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Democratisation of Water and Sanitation Governance by Means of Socio-Technical Innovation

Cross Comparative Analysis

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Article 1

Pinto, R., Z. Teixeira, and M. Cunha (2015), "Cross Comparative Analysis of Case Studies Report" (pp. 11-88)

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Democratisation of Water and Sanitation Governance by Means of Socio-Technical Innovation

Cross Comparative Analysis

Article 1

Cross Comparative Analysis of Case Studies Report, Article 1 (pp. 11-88)

Keywords
Water and sanitation, socio-technical innovations, inequality, vulnerability, democratization, rural sanitation, community participation, citizenship, water politics

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Presentation of the SPIDES Series and the Working Paper

SPIDES stands for Research Projects Series (SPI), DESAFIO Project, for its acronym in Portuguese and Spanish. WATERLAT-GOBACIT is a network dedicated to research, teaching and practical interventions connected with the politics and management of water and water-related activities. The DESAFIO Project (www.desafioglobal.org) was developed by researchers of WATERLAT-GOBACIT's Thematic Area 3, dedicated to the Urban Water Cycle and Essential Public Services, jointly with invited partners.

DESAFIO had a lifetime of 30 months, from 1 February 2013 to 31 July 2015. It was funded by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement N^{o} 320303. The information contained in the documents published in the SPIDES Series reflects only the views of the researchers, and the European Union is not liable for any use that may be made of the information contained therein.

DESAFIO is the acronym for "Democratisation of Water and Sanitation Governance by Means of Socio-Technical Innovations", the project's full title. DESAFIO literally means "challenge" in both Portuguese and Spanish, the two main working languages of the project owing to its focus on Argentina, Brazil, and Colombia. This was a fitting acronym for the project, as it concerned what still now after the end of the Millennium Development Goals in 2015, constitutes one of the most difficult challenges facing developing regions: eradicating structural social inequality in the access to essential water and sanitation services. In other words, as the full title states, the project was about the democratization of the politics, management, and access to essential public services, with an empirical focus on water and sanitation services.

The project focused on the study of eight experiences identified in Brazil, Argentina and Colombia, which targeted the deficit of essential services in vulnerable communities through the design and implementation of socio-technical innovations. These experiences had in common an approach that articulated technological development with a clear concern for some aspects of the democratization process, for instance involving community members in one or more stages of the design, implementation, and long-term maintenance of the systems. Bolder initiatives extended the involvement of common citizens to the design of public policy and introducing mechanisms of radical democracy to empower citizens-users to monitor the performance of the government, the service providers, and other relevant power holders. Latin America has been an experimental field for this kind of developments, and the project chose a range of experiences in order to cover a variety of socio-political, cultural, and policy-institutional contexts, in addition to a wide selection of settings including urban and rural communities in the three countries. DESAFIO placed these experiences of socio-technical innovation at the heart of the study: "the main tenet of [the project] is that achieving the development goals set by the international community […] crucially depends on harnessing existing and developing new appropriate and innovative socio-technical solutions for the provision of safe water and sanitation services" (Castro, 2013: 3).

This way of framing the research problem led to the formulation of specific questions that guided the study:

> How can we harness existing and develop new socio-technical innovations in order to change policies, to develop strategies and practical interventions, and to enhance policy learning for tackling unacceptable inequalities and injustice in the access to essential water and sanitation? What conditions, factors and processes facilitate the emergence of socio-technical innovations in this sector? What are the critical requirements to make successful socio-technical innovations sustainable and replicable? What are the obstacles to their sustainability and replication? (Castro, 2013: 3).

In order to respond to these research questions, DESAFIO adopted a comparative, interdisciplinary approach grounded in the social sciences and involving the participation of technical disciplines, particularly sanitary engineering, epidemiology, health, and ecology. It was also transdisciplinary, as the research team included practitioners from public sector and civil society institutions, and was developed in close co-operation with community organizations and other relevant actors. We present a more detailed discussion of the methodological approach employed by the project in another Working Paper of the SPIDES Series (Castro, 2015).

This Working Paper presents an edited version of two research reports corresponding to the cross comparative analysis of the 10 case-study reports that composed the core of the project work. Article 1 presents a systematic comparative analysis of the case-study results elaborated by our researcher partner at Coimbra University in Portugal. The team was coordinated by Prof. Maria da Conceição Cunha, and the comparative work was led by Dr. Rute Pinto. Article 2 was developed by DESAFIO's Coordinator, Prof. Jose Esteban Castro. The nature of the articles is very different. Article 1 systematizes the analysis looking for common patterns, findings, and weaknesses across all 10 case study reports. Article 2 has the objective of identifying the key lessons learned from the studies that may contribute to the development and implementation of public policies that promote the democratization of water politics and management in Argentina, Brazil, and Colombia, the three countries covered in the research.

In addition to the reports presented in this Working Paper, the reader may benefit from complementary information that we have made available online, including video records of public presentations made by the researchers in a number of events organized by DESAFIO. These include the First Project Conference, which took place in Recife on 25 February 2013 (http://desafioglobal.org/meetings/open-meetings/conference/), the Final Project Conference that took place in Rio de Janeiro on 27-28 July 2015 (http://desafioglobal.org/meetings/open-meetings/second-international-conference/), and a special dissemination seminar that took place in the city of Brasilia on 9 September 2015 (http://desafioglobal.org/meetings/open-meetings/post-project-meetings/seminar-in-brasilia-9-10-september-2015/day-1-a-seminar-for-research-and-debate-desafio-project-9-september-2015/). The presentations of the First Conference were published in the SPIDES Series of Working Papers (CASTRO et. al, 2013, available at: http://waterlat.org/WPapers/WATERLAT%20Working%20Paper%20SPIDES%201.pdf).

The Working Paper constitutes work in progress that may be revised, and may be further developed and later published in journals or as book chapters. We are pleased to present this work to the interested public.

Jose Esteban Castro
Project Co-ordinator

Newcastle upon Tyne, December 2015

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List of Acronyms

ALBA	Bolivarian Alliance for the Peoples of our America
APLA	Planning Agency (Argentina)
ASSEMAE	National Association of Municipal Water and Sanitation Services
AySA	Argentinian Water and Sanitation (Argentina)
BAMA	Buenos Aires Metropolitan Area
BRL	Brazilian Real
CAF	Andean Decelopment Corporation
COP	Colombian Peso
CRA	Regulatory Commission for Drinking Water and Basic Sanitation (Colombia)
CoFAPyS	National Council for Potable Water and Sanitation (Argentina)
DESAFIO	Democratisation of Water and Sanitation Governance by Means of Socio-Technical Innovation
ECLAC	UN-Economic Commission for Latin America and the Caribbean
ENOHSA	National Entity of Sanitation Water Works (Argentina)
ERAS	Water and Sanitation Regulatory Entity (Argentina)
ETOSS	Tripartite Entity of Sanitary Works and Services
IBGE	Brazilian Institute of Geography and Statistics
IDB	Inter-American Development Bank
IFIs	International Financial Institutions
INAP	National Institute of Public Administration (Argentina)
INDEC	National Institute of Statistics and Censuses
ISGSD	International Society of Groundwater for Sustainable Development
KAF	Konrad Adenauer Foundation (Germany)
KfW	Reconstruction Credit Institute (Germany)
LA&C	Latin America and Caribbean
MDGs	Millennium Development Goals
MINPLAN	Ministry of Federal Planning, Public Investment, and Services (Argentina)
MPG	Participatory Management Model
NGA	Great North Region (Argentina)
NGOs	Non Governmental Organizations
OSN	National Sanitary Works (Argentina)
PAHO	Pan American Health Organization
PDA	Department Water Plan (Colombia)
PDS	Water Supply and Sanitation Master Plan 2006-2020 (Argentina)
PIA	Immediate Action Plan (Argentina)
PMSS	Project for the Modernization of the Water and Sanitation Sector (Brazil)
PBQ	Quilombola Brazil Programme
PRONAPAC	National Programme of Potable Water and Sewerage (Argentina)
RJMR	Rio de Janeiro Metropolitan Region
SDGs	Sustainable Development Goals
SDGIs	Sustainable Development Goal Indicators
SEPPIR	Secretariat of Policies to Promote Racial Equality (Brazil)

SISAR	Integrated Rural Sanitation System
SNAP	National Service of Rural Potable Water and Sanitation (Argentina)
SSPD	Superintendence Domestic Public Services (Colombia)
SSRH	Under-Secretariat of Water Resources (Argentina)
UFMG	Federal University of Minas Gerais, Brazil
UFRJ	Federal University of Rio de Janeiro, Brazil
UFPE	Federal University of Pernambuco, Brazil
UN	United Nations
UNDP	United Nations Development Programme
UNR	National University of Rosario, Argentina
UNIVALLE	University of the Valley, Colombia
WHO	World Health Organization
WSS	Water and sanitation services

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Article 1

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Original report cover – Article 1

DESAFIO
Democratisation of Water and Sanitation Governance by Means of Socio-Technical Innovation

CROSS COMPARATIVE ANALYSIS OF CASE STUDIES REPORT

Work Package 5 Report
(Deliverable D5.1)

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Coimbra, Portugal, 31 July 2015

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Article 1

Cross Comparative Analysis of Case Studies Report

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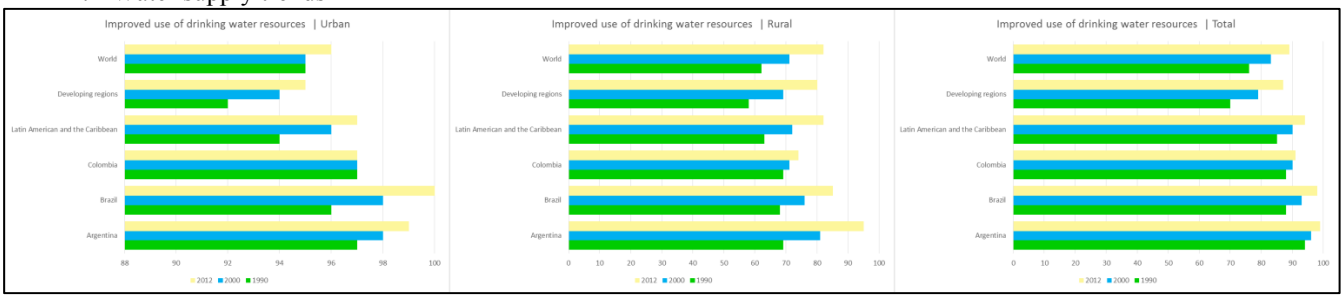
1. Introduction

Water supply and sanitation are key issues at the global scale. With the establishment of the Millennium Development Goals (MDG) an effort has been done to improve water supply (Figure 1A) and sanitation (Figure 1B) conditions worldwide to the most vulnerable communities, especially in rural areas. The MDGs have defined the targets that should be attained for water supply and sanitation issues worldwide: to decrease by half the proportion of world population living without proper access to drinking water and basic sanitation (WHO 2008; UN 2012). While, according to official reports, the target for water supply has been attained in 2010 (5 years before the targeted year), the same has not been verified for the sanitation target. Despite evidence confirming the cost-effectiveness of water and sanitation interventions (e.g. Walsh and Warren 1979; Hutton and Haller 2004; UNDP 2006; WHO 2011) additional efforts are needed to achieve the established targets for sanitation. Cost-effectiveness analysis might be a powerful tool since it relies on the comparison between the relative spending (costs) and physical benefits (effects) associated with the implementation of at least two management strategies (WHO 2011). According to World Bank data, for each US$1 spent on sanitation, a return of US$5.50 is attained by ensuring healthy and productive populations (World Bank 2015). On the other hand, poor sanitation facilities can cost countries between 0.5 to 7.2% of national GDP (e.g. 2.3% of Indonesia GDP is lost due to poor sanitation facilities, corresponding to a total amount of US$6.3 billion). In this context, some governments and NGO's are examining alternative ways of providing water and sanitation systems, especially to vulnerable communities.

