

De auteur concludeert dat het ‘chain-linked’ model, een op ondernemerschap gebaseerde aanpak, beter van toepassing is op de ontwikkeling en verspreiding van MF in TRANSCOL dan het conventionele kennisoverdrachtmodel, maar geeft tevens aan dat een veel beter begrip wordt verkregen door het toepassen van de Actor Netwerk Theorie (ANT). MF-systemen hebben de karakteristieke eigenschappen van wat in deze theorie grensobjecten worden genoemd, abstracte of concrete objecten die verschillende ‘sociale’ werelden in zich bevatten en daarin een gezamenlijk referentiepunt vormen. ANT biedt de mogelijkheid om beter begrip te krijgen van de interactie tussen de verschillende menselijke actoren, het watervoorzieningssysteem en de natuurlijke omgeving.

Een positieve bevinding van de studie is dat ‘scaling-out’ (de verdere verspreiding van een lokaal succesvolle innovatie) van MF technologie heeft plaatsgevonden in Colombia en dat deze technologie nu ook door CINARA, de organisatie die TRANSCOL in Colombia coördineerde, in andere landen wordt geïntroduceerd. Echter, de noodzakelijke scaling-up (de aanpassing van het bestaande organisatorische en institutionele kader waarin de technologie moet functioneren) om MF systemen duurzaam te ondersteunen, heeft nog niet plaatsgevonden.

De staf in de watersector is nog sterk hardware-gericht, terwijl de sector een ‘soft systems’ aanpak nodig heeft, omdat er onder de verschillende belanghebbenden een veelheid van percepties bestaan over de problemen en mogelijke oplossingen. Sectorstaf en gebruikers moeten in staat zijn om niet alleen de ‘hardware’ te begrijpen, maar ook de ‘software’, die betrekking heeft op de relatie tussen de technologie (het watervoorzieningssysteem), het bedienend personeel, de gebruikers en mogelijke andere belanghebbenden; de ‘orgware’, de organisatorische basis voor het systeem en de daarbij behorende regelgeving; en de ‘ecoware’, de relatie tussen de technologie, ecologie en de natuurlijke omgeving.

De auteur eindigt de studie met het voorstel tot een op FLAIR gebaseerde aanpak, een aangepaste vorm van het in TRANSCOL ontwikkelde concept van leerprojecten. Deze aanpak zal helpen om begrip te ontwikkelen onder sectorstaf voor de behoeften en wensen van de belanghebbenden, hen inzicht te verschaffen in de problemen en hen de mogelijkheid te bieden deel te nemen aan de oplossingen. Facilitatie van het proces met gebruikmaking van participatieve methodes is essentieel in ieder waterproject. Dit vereist dat staf in de watersector zich een aantal kernconcepten eigen moet maken zoals de ‘soft systems’ benadering, duurzame en eerlijke financiering, efficient watergebruik en waterkwaliteitsbenaderingen. Daarnaast zal staf zich ofwel moeten ontwikkelen tot procesbegeleiders ofwel procesbegeleiders bij projecten moeten betrekken. Een op FLAIR gebaseerde aanpak maakt het mogelijk om nieuwe concepten te introduceren en/of de resultaten in de sector in bredere zin te verbeteren. Door een aantal normale projecten te veranderen in ‘parallelle leerprojecten’ worden er ‘theaters van vernieuwing’ gecreëerd. Dit zijn leerplekken waar actoren kunnen experimenteren met nieuwe aanpakken, strategieën en technologieën, en zich deze eigen kunnen maken, om ze vervolgens te introduceren in andere projecten. De essentie is om alle belanghebbenden en met name die uit de politiek en het management bij de dialoog over problemen en oplossingen te betrekken en samen te bespreken hoe de ‘scaling-out’ en ‘scaling-up’ van vernieuwingen kan helpen ‘hun’ problemen op te lossen, waarbij rekening wordt gehouden met hun belangen.

De op FLAIR gebaseerde aanpak en de algemene bevindingen van de studie betekenen een belangrijke uitdaging voor alle actoren in de sector, en met name voor overheden en universiteiten, om de essentiële verandering in het denken over de noodzaak van duurzame en ecologisch betrouwbare watervoorziening door te voeren, waarbij het belang van waterkwaliteit en het sociale proces serieus genomen moet worden. Dit biedt ook mogelijkheden aan bewoners van gemeenschappen die al middels een op FLAIR gebaseerde aanpak een verbeterde watervoorziening hebben, om andere gemeenschappen te helpen in het proces. Op deze manier kan schaalvergroting snel worden bereikt.