A. Water supply trends



B. Sanitation trends

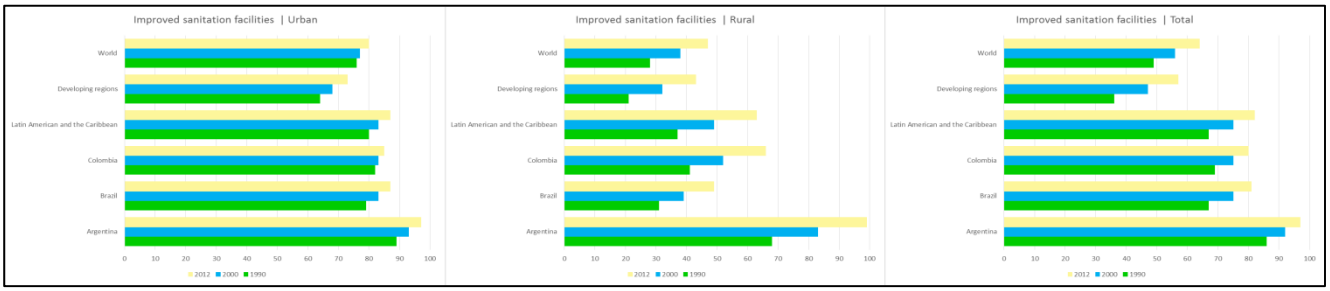


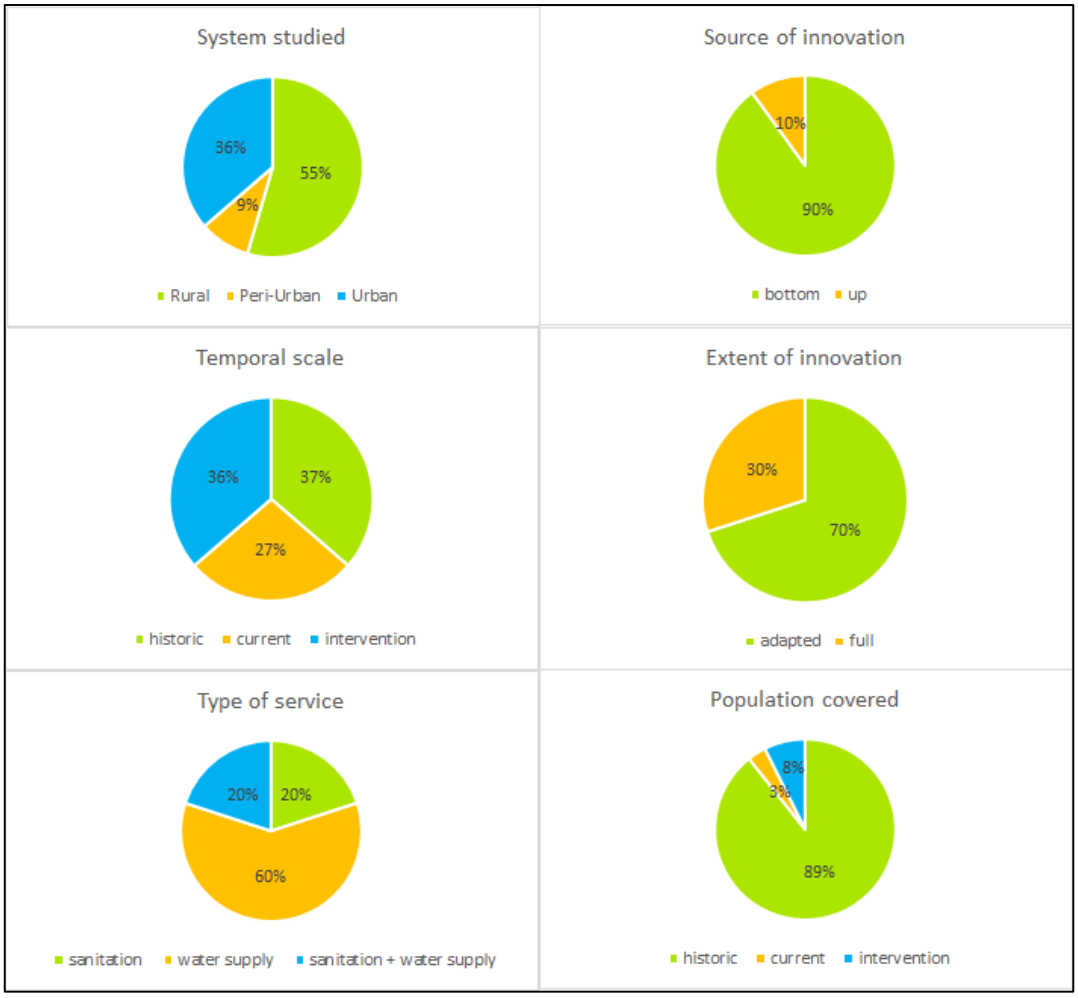
Figure 1. Worldwide, Developing countries, Latin America and the Caribbean, Colombia, Brazil, and Argentina trends for: A. Water supply, and B. sanitation (data source: WHO/UNICEF (2014) Progress on Drinking Water and Sanitation: 2014 Update).

It was in this context that the DESAFIO project has emerged. This project aimed to evaluate recent and current strategies, as well as innovative socio-technical interventions, for the design and implementation of sustainable, appropriate, and innovative socio-technical solutions for the provision of water and sanitation services (WSS) in conditions of social vulnerability and inequality. In this context, DESAFIO was structured around the following questions:

- *'How can we harness existing and develop new socio-technical innovations in order to change policies, to develop strategies and practical interventions, and to enhance policy learning for tackling unacceptable inequalities and injustice in the access to essential WSS?*
- *What conditions, factors and processes facilitate the emergence of socio-technical innovations in this sector?*
- *What are the critical requirements to make successful socio-technical innovations sustainable and replicable?*
- *What are the obstacles to their sustainability and replication?'* (Castro 2012).

Trying to give some insights to these questions, DESAFIO considered several experiences and case studies, in urban, peri-urban, and rural areas, of South America, with a particular emphasis on Brazil. 10 case studies were selected that allowed to develop a holistic and comprehensive assessment of these processes. Figure 2 and Tables A1, A2 and A3, from the Appendix, summarise some of the features of these case studies.

Figure 2. Percentage of case studies per system studied; source of innovation; temporal scale; extent of innovation; type of service and population covered by the innovation.



The DESAFIO project characterised the selected case studies into historical, current or new intervention cases (Figure 2), allowing for a temporal (short- and long-term) comparison of water and sanitation services effects. Additionally, it also defined six analytical dimensions according to which each case study ought to be contextualised, analysed and discussed: policy-institutional, socio-political and cultural, economic-financial, techno-infrastructural/operational, health and ecological-environmental (Castro 2012).

This report reviews and performs cross-comparisons of alternative socio-technical innovations of water and sanitation systems, focusing on the role that democratisation might have on these issues. It assesses the main lessons learned and main policy issues which have to be addressed before such alternative ways of providing water and sanitation services can be widely applied.

There are some debates about the advantages and drawbacks of water and sanitation socio-technical innovation systems, and about the contexts where they might be viable. This report aims to contribute to these debates, by comparing the results and experiences from these 10 case studies from 3 different countries. It identifies contexts where socio-

technical innovation water and sanitation systems might be considered as an option for governments and municipalities. It also identifies some precautionary principles that should be regarded before these innovations can be installed and contribute to tackling the main challenges in implementing it. This is a preliminary exploitation of results, and more work is needed to collect evidence and bring more light on these issues.

In this context, the objective of this report is to identify:
- the critical requirements to ensure the socio-technical innovations sustainability and reproducibility;
- the main disadvantages to its wide implementation; and
- the open issues that require further investigation and analysis.

This report is structured in six main sections. Section 1 (current one) sets the context, recalling the worldwide challenges regarding water and sanitation issues. Section 2 describes and characterises the innovations considered in the case studies. Section 3 explores the factors and processes that explain the emergence and need for innovations Section 4 analyses and assesses the results obtained from the case studies, comparing them within the DESAFIO context. Section 5 tries to explore the underlying causes, factors and conditions that determined the innovations success or failure, summarising the obstacles and critical requirements to the sustainability and replication of the socio-technical innovations under study. Finally, Section 6 addresses the main lessons learned and implications of the DESAFIO project to other similar contexts/situations.

2. The character of the innovations

Understanding the specific characteristics of the socio-technical innovations under study was the DESAFIO first step towards the more general goal of providing insights about the potential implementation of the socio-technical innovations to other systems. The following questions were address by the DESAFIO partners in their case studies to characterise the socio-technical innovations (between brackets is the reference to the section, in this manuscript, that summarises the information gathered in the field):

- What exactly is the innovation under study? (Section 2.1)
- What are its objectives and main characteristics? (Section 2.2)
- Who are the key agents/social actors in the different stages of design, implementation, etc. of the innovation? (Section 2.2.1)
- What is the temporal scale of design and implementation of the innovation? (Section 2.3)
- What is/are the temporal scale/scales of the impact sought through the innovation? (Section 2.3)
- What kinds of transformations are intended through the innovation? (Section 2.4)
- What mechanisms are used by the innovation to produce these transformations? (Section 2.4)
- In what sense/to what extent the innovation is "social"? (Section 2.4.1)
- In what sense/to what extent the innovation is "technical"? (Section 2.4.1)

- What is the relationship between the innovation and the process of democratisation of the access to and the management of water and sanitation services? (Section 2.5)
- What are the criteria used to define the "zero point", the baseline, to evaluate the functioning and results of the innovation? (Section 6.2)

Sections 2.1 and 2.2 aim at responding to the questions '*what exactly is the innovation under study?'* and '*what are its objectives and main characteristics?'* To achieve this goal, the key marker analytical dimensions of each innovation are highlighted (Table 1) and the main characteristics are identified (section 2.2). The case studies are separated by historical, current and intervention.

2.1. Describing the socio-technical innovations

Of the four (recent) historical case studies evaluated, two describe the implementation of a water supply system (D2.1 and D2.3), one describes the implementation of a sanitation system (D2.2), and a fourth describes a system for both water supply and sanitation (D2.4). Of the three case studies analysed to evaluate current experiences, two describe the implementation of a water supply system (D3.1 and D3.3) and a third one describes the implementation of a sanitation system (D3.2). Of the three case studies for which new interventions were developed, two describe the implementation of a water supply system (D4.1 and D4.3) and one describes the implementation of a water supply and sanitation system (D4.2) (Tables in the Annex A1, A2 and A3).

Six dimensions have been analysed under the umbrella of the DESAFIO project to characterise the socio-technical innovations selected to implement these water and sanitation services systems: policy-institutional, socio-political and cultural, economic-financial, techno-infrastructural/operational, health and ecological-environmental. However, each innovation water and sanitation system was characterised by only few key markers which differ between case studies (Table 1). For example, in some cases the operational dimension plays a central role in the definition of the innovation, as is the case for the SISAR model (D2.1, D3.1, D4.2). In other cases, the socio-political dimension, and particularly social participation throughout the process, is one of the key markers of the innovation. An example is the Echo-technological system (D2.4) whose process of selection of the best technological solution relies on strong community mobilization and awareness. Though some of the implementation processes took into account the health and the ecological-environmental dimensions, these dimensions were not key markers of any of the case studies evaluated. The innovation implemented in each case study is briefly explained next.

Table 1. Key marker dimension(s) of type of innovation.

DESAFIO Dimensions	Case study									
	Historical				Current			Intervention		
	SISAR - Policy-Institucional Evaluation	Condominial Sanitation System	Communal Springs	Echo-technological System	SISAR- Ethnographic Assessment	Integrated Sanitation System	Community Management	Participative Generation of a Water Treatment	SISAR - Community oriented water and sanitation services	Capacity Building for Monitoring Water Quality in Vulnerable Communities
	D2.1	**D2.2**	**D2.3**	**D2.4**	**D3.1**	**D3.2**	**D3.3**	**D4.1.**	**D4.2**	**D4.3**
policy-institutional		X				X	X			
socio-political and cultural	X	X		X	X	X	X	X	X	X
economic-financial	X				X				X	
techno-infrastructural / operational	X	X	X	X	X				X	
health										
ecological-environmental										

2.1.A. Historical case studies

The SISAR/CE model (D2.1) is a shared management and operational model for water supply: the public authorities provide the physical infrastructure for water supply and treatment systems, while the local community takes responsibility for the systems' maintenance and operation in an attempt to make them more efficient and sustainable. Its economic-financial structure and the mechanisms it deploys are innovative in the sense that they had never been applied to rural areas.

The Condominial Sanitation System (CS) (D2.2) implements a sanitation system based on simplified, flexible and low-cost technical solutions, which entail a very active participation of the beneficiary population in some aspects of the implementation and maintenance of the system. The innovation did not require the introduction of new infrastructural elements, as the system relied on existing elements and mechanisms. The innovative element in the techno-infrastructural and operational dimension was, firstly, the decentralizing reordering of the elements of the infrastructure, making the block of houses (the condominium) the modullar centre of the system. Secondly, the innovation was also in the simplification of the system's structure, reducing the dimensions both of the network as a whole as well as of its individual components, pipes, connectors, etc.

The Communal Springs' model (D2.3) has no underlying planning and no interference from public entities. It relies on physical infrastructures (wells and springs) built by residents, without any planning and with informal or absent management, to guarantee water supply to low-income populations in peri-urban areas.

The Eco-technological model (D2.4) is a community-led model for the implementation of eco-technologies to improve the water supply and sanitation services. The model is based on a water treatment infrastructure, with two parallel processing lines, and a simplified sewerage system that allows a flexible design associated with lower costs

and a higher number of connected households. Its main goal is therefore to develop and provide technologies adapted to local social and cultural realms, as well as to municipal and national policies, to solve problems of water contamination in peri-urban areas, reducing associated problems of water supply and sanitation.

2.1.B. Current case studies

The SISAR/CE model has evolved throughout the years and was adapted to other regions. Currently, new communities wishing to enrol the SISAR's services have to be equipped with a water distribution network (D3.1). This modified model implements only specific measures, adapted to the local reality, regarding the operational and economic-financial dimensions of the water supply system. The Integrated Sanitation System (D3.2) implements an adapted model for effective sanitation provision that does not introduce new designs or technologies. Instead it proposes the integration of sectors and institutions to assure the long-term sustainability of the system based on three main principles: establishing inter-sector coordination, inter-federative collaboration, and qualified citizen-user participation at all stages of the process, from design and implementation to monitoring. The overall goal of the Community Management model (D3.3) is to promote, in a concerted and methodical way, inter-institutional and interdisciplinary coordination to enable the identification of problems and their causes in the water supply system and in its institutional component and community participation, enabling the search for solutions through teamwork with the beneficiary community, while guaranteeing their effectiveness and permanence. It proposes a structure to assist the community and partners on finding technological alternatives to solve water quality related problems, based on a participative process involving the community at all stages, from problem identification to operation, monitoring and maintenance.

2.1.C. Intervention case studies

The objective of the Participative Generation of a Water Treatment System (D4.1) is the discussion, selection, installation and operation of a potable water supply system in a rural community. It proposes a participatory process to select water treatment technological alternative solutions. The implemented participatory techniques include both students and professionals from public institutions, stimulating the community to actively participate in the research process as well as in the process of selection of the alternative that best suits the cultural specificities of the community.

The SISAR/CE model was initially designed and implemented to guarantee the provision of water to low-income populations in rural areas. More recently, the SISAR/CE model has also been dedicated to the implementation of dwelling-specific sanitary units (D4.2). The example presented is the first approach of SISAR/CE to the implementation of essential sanitary units. The case study presented shows that the model still relies on the implementation of a specific operational and economic-financial model for the management of a water supply system, but additionally it provides sanitation infrastructure.

The Capacity Building model (D4.3) proposes a method of capacity building of students and teachers, from secondary schools, to guarantee the engagement of the community on the solution of water quality related problems. The model is based on knowledge transfer from researchers to students and from them to the entire community

as a mean to build public autonomy. Four main goals were established: a) define and build a new methodological framework on the base of linking social actors trained with research/technical teams; b) build a new set of links between individuals in order to know, understand and solve immediate necessities, using technology and social networking; c) test empirical instruments to create knowledge transfer networks between academic researchers and civil society organisations; and d) develop learning mechanisms to encourage people for the engagement on social control of water and sanitation provision, based on existing standards.

2.2. Characteristics of the innovation per dimension

Despite being characterised by key marker dimensions (Table 1), as identified in the previous section, the case studies selected have features that can be described in light of the six analytical dimensions defined by the DESAFIO project. Notice, however, that not all dimensions were covered by all case studies and different sets of dimensions were covered for contextualization purposes, for description of the socio-technical innovations and for the analysis and discussion of the results.

2.2.1. Policy-institutional dimension

The water governance regimes adopted in the case studies analysed emerged under an historical framework of changes between regimes that saw water as a commodity, limiting the service coverage to those areas considered profitable by the private companies, and regimes with management models centred on the control and direct intervention of the state, seeking for the universalization of water and sanitation services (D1.1). Currently, in some countries of Latin America, like Argentina, though privatist regimes have been in reverse, the notion that the access to water and sanitation services is a social right and a public good has been almost eradicated and public companies run their services on a similar basis that private utilities. As a consequence the state tends to limits its role to that of enabler and guarantor of "privatised" public services". This profit-oriented approach left poor urban and rural communities out of target, but social pressure led to the arrangement of alternative political-institutional systems to guarantee the provision of water and sanitation services to unserved areas. Such approaches involved the participation of both public (i.e., the state) and private actors, which include the participation of private companies, not-for profit organizations and other social actors, such as the end-users. With exception from the Communal Springs' model (D2.3), which has been implemented without any institutional framework, all case studies analysed have implemented a political-institutional system with contributions from the state and from some other profit and/or non-profit entity (Figure 3). D2.4, D3.3 and D4.1 have implemented political-institutional systems involving partnerships between the state, private companies, a not-for-profit organization and end-users. D2.1, D2.2, D3.1 and D4.2 have implemented political-institutional systems involving collaborations between the state, private companies and end users. D3.2 had contributions only from the state and the community.

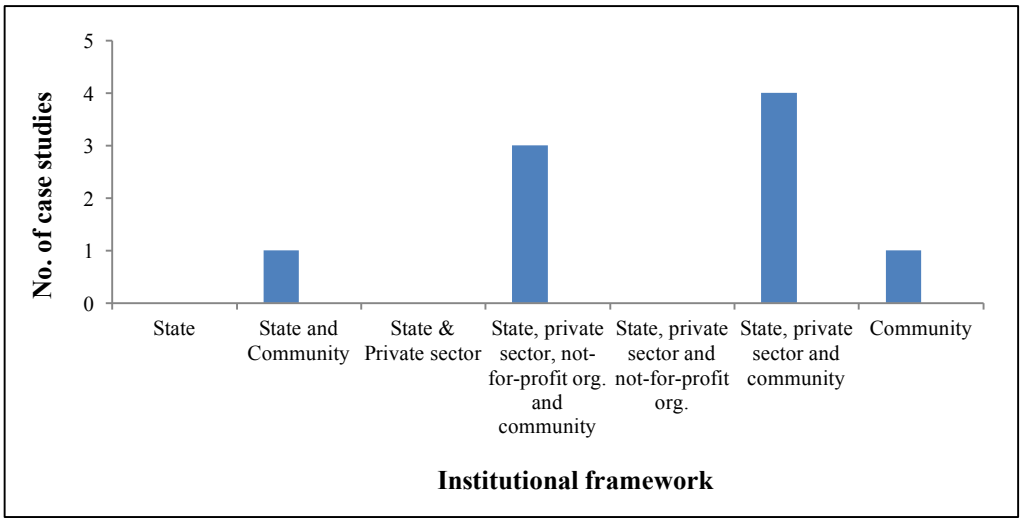


Figure 3. Policy-institutional dimension: Number of case studies per political-institutional system.

This section summarises the characteristics of the innovations regarding the policy-institutional dimension and tries to respond to the question '*who are the key agents/social actors in the different stages of design, implementation, etc. of the innovation?'*

2.2.1.A. Policy-institutional: Historical case studies

Within the SISAR/CE model (D2.1) the public Water and Sewerage Company of Ceará (CAGECE) offices provide technical and social assistance in the creation of community associations. Its Rural Water and Sanitation Management Department (GESAR) is responsible for the systems' management which is shared with local community associations. Executive representatives of local associations commit to a partnership with the SISAR/CE in which they assume the responsibility of playing an essential role as mediators between the SISAR managers and local water users. Initially, funding was provided by the German KfW Bank. The systems require a resident operator in the community who is chosen with the objective of insuring rapid response to operational problems and maintaining adequate communication with the population and the SISAR/CAGECE's offices, striving to solve more complex technical operations. The implementation of the Condominial Sanitation System (D2.2) was a political experience based on intense mobilization of the population in the initial stages of the project. This model proposes a redefinition of the institutional role in the provision of basic services, promoting decentralization and community engagement. As such, municipal authorities, and more precisely its social and technical departments, were responsible for the design, implementation, and community accompaniment. The community was responsible for the implementation, management, operation, and maintenance of the system. The model introduced the Condominial Agreement as a formal partnership between the user community and the local authority, which represented a potentially transforming change in the institutional dimension, mainly because it assumed the necessary negotiation between local authority and user community. The implementation of the Echo-technological model (D2.4) in the municipal area of Cali benefited from a previous

interdisciplinary and inter-institutional cooperation within the TRANSCOL Program (Technology Transfer Program in Water Supply Systems in the Republic of Colombia). A partnership was established between regional and municipal public entities (Public services municipal entity; regional environmental entity; Public Health entity; municipal government), the Cinara Research Institute, Private companies (for infrastructure construction) and the community to select priority areas and implement the best alternative solution. The development and selection of the optimal solution has into account the social and cultural conditions of local communities, as well as national and local policies. The model promotes community participation in the processes of planning, execution and evaluation of projects.