About the author

Jan Teunis Visscher was born in Vroomshoop, the Netherlands, on 11 April 1950. In 1968, he completed his pre-university education (HBS B) at the Christelijk Lyceum in Almelo. In 1977, he obtained his MSc degree in sanitary engineering and his teaching degrees in mathematics and physics at the Delft University of Technology. His main topics were water supply, sanitation, hydrology and functional design. During his study he was secretary of Practische Study, the student association of the civil engineering faculty and chaired the local group of Milieu Defensie in Delft. As a student he made extensive visits to different countries in Asia.

From 1977 to 1979, he was staff member of the Delft University of Technology responsible for the development of a course concerning sanitary engineering in developing countries and for establishing contacts with universities in these countries. From 1980 to 1982 he joined UNDP to support the development of the hand pump installation and maintenance section in the Ministry of Natural Resources in Guinea Bissau and to guide the development of the sanitation component of the UNDP project GBS002 in this country.

In 1982, he joined the IRC International Water and Sanitation Centre as a consultant to make a publication on the Buba Tombali Project in Guinea Bissau, a handpump programme that was implemented in two regions in the South of Guinea Bissau dealing both with technical and socio-economical aspects. Thereafter he became staff member of IRC taking over the management of the SSF project which was then in its third phase, which involved the implementation of international seminars in the six participating countries. He continued as manager of the extension of this project and became responsible for the development and implementation of both, the research and development project on Pretreatment and the TRANSCOL project. In parallel he became increasingly involved in other projects, became member of the management team of IRC and subsequently headed one of the two sections in IRC which comprised of a multi-disciplinary team. During this period he also managed a series of other projects which involved support from different external support agencies, became advisor to the water supply and sanitation programme of the Netherlands government in India, carried out review and support missions to different countries and published extensively on different subjects.

From 1997 to 2003, he was director of IRC during which period he led the reorganization needed to accommodate the changes in financial support from the Netherlands government and the overall changes in the water supply and sanitation sector. During this period he also obtained his certification as mediator. From 2003 to 2005 he was senior advisor in IRC and was responsible for the organisation of the 5th Water Information Summit. In 2005 he established his own private firm, continued as an advisor to IRC and worked as a consultant in different countries.

List of abbreviations

AFRIDEV	A VLOM pump developed by a World Bank project
AIT	Asian Institute of Technology
ANT	Actor Network Theory
AP	Andhra Pradesh
CBO	Community Based Organization
CPHEEO	Central Public Health and Environmental Engineering Organization
CINARA	Centro Interregional de Abastecimiento y Remoción de Agua
DyGF	Dynamic Gravel Filtration
IRC	IRC International Water and Sanitation Centre
IHE	Institute for Hydraulic and Environmental Engineering, now UNESCO-IHE Institute for Water Education
FC	Faecal Coliform
FCC	Faecal Coliform Count
FLAIR	Facilitating of learning, Application, Implementation and Reflection
INS	Instituto Nacional de Salud
IRWG	InterRegional Working Group
JLP	Joint Learning Project
JMP	Joint Monitoring Programme
LP	Learning Project
MOLP	Mainstream Optimizing Learning Project
MSF	Multi Stage Filtration
MDG	Millennium Development Goal
NEERI	National Environmental Engineering Research Institute
NGO	Non Governmental Organization
NTU	Nephelometric Turbidity Units
OECD	Organization for Economic Cooperation and Development
OECD/DAC	Donor Advisory Committee of the OECD
pH	A measure of the acidity or alkalinity of a solution
PMC	Project Management Committee
PWA	Provincial Waterworks Authority
RSF	Rapid Sand Filtration
SLIM	Social Learning for the Integrated Management
SSF	Slow Sand Filtration
TDLP	Technology Development Learning Project
TCU	True Colour Units
TRANSCOL	Programa de Transferencia de tecnología simplificada para el tratamiento de agua en sistemas de abastecimiento en Colombia
TTLP	Training and Transfer Learning Project
UASB	Upflow Anaerobic Sludge Blanket
UGF	Upflow Gravel Filtration
UGFL	Upflow Gravel Filtration in Layers
UGFS	Upflow Gravel Filtration in Series

UNDP	United Nations Development Programme
UNICEF	United Nations Children Fund
UNIVALLE	Universidad del Valle
VENN diagram	Drawing to show relations, first introduced by John Venn
VLOM	Village Level Operation and Maintenance
WHO	World Health Organization
WSS	Water Supply and Sanitation