2.2.1.B. Policy-institutional: Current case studies

The current case study assessed to evaluate the SISAR/CE model (D3.1) follows the same policy-institutional framework as the case study assessed in the D2.1. The Integrated Sanitation System (D3.2), implemented after the lack of success of the Condominial Sanitation System, relies on inter-sector coordination, assuming that sanitation is not just about water and sewerage infrastructure, but it is rather a full-scale process of urbanisation. The Integrated Sanitation System assumes urbanisation of irregular areas as a fundamental component of its interventions. The Integrated Sanitation System model also relies on inter-federative collaboration, assuming that the financial and institutional efforts require the involvement of all levels of government, municipal, provincial and federal, including the participation of the water and sanitation service provider (the Pernambuco's Water and Sanitation Company, COMPESA). To enable the effective participation of the community, the municipality introduced deliberative mechanisms for the design of an Integrated Sanitation policy programme (debates and workshops) and created the Local Integrated Sanitation Desks in the neighbourhoods where the Integrated Sanitation System was implemented. This model also included the creation of Monitoring Commissions for the Works of Integrated Sanitation, composed by members of the community, professionals, members of civil organizations, and representatives of the local and provincial governments. The Community Management model (D3.3) shares responsibilities between the community and a public-private partnership. This model includes private companies responsible for project management and infrastructure building; national and international NGOs; international cooperation organisms; national, regional and municipal governments, which are responsible for funding, logistic support, work labour, material and monitoring. The Cinara Institute from the University of Valle is also involved in the project acting as a facilitator. From the community, the model has the support of the Aqueduct board Administration, of community leaders, of an educational institution and also community support groups and the users themselves. Research on the best pre-treatments was developed by local research teams, together with field social-technical teams and the community.

2.2.1.C. Policy-institutional: Intervention case studies

The Participative Generation of a Water Treatment System (D4.1) relies in an inter-institutional collaboration at the national and state level with parties that have some relation with the local Quilombola context: social movements and NGOs, which act as facilitators, and federal government institutions, responsible for infrastructure installation, distribution and storage and water treatment. The laboratory tests are carried out in the Department of Sanitary and Environmental Engineering (DESA) at the UFMG and in the Minas Gerais Sanitation Company's (COPASA) Water Treatment Station. The community is responsible for the system's maintenance and has an active role in the selection of the best alternative. The intervention case study assessed to evaluate the SISAR/CE model (D4.2) follows the same policy-institutional framework as the case studies assessed in the D2.1 and D3.1 The Capacity Building model (D4.3.) evaluated the provision of water supply services in 5 communities' located in Argentina, Santa Fé. Three different schemes of water provision were evaluated: through Cooperatives, through public water and sanitation services Company and water supply without formal network. The model proposes linking local wisdom with academic knowledge promoting collective knowledge. The political-institutional system has not been described.

2.2.2. Social-political and cultural dimension

In the perspective of the DESAFIO project one of the main obstacles for meeting the Millennium Development Goals is the protracted exclusion of substantive citizen involvement and democratic governance in the relevant processes. The pressure on governments from social actors, demanding greater transparency and accountability from the authorities and service providers, has led to the increasing popularity of "social participation" mechanisms, which in turn have been seen by governments as the ideal tool to control social conflicts. Several forms of social participation can be identified in Latin America (D1.1) and others can be envisioned for the future, but effective social participation can only be expected if citizens and service-users are informed and provided with organizational capabilities. In peripheral urban and rural communities this is less expected unless mechanisms of community empowerment are also employed, such as education, training and discussion forums. All the case studies analysed in the scope of the DESAFIO project include some form of social participation mechanism. The mechanisms implemented depend on whether the community is sought to participate at all stages of the implementation process, as for example in the Echo-technological model (D2.4) and in the Community Management model (D3.3), or just required to participate, for instance, as a control and or monitoring actor. In the most recent interventions of the SISAR model, for instance, the community wishing to enrol the SISAR services must already be equipped with a water supply system and an *a priori* designed operational and management model of shared responsibilities is implemented.

2.2.2.A. Socio-political and cultural: Historical case studies

The SISAR model (D2.1) is an example of a top-down model for the implementation of water and sanitation services, but seeking the participation of communities to guarantee a less centralised and more participative management model. Guidance, either through education,

training and meetings, was provided to the communities to help in the creation of community associations that would become the residents' legal representatives. Community involvement is valued from the request for a system to the discussion of projects and afterward in the construction, operation and maintenance of these systems. Once the system is implemented, the model's guidelines ideally implicate that users with questions or complaints will communicate them to their local operator first. One of the innovative elements of the Condominial Sanitation System (D2.2) is the required negotiation, from both the political and social perspectives. The Condominial Sanitation System envisioned social participation through a wide range of contributions from the community: adhesion to the system, agreement to pay the condominium extensions, commitment to guarantee the system maintenance and infrastructure construction. The long-term feasibility of the model was encouraged through environmental and health educational campaigns, which should contribute to the awareness of the community for the importance of water and sanitation services systems. Though without a formal management model, the implementation of the Communal Springs (D2.3) proved that a certain level of community organization is always necessary. As an example, one of the springs analysed was located in a private area but the residents managed to guarantee the public access to the water source. One of the goals of the Echo-technological model (D2.4) was to stimulate the community participation at all steps, from design and planning to implementation and evaluation, strengthening the management capacity of the community, providing technical advice and training.

2.2.2.B. Socio-political and cultural: Current case studies

The current case study assessed to evaluate the SISAR/CE model (D3.1) follows the same socio-political and cultural framework as the case study assessed in the D2.1. The Integrated Sanitation System (D3.2) foresees basic sanitation services as instruments of social equalization and citizenship building. While assuming that the primary responsibility for essential services provision lies in the state, proposing mechanisms for effective public responsibility, this model also proposes forms of co-responsibility of citizens-users at all stages of interventions, including management monitoring and long-term maintenance. Additionally, it incorporates the educational dimension as a central element of interventions to strengthen the capacity of citizens-users to participate qualifiedly in the different stages of the interventions. The Integrated Sanitation System provided community education and training in a range of areas, including technical aspects of the systems (needed to participate in monitoring the works and the performance of the services), public health, and environmental aspects. The Community Management model (D3.3) is greatly concerned in developing a participative methodological process in which the communities are involved from identifying the problem, to operation and maintenance. Community independence regarding system's operation and maintenance is provided through formal education of resident operators.

2.2.2.C. Socio-political and cultural: Intervention case studies

The Participative Generation of a Water Treatment System (D4.1) is also concerned in implementing a participative methodological process, in which the community

participates from the first step of problem identification, to the discussion, selection and implementation of the best solution. One of the guiding principles of this model, implemented in one the most traditional Brazilian communities, was to respect the history of struggle for the rights of all the traditional populations in Brazil. A model where students and professionals are trained in use of the participatory process was applied, and the gained skills should then be applied to encourage the active participation of the entire community throughout the whole process. The intervention case study assessed to evaluate the SISAR/CE model (D4.2) follows the same socio-political and cultural framework as the case studies assessed in the D2.1 and D3.1. Social participation and community empowerment within the water supply systems in use in the Santa Fe communities were evaluated by the Capacity Building model (D4.3) to evaluate community perception. This would provide a working knowledge basis to justify and contextualise the necessity of a model which seeks to promote and strengthen the participation of the community and its stakeholders, trying to make them real agents of their own changes. The model proposes to work initially with students and teachers from secondary-education schools to promote the communities engagement on the solution of their own problems.

2.2.3. Economic-financial dimension

The governance regime selected by each model has implications in the economic-financial mechanisms adopted to fund the systems' implementation. For one hand, fully privatist regimes were not attractive because the provision of water and sanitation services is seen, by private investors, as a non-profitable commodity when implemented in low income communities, frequently located in areas lacking urban planning. On the other hand, administrative regimes became bureaucratic and with the only intention to create powerful public institutions and with little room for exercise of political rights in relation to decision-making processes. The majority of the case studies evaluated, as for instance the SISAR/CE (D2.1) and the Community Management model (D3.3), applied a governance regime with characteristics from both the abovementioned approaches, where the state would contribute to system implementation, relying on public-private partnerships (which include non-profitable organizations and at times the community itself) (Figure 4). To guarantee the economic-financial sustainability of the systems, the majority of the systems also implemented a management model based on shared responsibilities between the providers and the user-community, applying a variety of billing systems. Even for the case where the state assumed the total cost for implementation -the Integrated Sanitation system D3.2- the community was responsible for purchasing the water and sanitation service, in the form of tariffs.

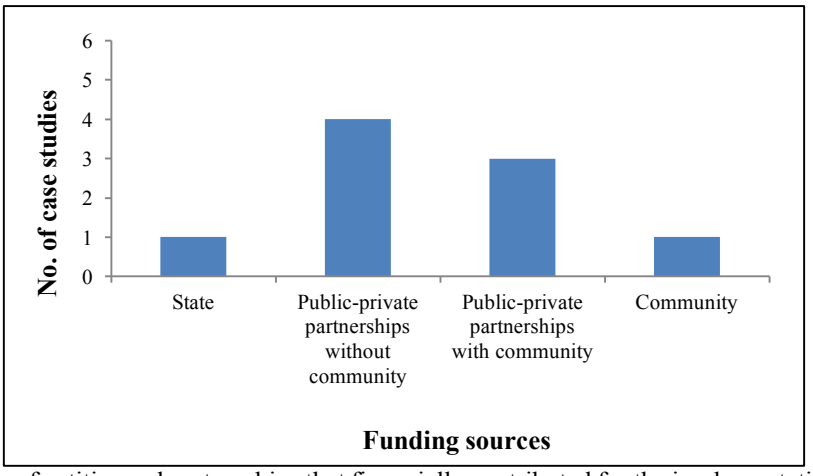


Figure 4. Types of entities and partnerships that financially contributed for the implementation of the water and sanitation systems.

2.2.3.A. Economic-financial: Historical case studies

Throughout its history, the SISAR/CE model (D2.1) has altered the form of its *quid pro quo* with communities. Initially, interventions occurred in Ceará's rural water and sanitation services by means of the partnership between the Brazilian public authorities and the German KfW Bank, within the scope of transformations in Latin American water and sanitation system policies. In January 1990 a contract was signed for a loan of 15 million German marks between the Brazilian and German governments with the KfW Bank as main financial agent, for the implementation of water supply systems. The public authority took responsibility for providing the physical infrastructure for water supply and treatment systems, while users should pay for SISAR services by dwelling or establishment. Service payment was established through the implementation of tariffs that included fees for water consumption, electricity, operator gratification and an administrative fee. The SISAR model strives to guarantee financial surpluses, even if the construction of systems is subsidised. The Condominial Sanitation System (D2.2) envisages a low total cost solution, with low investment from the public sector and with community investment from the beneficiaries. The contribution from the user community can include the payment of condominium extensions (the private part of the system), the maintenance costs of home extensions, and even the absorption of the private system construction (under technical guidance of the service provider). Due to the lack of formal planning, management and operation, the Communal Springs' model (D2.3) provides free water supply services lacks any economic-financial framework. The financial support to implement the low-cost solution envisioned by the Echo-technological model (D2.4) came from several public entities: public services' providers, health and environmental authorities and universities. The community also contributed financially to its implementation, to guarantee the necessary funds to implement a water supply system with associated water treatment plants.

2.2.3.B. Economic-financial: Current case studies

The SISAR/CE model (D3.1) follows an identical economic-financial framework as the previous SISARs, but has recently introduced a progressive price table (value increases after a certain volume of water consumption) and the interruption of service for users with unpaid bills. Moreover, currently local associations are encouraged to participate in the decision of certain fees' amounts. Contrary to the Condominial Sanitation System (D2.2), the Integrated Sanitation System (D3.2) claims that the communities are too vulnerable to support part of the costs and therefore interventions must be fully funded by state public institutions, through planned actions in an integrated and coordinated way in order to join forces and resources, through a cooperatively approach. In the particular case of Mustardinha, over 70% of the investment was funded by the municipality, and the rest came from the provincial government. The Integrated Sanitation System established tariffs based on social equity. The Community Management model (D3.3) guarantees its inter-institutional nature also through the allocation of funds which come from a variety of different institutions on a private-public partnership. The community, which actively participated at all stages of the implementation process, also provided labour and financial resources.

2.2.3.C. Economic-financial: Intervention case studies

The Participative Generation of a Water Treatment System (D4.1) guarantees financial support from federal public institutions which seek for public-private partnerships. Other federal institutions provide technical and financial support for disease control. Locally, the community has the financial support from state and municipal institutions for infrastructure construction. The intervention case study assessed to evaluate the SISAR/CE model (D4.2) follows the same economic-financial framework as the case studies assessed in the D2.1 and the D3.1 The Capacity Building model (D4.3) evaluated the provision of water supply services in 5 communities' located in Argentina, Santa Fé. Three different schemes of water provision were evaluated: through Cooperatives, through public water and sanitation services Company and water supply without formal network. Though the information gathered evaluates the water price perception, indicating that the system relies on a pay-per-use approach, there is little information with respect to the economic-financial system.

2.2.4. Techno-infrastructural /operational dimension

The DESAFIO project selected a variety of examples that range from communities without water supply, to communities with non-potable water supply and others with non-treated residual water. The socio-technical innovations implemented were designed, and/or, adapted, to guarantee alternative solutions suitable to solve the above-mentioned problems and feasible for implementation in rural areas or urban areas without urban planning. The considered models had into consideration the local realm and the solutions presented and have either evolved in time to meet the rural communities' needs, as is the case of the SISAR/CE model (D2.1, D3.1. and D4.2), or were designed together with the user community to guarantee that their needs would be attended, as is the case of the

Community management model (D3.3). The techno-infrastructural/operational specificities of each case study evaluated are described next.

2.2.4.A. Techno-infrastructural/operational: Historical case studies

In the beginning, the communities wishing to enrol the SISAR/CE model (D2.1) had to contribute in the various tasks involved in the implementation of systems (excavating ditches to install distribution networks, for example), whereas the public authorities were responsible for the installation of water meters. Operationally, the community associations are expected to provide preventative and corrective technical assistance, monitor water quality, perform educational activities in relation to water and sanitation services, and provide operational information about the systems to public authorities. The users are responsible for service payment, preservation of water distribution system and reinforcement of local associations. The SISAR is responsible for management, maintenance and water quality control and environmental training. The Condominial Sanitation System (D2.2) introduced the condominium as an innovative element in the techno-infrastructural and operational dimensions. Its goal was to implement a simplified infrastructure by reducing the network size, reducing the pipe diameter, introducing flexible infrastructures adaptable to irregular areas and introducing network extensions with shallower depths. Communication between local authorities and the community are encouraged throughout the entire process of system implementation, including operation and system management. The Communal Springs' model (D2.3) provides technically simple solutions (wells and springs) implemented at will by the community. The Echo-technological model (D2.4), as the name suggests, proposes the development and transfer of echo-technologies for potable water and residual water treatment. It offers simplified systems, with associated environmentally-friendly and low cost solutions: construction at low depths; pipes far away from locations with heavy traffic; strategic location of the wastewater treatment plant to avoid rainfall water and aggregate domestic water from as many houses as possible; pre-treatment systems inside each house. The community is responsible for management, operation and maintenance of systems, after training provided by the public entities.

2.2.4.B. Techno-infrastructural/operational: Current case studies

The techno-infrastructural framework of the current case study selected to evaluate a current example of the implementation of the SISAR/CE model (D3.1) is similar to older implementations, however, currently, a community wishing to enrol the SISAR/CE services must already be equipped with a water distribution network including canalizations, individual water meters for each dwelling or establishment, a water macro-meter and appropriate electric installations for the operation of a water distribution station. The Integrated Sanitation System (D3.2) did not introduce new designs and technologies, though it rejected to introduce the Condominial Sanitation System (D2.2) in unserved areas and proposed only the upgrade of previous condominial systems where it had already been implemented. Technically, the Integrated Sanitation System adapted previously existing sanitation models. This model also adopted an integrated perspective of infrastructure implementation, where the water network, sewerage and drainage should

be combined with paving and household improvement. The Community management model (D3.3) strives to provide echo-technological alternatives for the provision of water with good quality for human consumption. The proposed alternatives, which should encourage the use of local materials, are selected in conjunction with the community and taking into account the local reality. The operation and maintenance mechanisms are simple and easy to understand by local workers with low education level.

2.2.4.C. Techno-infrastructural/operational: Intervention case studies

The Participative Generation of a Water Treatment System (D4.1) also proposes the analysis of several alternative collective water treatment techniques in use in the community and the participatory selection of the optimal solution. The intervention case study assessed to evaluate the SISAR/CE model (D4.2) follows the same techno-infrastructural framework as the case studies assessed in the D2.1 and D3.1, but only in what relates to the water supply network. Additionally, and for the first time, the SISAR/CE model (D4.2) included the provision of sanitation structures to communities lacking sewerage and other sanitation elements. The Capacity Building model (D4.3) is still under implementation and it has only achieved its first goal which was to strengthen citizen awareness regarding water and sanitation systems. A second demand, that is, the selection and construction of appropriate technology for water treatment is still under development.

2.2.5. Health dimension

Though some of the models might not include this dimension in a straightforward manner, the implementation of water supply and sanitation systems is by itself a mechanism for health and environmental improvement. Some socio-technical innovations are focused in water quality monitoring and in providing treated water, others in guaranteeing sanitation and waste disposal.

2.2.5.A. Health: Historical case studies

The SISAR/CE model (D2.1) was initially focused only in guaranteeing the provision of good quality water. The model proposes water quality monitoring by local associations and water quality control by the SISAR offices. More recently, the model has implemented promotion programs for community empowerment with impact on public health. The Condominial Sanitation System (D2.2) does not directly address the health dimension, though one of the main goals of this model was to reduce the prevalence of waterborne diseases related to lack of sanitary conditions in the Mustardinha region, Brazil. The Communal Springs' model (D2.3), as a result of its informal management, still lacks water treatment and has poor sewage coverage leading to water contamination of water table. The Echo-technological model (D2.4) in the community of La Vorágine - Colombia emerged due to the necessity of solving water contamination problems. During the 1980s, lack of maintenance of the existing sanitation systems contaminated nearby superficial waters, resulting in high negative impacts on local tourism and in community

health. The implemented solution intended to guarantee treated water supply and eliminate residual water contamination.

2.2.5.B. Health: Current case studies

The current case study assessed to evaluate the SISAR/CE model (D3.1) follows the same health guidelines as the case study assessed in D2.1. The Integrated Sanitation System (D3.2), similarly to the Condominial Sanitation System (D2.2), does not directly address the health dimension, though one of the main goals of this model was to reduce the prevalence of waterborne diseases related to lack of sanitary conditions in the Mustardinha region, Brazil. The core of the Community Management model (D3.3) is to implement technical alternatives to improve water quality. An echo-technological alternative denominated Multiple Stage Filtration (Slow sand filtration plus pre-treatment) was selected to solve water quality problems.

2.2.5.C. Health: Intervention case studies

The goal of the Participative Generation of a Water Treatment System (D4.1) is to adapt pre-existing water treatment systems and analyse all the alternative collective water treatment techniques used in the community, to find the best solution. Nevertheless, the health dimension was not a specific object in the D4.1 and thus, was not directly addressed. The adapted SISAR/CE model implemented and currently under evaluation as an intervention case study (D4.2) recognises that the relationship between public health and interventions in water supply and water sanitation must be understood in a broad context of environmental health. This explains this first approach of the SISAR to the implementation of a sanitation infrastructure. This study advances that the continuous distribution of water in appropriate quantity and quality, as well as improvements in dwelling-specific sanitation, are ways of promoting a community's health. It also advances that these practices do not only encompass individual behaviour but organizational forms of society and politics as well, with their respective organizational structures. The Capacity Building model (D4.3) was applied in a group of communities ranging from those with formal water supply systems to those without water supply providers. Model tasks included the collection of water samples for water quality analysis, whose results should support the discussion regarding water quality standards and raise community awareness about the quality of water consumed.

2.2.6. Ecological-environmental dimension

Regarding the ecological-environmental dimension, little attention has been paid to it and therefore, the information available is scarce. The lack of information in the different case studies occurs for different reasons: because the innovation disregards the ecological-environmental dimension and the alternatives selected are unaware of the ecological-environmental impacts; because the ecological-environmental dimension is defined solely as environmental sanitation, binding this dimension to the health dimension; because the DESAFIO partners have not fully addressed these dimensions; among other possible reasons. The health dimension was not directly addressed by several of the

innovations under study, though most of them report waterborne diseases and/or contaminated water in the communities assessed.
According to the available information, of the available historical case studies, D2.1, 2.2 and 2.3 have not directly addressed this dimension. Of the current case studies, those evaluated by the D3.1 and 3.2 have not also directly addressed this dimension. Of the intervention cases, the case studies evaluated in D4.1 and D4.3 assess this dimension as a mean to find the best solution to cope with the environmental problems encountered in the community with respect to water quality. The available information is described next for each case study.

2.2.6.A. Ecological-environmental: Historical case studies

The SISAR/CE model (D2.1) was implemented in the Ceará region, in Brazil, where it has long been necessary addressing the subject of the region's water, frequently that associated with irrigation, due to its climatological characteristics. Ceará is a semi-arid region characterised by high temperatures, an elevated solar index and high rainfall irregularity in terms of distribution in time and space. In periods of severe drought, increased levels of evaporation and generalised destruction of native hinterland drainage systems may be observed. The SISAR/CE model was designed to guarantee water supply to these climatically vulnerable areas, but the environmental dimension was not directly addressed and the concept of environment is tied to the concept of health and environmental sanitation. The Condominial Sanitation System (D2.2) and the Communal Springs' model (D2.3) also do not address the ecological-environmental dimension. In the case of the Echo-technological model (D2.4) the term innovation is closely linked to find creative ways to solve problems of water pollution, while adapting to the environmental conditions and to the local community socio-economic specificities. The main concern of the locals was to improve the water quality of the river Pance because their income had been affected by the decline in tourism. As a result, priority was given to the construction of the sewerage over the water supply system. Environmental constraints and environmental impacts were taken into consideration by the community while selecting the optimal echo-technology for wastewater decontamination as well as the location of the Wastewater Treatment Plan. Issues such as topography and land use were taken into consideration, for instance to avoid the entrance of rainwater into the sewerage.

2.2.6.B. Ecological-environmental: Current case studies

The SISAR/CE model (D3.1) was also designed to guarantee water supply to climatically vulnerable areas, but again the environmental dimension was not directly addressed and the concept of environment remains tied to the concept of health and environmental sanitation. Likewise, the Integrated Sanitation System (D3.2) did not directly address the ecological-environmental dimension. Nevertheless, the Integrated Sanitation System incorporates the environmental dimensions as integral components of interventions and introduces the concept of environmental sanitation. This model proposed to act on the living conditions by changing the set of physical environmental conditions that allow the reproduction of waterborne diseases in the critically affected areas. One of the goals was

to increase environmental quality through adequate regulation and treatment of collected sewage. Environmental issues were again strongly tied to the concept of health. The socio-technical solution designed and implemented by the Community Management model (D3.3) had into consideration the environmental characteristics of the region. Though implementing a viable, and operationally simple, solution for water purification was the main goal, it was necessary to adapt the technology to account for the climatic and hydrologic characteristics of the basin. Pre-existing technologies had shown to be infeasible due to the high turbidity of the water, especially in the rainy season. Moreover, the basin showed pollution-associated problems due to community wastewater discharges, small local industry discharges and damage caused by mining. A set of pre-treatments were designed, tested and implemented to account for the local realm.

2.2.6.C. Ecological-environmental: Intervention case studies

The Quilombola community, where the Participative Generation of a Water Treatment System model (D4.1) was implemented, directly consumed water from the river, without any treatment, even though the main water sources in the region were polluted due to industrial and agricultural contamination. The environmental dimension, in this model is shaped in such a way as to evaluate the community's environmental situation, to identify locations for the installation of a water supply system and to identify the best solution able to cope with the environmental problems encountered in the community with respect to water quality. The optimal solution selected was based on laboratory analyses of water. The intervention case study where the adapted SISAR/CE model (D4.2) has been implemented, also ties the concept of ecological-environmental dimension to the concept of environmental sanitation. The Capacity Building model (D4.3) also addressed the ecological-environmental dimension characterising the biophysical conditions of the region and assessing the environmental perception of the community. In this case, the goal was to provide a deeper understanding of the interviewees' previous knowledge on environmental conditions. The model intends to plan and define how to get closer to acquire consciousness and for that it was essential to know the environmental living conditions of the students and population.

2.3. Temporal scales

The following questions were asked to the partners: '*what is/are the temporal scale(s) of the design and implementation of each innovation* and *what is/are the temporal scale(s) of the impact sought through the innovation'*. Answering these questions will help understand whether successful innovations correspond to those that took longer to design, and if so, could that mean that they were more carefully designed? Moreover, the temporal scales within which the innovations were designed and implemented might give an indication of the time interval needed to implement future innovations of the same nature. The temporal scales of each innovation are presented on Table 2.

Two contrasting situations emerge from this table. The SISAR/CE model (D2.1, D3.1, D4.2) was carefully designed in the 1980s and is still under development as new challenges emerge, as for instance the need for sanitation (D4.2). This system has been successful until today. On the contrary, the Communal Springs' model (D2.3) had no

formal planning, but is still in use until today, as the communities resort to wells and springs when their potable water supply needs are not fulfilled by the local authorities.

Table 2. Temporal scale(s) of design and implementation of the innovation and temporal scale(s) of the impact sought.

	Case-study									
	Historical			**Current**				**Intervention**		
DESAFIO systems	SISAR - Politico-Institucional Evaluation	Condominial Sanitation System (CS)	Communal Springs	Ecothecnological System	SISAE/CE - Ethnographic Assessment	Integrated Sanitation System (IS)	Community Management	Participative Generation of a Water Treatment	SISAR/CE - Community oriented WSS	Capacity Building
	D2.1	**D2.2**	**D2.3**	**D2.4**	**D3.1**	**D3.2**	**D3.3**	**D4.1**	**D4.2**	**D4.3**
Temporal scale of design and implementation of the innovation										
design	1980s	late 1980s	-----	1993	1980s	2000-2001	1991 - 1994	2013	1995	2014
implementation	phase1: 1990s phase2: 2005 phase3:2011 phase4: under discussion	1993-1994	responds to needs	1995-1996	2013	2002	1995	2013-2015	2013	2014
analysed time interval		1993-2000	2009-2010	1993-1997	2013	2001-2004	1994-1995 2014	2013-2015	2013-2015	2014-2015
Temporal scale(s) of the impact sought through the innovation										
long-term	X	X		X	X	X	X	X	X	X
medium-term										
short-term			X							

2.4. Transformations through the innovation

This section aims at responding to the following questions '*what kind of transformations are intended through the innovation?'* and '*what mechanisms are used by the innovation to produce these transformations?'*

All models, except, the Communal Springs model (D2.3) proposed mechanisms that would guarantee the community engagement and empowerment and thus the preservation of an efficient service in the long-term. The Community Management model (D3.3) and the Integrated Sanitation System (D3.2) additionally envisioned the inter-sectoral and inter-institutional collaboration as a mean to guarantee an effective and

permanent service. In common, all these models have their source of innovation, which arose from above, with significant inputs from public entities.

The Communal Springs' model (D2.3) is a community-led model for free water supply, with informal planning and management. Its only purpose is to guarantee water for as many users as possible, building rudimentary infrastructures based on the community's water needs.

For the remaining innovations, the mechanisms used to produce the transformations are diverse and cover a wide range of dimensions. Economically, the SISAR/CE model (D2.1, D3.1 and D4.2) relies on the implementation of an economic-financial structure, whose tariffs have evolved from an equitable division of tariffs to a progressive price table. Likewise, the echo-technological model (D2.4) implemented water bills with differentiated tariffs. The Condominial Sanitation System (D2.2) implemented an economic-financial structure where the community had to invest in the infrastructure, whereas the Integrated System (D3.2) totally abolished the community funding. Technically, the SISAR/CE (D2.1, D3.1 and D4.2) introduced water meters as a mean to implement differentiated water bills, whereas the Condominial Sanitation System (D2.2) and the echo-technological model (D2.4) relied on the implementation of simplified structures to guarantee the service provision to the low-income population. Mechanisms were also introduced at the operational level: the Condominial Sanitation System (D2.2) introduced the Community Agreement to assure the population engagement; the echo-technological model (D2.4) created a working group to control system operation and maintenance and a community association to manage the water and sanitation system; the Integrated Sanitation System (D3.2) assured the close participation of the population allowing them to present complaints and requests. Institutionally, the SISAR/CE model created the Rural Sanitary Management Department (GESAR), whereas the Integrated Sanitation System (D3.2) and the Community Management model (D3.3) introduced mechanisms to guarantee inter-sectoral coordination and inter-federal collaboration. As for the socio-political dimension the mechanisms introduced were essentially to guarantee the communities' participation at all or some steps of the implementation and management process. Specifically, the Condominial Sanitation System (D2.2) strived to guarantee the adaptation of the local authorities' role; the Participative Water Treatment System (D4.1) organized local assemblies to select the most appropriate alternative solution considering the local reality; the Community management model (D3.3) developed and implemented an institutional program in a participatory and organized manner and the Capacity Building model (D4.3) based its' model on the participation of students and teachers from secondary schools which should later transmit the acquired information to the community. Some of the innovations also included education and training to the community, either on technical issues, operational, management, health and/or environment.

2.5. The innovation and the process of democratisation

This section aims to understand the relationship between the innovation and the process of democratisation of the access to and the management of water and sanitation services. The implementation of people-centred governance practices and institutions grounded on substantive democracy and citizenship implies social participation and control over the

decision-making process. Too often "citizen participation" in policy programmes means "willingness" to accept decisions already taken by power holders and technical experts with little or no consultation. The implementation of technically-centred projects where the role of beneficiaries comes down to providers of labour resources or mere service clients results in the weakening of local governments and civil society. The extent to which the socio-technical innovations are characterised by "social" and/or "technical" features, helps understanding the relationship between the innovation and the process of democratisation of the access to and the management of water and sanitation services.

2.5.1. "Social" and/or "technical" innovations

This section aims to respond to the question '*in what sense/to what extent the innovation is "social" and/or "technical"?'* Some of the case studies analysed are more focused on introducing social participation mechanisms, whereas others are more technically-centred. Here, we summarise the role of beneficiaries at all steps of the implementation process as a mean to understand whether the socio-technical innovation implemented active or passive citizen-user participation.

All the case studies analysed promote active participation of the community, though not all include mechanisms for citizen participation at all levels of the implementation process.

Of the four historical case studies, the Condominial Sanitation System (D2.2) is the most technically-centred, as participation of the community is incentivised to guarantee the acceptability of the Condominial Agreement, labour and service costs. Regarding the SISAR/CE (D2.1), the community is out of the decision-process regarding the design of the project, but the final goal is to implement a management model with shared responsibilities between the SISAR offices and the community, which is consulted on several aspects, such as in the decision of certain fee's amounts. On the contrary, the Communal Springs' model (D2.3) is by nature a socially-centred project, as all steps are a responsibility of the community. The Echo-technological model (D2.4) is also socially-centred as it a simplified sewerage for water decontamination, with active participation from the community at all steps: problem diagnosis; selection of the most appropriate technology; control over the construction of infrastructure and over the operation and system management, as well as water quality monitoring.

Regarding the current case studies, the SISAR/CE (D3.1) also excludes the community from the design-making process but also implements a shared-management model of the system, where the communities are able to take decisions. The Integrated Sanitation System (D3.2) and the Community Management model (D3.3) rely on qualified citizen-user participation at all stages of the process.

With respect to the intervention case studies, the SISAR/CE (D4.2) implements a model similar to the previous SISAR/CE, in what concerns the "social and/or technical" nature of the model. On the contrary, the Participative Generation of a Water Treatment System (D4.1) promotes the participation of the community from the first step of problem identification. The Capacity Building model (D4.3) actively incentivises the community participation as this model intends to intends to build a new set of links between individuals in order to know, understand and solve immediate necessities, using

technology and social networking, as well as develop learning mechanisms to encourage people for the engagement on social control of water and sanitation provision.

2.6. Advantages and drawbacks of the socio-technical innovations

To harness existing and developing new appropriate and innovative socio-technical solutions requires the acknowledgement of the pitfalls and shortcomings, as well as the advantages, of existing solutions. DESAFIO covers a wide range of different socio-technical innovations from which we can draw lessons for the future. The advantages and drawbacks of the historical, current and intervention case studies are summarised on tables 3 to 12.

2.6.A. Advantages and drawbacks: Historical case studies

Table 3. Advantages and drawbacks of the SISAR/CE innovation (D2.1).

Advantages	Drawbacks
a) full and uninterrupted operation of systems b) systematic preventive and corrective maintenance c) supervision of water quality d) low cost for communities e) financial and operational support f) role of communities in the supervision of systems g) dissuades excessive or irresponsible uses of water h) financial sustainability	a) implementation of user bill payment without auxiliary income generating projects b) in the beginning, communities were meant to contribute in the various tasks involved in the implementation of systems, but these conditions were suspended due to the socioeconomic conditions c) some of the SISARs became financially unsound and measures had to be taken to guarantee their self-sustainability

Table 4. Advantages and drawbacks of the Condominial Sanitation System innovation (D2.2).

Advantages	Drawbacks
a) improvements to sanitary conditions b) increased community awareness about the interrelations between sanitation, public health, and the environment c) suitable for unplanned and disorganised urban areas, as well as for all other urban designs d) suitable for developing countries, with high urban growth and great demand for sanitation services	a) sewer network, disconnected from other infrastructures (e.g. drainage, garbage) b) requires high level of user commitment and organization

Table 5. Advantages and drawbacks of the Communal Springs' innovation (D2.3).	
Advantages	**Drawbacks**
a) water provision to peri-urban areas, without adequate formal public water supply b) experience accumulation from technicians from public authorities; c) promotes socialization	a) difficulties in monitoring the quality of all alternative sources of water b) time spent for water collection c) informal management creates risks for human health due to water contamination d) lack of efficient sewage collection and treatment systems, which may be causing the contamination of the water table, and therefore the water extracted through wells and springs (unregistered cases of diarrhoea and hepatitis A) e) low water quality perception, though it differed between communities

Table 6. Advantages and drawbacks of the Echo-technological innovation (D2.4).	
Advantages	**Drawbacks**
a) simplified sewerage system b) flexible design c) adapted to local social and cultural realm d) low cost solution e) differentiated tariffs	a) unsuitable to collect rainwater b) collapse of WWTP

2.6.B. Advantages and drawbacks: Current case studies

Table 7. Advantages and drawbacks of the SISAR/CE innovation (D3.1).	
Advantages	**Drawbacks**
a) full and uninterrupted operation of systems b) systematic preventive and corrective maintenance c) supervision of water quality d) low cost for communities e) financial and operational support f) role of communities in the supervision of systems g) dissuades excessive or irresponsible uses of water h) financial sustainability	a) implementation of user bill payment without auxiliary income generating projects b) in the beginning, communities were meant to contribute in the various tasks involved in the implementation of systems, but these conditions were suspended due to the socioeconomic conditions c) some of the SISARs became financially unsound and measures had to be taken to guarantee their self-sustainability d) expenses related to electricity paid by the municipal government, and not equally distributed throughout the user base in the SISAR's monthly bill e) anarchic operational model f) not able to supply potable water, especially during the summer g) absence of appropriate democratic forums h) nowadays, contrary to years passed, many governmental programs will no longer invest in infrastructural projects if there is no guarantee of a subsequent management organisation (like the SISAR or an SAAE) that will take charge of the constructed system

Table 8. Advantages and drawbacks of the Integrated Sanitation System (D3.2).

Advantages	Drawbacks
a) no cost to communities b) public financial and operational support c) public participation in all stages of the process d) inter-sector coordination e) inter-federal collaboration	a) the creation of Local Integrated Sanitation Desks in the neighbourhoods exposed the authorities to public scrutiny and accountability and the tensions created by this innovation led first to the weakening of these participatory mechanisms

Table 9. Advantages and drawbacks of the Community management model (D3.3).

Advantages	Drawbacks
a) improved physical, chemical and bacteriological quality of the water b) simple construction, with local material and handwork c) reduced costs of construction and operation d) operation and maintenance are easy and can be operated by local workers with low education level e) reliable system as there is no need to stop water flux to solve some imminent problem f) simple cleaning though laborious	a) echo-technological solution with limitations and cannot be implemented in every context b) depends on political willingness

2.6.C. Advantages and drawbacks: Intervention case studies

Table 10. Advantages and drawbacks of the Participative Generation of a Water Treatment System (D4.1).

Advantages	Drawbacks
a) community education and training b) professionals training in the participatory process c) process of selection of the most appropriate technique guarantees the community engagement	a) difficult cooperation with collective activities due to internal conflicts, financial and managerial problems b) selection of the most appropriate technique was done without taking into account easiness of construction: difficulties emerged when hiring a company willing to construct the solution selected

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Table 11. Advantages and drawbacks of the SISAR/CE innovation (D4.2).

Advantages	Drawbacks
a) full and uninterrupted operation of systems; b) systematic preventive and corrective maintenance c) supervision of water quality d) low cost for communities e) financial and operational support f) role of communities in the supervision of systems g) dissuades excessive or irresponsible uses of water h) financial sustainability i) water supply to households in less than five minutes j) provide sanitation and waste disposal infrastructures k) health and environmental problems' decrease	a) implementation of user bill payment without auxiliary income generating projects b) In the beginning, communities were meant to contribute in the various tasks involved in the implementation of systems, but these conditions were suspended due to the socioeconomic conditions c) some of the SISARs became financially unsound and measures had to be taken to guarantee their self-sustainability d) implementation of user bill payment without a differential billing structure for low-income users e) infant diseases not eliminated

Table 12. Advantages and drawbacks of the Capacity Building model (D4.3).

Advantages	Drawbacks
a) community education and training b) process of selection of the most appropriate technique guarantees the community engagement	(the model is still under development and no information regarding possible drawbacks is yet available)

3. Factors and processes that explain the emergence of the innovations

This section compiles the factors and processes that facilitated the emergence of the socio-technical innovations. National, regional and/or local political, social, cultural and/or environmental circumstances are able to explain the development of the solutions implemented.

3.A. Factors and processes: Historical case studies

Three of the historical cases were implemented in Brazil and emerged under an economic-financial crisis occurred throughout the 1980s, which caused the deterioration of the water and sanitation sector, especially regarding the provision of water and sanitation services for poor populations, due to the reduction of national public investment. This period was also characterised by institutional instability and instability of national policies, followed by policies embracing processes of privatization of state companies. As a result, national public policies for rural regions, and especially for the semi-arid region, were abandoned. The situation changed from mid-1980s onward, when international cooperation was promoted to invest in areas such as water and sanitation services. The SISAR/CE model (D2.1) was designed to serve rural regions with high demographical occupation, low-income population and health and education indicators below national averages. Additionally, the system intended to solve water supply problems to semi-arid regions with long drought periods, and more recently, to diminish water sanitation deficiencies. The Condominial Sanitation System (D2.2) emerged to assist poor urban areas with high and unplanned urban growth and with great demand for sanitation services, exposed to water-related infections (lymphatic filariasis). Both the SISAR/CE model and the Condominial Sanitation System benefited from high social mobilization and community participation and the level of commitment of local associations and public entities. The Communal Springs' model (D2.3) emerged as a response to the insufficient coverage of WSS networks in Brazilian peri-urban areas, whose implementation depended on political power. Because there was no intention, whatsoever, of public authorities to expand the formal network system in the short-term, peri-urban communities were consistently left out of the investment programs facing severe water supply problems: absence of network, intermittent supply, frequent shortages of water and water quality' problems. These regions were characterised by high social-environmental vulnerable communities, high and unplanned urban growth, high population growth and with a complex hydrographical network. This informal water supply system emerged under the cultural belief that water from wells and springs is of better quality. The emergence of the Eco-technological model (D2.4) was not possible until the 1990s, when a new directive stating that the public services could be provided by any type of actor (public, private or both) came into action. This meant that autonomous community management was finally a possibility. In addition, in 1994, another directive implemented public participation as a control mechanism of public management, providing the basis for the democratisation of water and sanitation services. At the time, high inequalities existed in the provision of water and sanitation services, since rural and peri-urban areas were poorly covered and frequently relied on artisanal water supply infrastructures and had no sanitation coverage. The community where the

Eco-technological system was implemented is characterised by high population fluctuations due to tourism (between 500 (residents) up to 30000 (tourists), high environmental pressure and high levels of water contamination. A cholera outbreak registered in Colombia, during the 1990s, was also observed in this community and four, out of ten, diseases were water-related. The necessity for the implementation of the innovation emerged after tourism decline, in the beginning of the 1990s, due to sewage contamination of the Pance river.

3.B. Factors and processes: Current case studies

Regarding the current case studies, the SISAR/CE model (D3.1) was implemented in a community where rainwater was the most valued water source due to water contamination as a result of illegal modifications to the distribution network performed by the users. As a consequence, the water distribution network was disabled between 2000 and 2005 and a new distribution network was built funded by the public entities, in 2008. The Integrated Sanitation System (D3.2) was implemented after the failure of the Condominial Sanitation System (D2.2). As elections approached, the living conditions of vulnerable communities became key elements in the electoral campaign and more attention was paid to the provision of water and sanitation services. The implementation process relied, thus, on political commitment, which culminated in the creation of the Secretary of Sanitation to take charge of the design and implementation of the programme to provide a definitive solution to the lack of sanitation in Recife's vulnerable areas. The Community Management model (D3.3) also emerged in Colombia, during the 1990s, under a cholera outbreak. During this period, the national government created the Departmental Water Plans (PDA) as the national strategy for water and sanitation sector, which assigned the responsibility for planning, infrastructure construction and even creating regional companies of water and sanitation service to the lowest administrative unit (the departments). By the time, the water and sewerage coverage reached 98% in urban areas, while in rural areas only reached 49% and 15% respectively. In the specific case study evaluated, the already vulnerable water supply system totally collapsed after a severe earthquake that occurred in 1994. Though the water service was restored right after the earthquake, it was identified that 45% of the population located in the highest part of the town had no water supply and 75% had health problems related to water-related diseases, because 100% of the population was consuming poor quality water, due to the mixture of water supply networks with domestic wastewater. It was declared the state of sanitary emergency for the community.

3.C. Factors and processes: Intervention case studies

Regarding the intervention case studies, the Participative Generation of a Water Treatment System (D4.1) arose has a necessity to adapt potable water distribution systems to rural communities, with lack of organizational capacity and trained personnel for systems' operation and maintenance. The implementation process benefited from collaboration with national and local NGOs familiar with the local reality and willing to support the process. Additionally, it benefited from cooperation from University and public institutions. The SISAR/CE (D4.2) intervention case was implemented in a

community with low quality sanitation infrastructures and low coverage of water supply systems. Wells, springs and rainwater constitute the main water sources. The community is characterised by low-income population, whose houses are scattered throughout the territory. The Capacity Building model (D4.3) arose has a necessity to empower populations without potable water supply. High levels of arsenic were known in the evaluated region, mainly those from small communities, but the high cleaning costs prevented from solving the problem.

4. Evaluation of the socio-technical innovations

4.1. Methodological framework

The methodological framework employed for the evaluation of the case studies comprised a) literature review for the assessment of the state of art, b) data compilation from both primary and secondary sources of information, c) data record and d) analysis of results.

All case studies followed a mixed methods approach for the analysis of the results, i.e,, both quantitative and qualitative methods were employed, for which both primary and secondary sources of information were collected. The primary sources of information, which were collected in the field, consisted mainly of semi-structured interviews (Table 13), both at the individual and collective level, after the identification of the communities (Table 14) and the key players (Table 15). The secondary sources of information were gathered from national, regional and/or local authorities and/or non-governmental institutions (Table 16).

Table 13. Field work approach for each case study.

Case study			Field Work
Historical	D2.1	SISAR/CE	A. Semi-structure interviews (individual) No. of communities: 11 No. of interviewed inhabitants: 36 B. Participant observation
	D2.2	Condominial Sanitation System	A. Semi-structured interviews (individual and collective): No. of individual interviews: 16 No. of collective interviews: 10 No. of persons in collective interviews: 2 to 10 B. Workshops: B1. with community members B2. with techno experts involved in the implementation and management of the system C. Participant observation D. Large public events to promote debate among key actors (a conference) E. Data record: Multi-media platforms (photographic, video and audio)
	D2.3	Communal Springs	A. Semi-structured interviews: Field campaign temporal interval: between January and February 2014 (summer) Questionnaire duration: 5 to 6 hours No. of questionnaires: 90: 55 from Jardim da Fonte and 35 from Vila do Rosário No. of questions: 9 B. Participant observation

			C. Data record: Researcher's personal journals and photographic record
	D2.4	Echo-technological	A. Semi-structured interviews to non-users players B. Workshops with the community association. No. of participants: 15 C. Questionnaire applied to end-users
Current	D3.1	SISAR/CE	A. Interviews * Local Communities: Immersive approach (semi-structured or non-structured interviews and informal conversations were carried out) * Public entities: semi-structured interviews * Field campaign temporal interval: 3 phases, of 3 weeks each. 1st phase - professionals linked to SISAR 2nd and 3rd phase - research in the communities A.1. local communities: semi-structured, non-structured (informal conversations to local residents): No. of interviews 80 (40 per community). Most were SISAR users. A.2. Public entities: SISAR managers, CAGECE employees and professionals from other organisations (i.e. the World Bank) No. of interviews: 6 with representatives of local associations; 2 with the operators of each of the communities; 3 with the SISAR-BME's managers; 1 with the social coordinator of the CAGECE's Rural Sanitation Management (GESAR) service; 1 with a World Bank representative; B. Participant observation B.1. Observation of an 'accompaniment reunion', between SISAR managers, local delegates and community users B.2. Observation of the fifth assembly of SISAR-CE and the Bahia Central Community Association for Water Systems Maintenance (CENTRAL-BA)
	D3.2	Integrated Sanitation System	A. Semi-structured interviews (individual and collective): Questionnaire with 48 questions Sample criteria 1) Census Sector 033: 1 out of 3 households, with an error margin of 7% and considering a potential loss of 10%, which gave us an expected number of 90 questionnaires. 2) remaining sectors: 1 out 9 households, also with an error margin of 7% and considering a potential loss of 10%, which gave us an expected number of 150 questionnaires. B. Workshops: B1. with community members B2. with techno experts involved in the implementation and management of the system C. Participant observation D. Large public events to promote debate among key actors (a conference) E. Data record: Multi-media platforms (photographic, video and audio)
	D3.3	Community management	A. Semi-structured interviews (non-users) B. Workshops with plumber, system operator, plant operator, members of the Board and former president of the same C. Questionnaire applied to end-users: Sampling design: random and systematic (1 out of 3 houses and a total of 180)
Intervention	D4.1	Participative Generation of a Water Treatment	A. Rural Participatory Appraisal (4 stages: exploratory, planning, action, evaluation (intermingled)) A.1. Preliminary survey: compilation of basic information to assist in the identification of the criteria in each community No. of surveys: 40 A.2. Exploratory visits: semi-structured interviews, daily routines and crossings and group activity for participatory mapping Lagedo was the 1st community: 23 houses out of 40 Mensal visits have been done to the Lagedo community with a community meeting

			Some questionnaires, simple, have also been applied
	D4.2	SISAR/CE	Data collection time interval: May to November 2014 A. Semi-structured interviews B. Water sampling and quality analysis (a total of 46) C. Blink calendars: to seize the flashing in the various collective water sources D. Stool tests to children up to 5 years E. Participant observation
	D4.3	Capacity Building	A. Questionnaires to determine vulnerability degree of population 13 questions; oral and written Survey is applied to community by the students. Each has made 5 surveys, geographically distributed B. Georeferencing sources of pressure C. Water samples' collection and analysis D. Photographic records of phenological stages of winter crops (wheat) and summer (soybean and corn) E. Survey of the various sources of bottled water consumed

Table 14. Criteria for the selection of the communities to evaluate.

Case study			**Communities' selection criteria**
Historical	D2.1	SISAR/CE	* geographic location within the same Regional Department as the CAGECE office * out of the municipal centre * geographic location in relation to the state's climatic zones * population between 250 and 2 000 inhabitants * localities with available electricity * with effective participation between involved parties * systems' age (both old and recent systems' were chosen)
	D2.2	Condominial Sanitation System	* The Mustardinha ZSSI was one of two ZSSI's in the city to be given top priority in the implementation of the sanitation system, among other issues owing to the high rates of water-related infections, particularly lymphatic filariasis, recorded there
	D2.3	Communal Springs	
	D2.4	Echo-technological	
Current	D3.1	SISAR/CE	
	D3.2	Integrated Sanitation System	* out of the 12 census sectors, one was selected due to comprehensive implementation of the SI system (1 out of 3 houses with a total of 90 questionnaires) * out of the remaining sectors, 5 were randomly selected (1 out of 9 houses)
	D3.3	Community management	
Intervention	D4.1	Participative Generation of a Water Treatment	* community with surface water catchment with high turbidity, that was recognised as a Quilombo by the Palmares Cultural Foundation (FCP) and titrated, or in the titling process, by INCRA No. of communities: 23, based on preliminary surveys
	D4.2	SISAR/CE	* communities' selection: 1 intervention case (Cristais) and 3 control case studies (SISAR communities)
	D4.3	Capacity Building	

Table 15. Criteria for the selection of the key players to interview.

Case study			Players' selection criteria
Historical	D2.1	SISAR/CE	* geographic location (both centre and peripheral zones) * role in the communities (users, system operators, communities' associations administrators, SISAR and GESAR employees)
	D2.2	Condominial Sanitation System	* role in the design and implementation (model founder; community leaderships; NGOs representatives; health, environment and WSS specialists; local government other public institutions representatives)
	D2.3	Communal Springs	* developed role in the local community * knowledge pertaining to the research subject * availability in collaborating with the research * ability to communicate his/her knowledge; * impartiality
	D2.4	Echo-technological	* role in the entire process from design to maintenance * operation and maintenance technician * system design engineers (3) * representative of municipal health authorities * end users (>18)
Current	D3.1	SISAR/CE	
	D3.2	Integrated Sanitation System	
	D3.3	Community management	* role in the entire process from design to maintenance * operation and maintenance technician * system design engineers * representative of municipal health authorities * end users (>18)
Intervention	D4.1	Participative Generation of a Water Treatment	
	D4.2	SISAR/CE	
	D4.3	Capacity Building	* 1st phase: Schools of secondary education Criteria: WSS services in the community * 2nd phase: community

Table 16. Type of secondary sources of information collected by each case study team.

Case study			Secondary Sources
Historical	D2.1	SISAR/CE	* Statistical sources: national censuses, special surveys by local, regional, and national authorities * Documentary material: SISAR reports; water analyses informs; communities' associations minutes
	D2.2	Condominial Sanitation System	* Statistical sources: a) national censuses; b) special surveys by local, regional, and national authorities * Documentary material: a) official public archives (mainly from Pernambuco's Water and Sanitation Company, COMPESA, and Recife's Municipality); b) local community and private archives especially archives from several associations of Mustardinha and community leaders
	D2.3	Communal Springs	* Statistical sources: national censuses, special surveys by local, regional, and national authorities * State and local press * Web pages: City Hall, resident groups and associations

	D2.4	Echo-technological	* Statistical sources: national censuses, special surveys by local, regional, and national authorities * Community association archive * Photographic and audio-visual material * Local press
Current	D3.1	SISAR/CE	* Statistical sources: national censuses, special surveys by local, regional, and national authorities
Current	D3.2	Integrated Sanitation System	* Statistical sources: national censuses, special surveys by local, regional, and national authorities * Documentary material: a) official public archives (mainly from Pernambuco's Water and Sanitation Company, COMPESA, and Recife's Municipality); b) local community and private archives especially archives from several associations of Mustardinha and community leaders
Current	D3.3	Community management	* Statistical sources: national censuses, special surveys by local, regional, and national authorities * Community association archive * Photographic and audio-visual material * Local press
Intervention	D4.1	Participative Generation of a Water Treatment	(no information available)
Intervention	D4.2	SISAR/CE	(no information available)
Intervention	D4.3	Capacity Building	* Statistical sources: national censuses, special surveys by local, regional, and national authorities * Local press * Satellite images analysis and photographic validation * Water and sanitation bills

4.1.1. Evaluation criteria per analytical dimension

A compilation of all the indicators and corresponding metrics, when available, used by each study to analyse the socio-technical innovations is available on Tables A4 to A9 of the appendix. Each table corresponds to one of the six analytical dimensions defined by DESAFIO: policy-institutional (Table A4), socio-political and cultural (Table A5), economic-financial (Table A6), techno-infrastructural/operational (Table A7), health (Table A8) and ecological-environmental (Table A9). The tables are divided into 5 columns. The first three correspond to a hierarchical representation of the indicators used. The fourth column shows the metrics employed to measure the indicator. As the methodological approach has, in many cases, relied on semi-structure interviews, the specific quantitative/qualitative metric used to assess each one of the indicators cannot be, in many cases, clearly defined. Take the Communal Springs' model (D2.3) as an example: the report presents the results of questions related to water sources and water uses as the % of answers per category and presents the results related to the water quality perception as a detailed, not systematised, description of interviewees' answers.

When no metric was identified the field was left in blank. The fifth column shows the case studies that have measured the indicator.

Figure 5 shows an example of how the indicators have been systematised into hierarchical categories. The diagram presented in the figure shows the type of indicators for the assessment of citizen-empowerment, within the socio-political and cultural dimension (also available on Table A5). Citizen-empowerment has been analysed evaluating community and institutional mobilisation, social participation, community attitudes and institutional transparency perception. Each one of these sub-indicators have been, whenever appropriate, analysed through other sub-indicators.

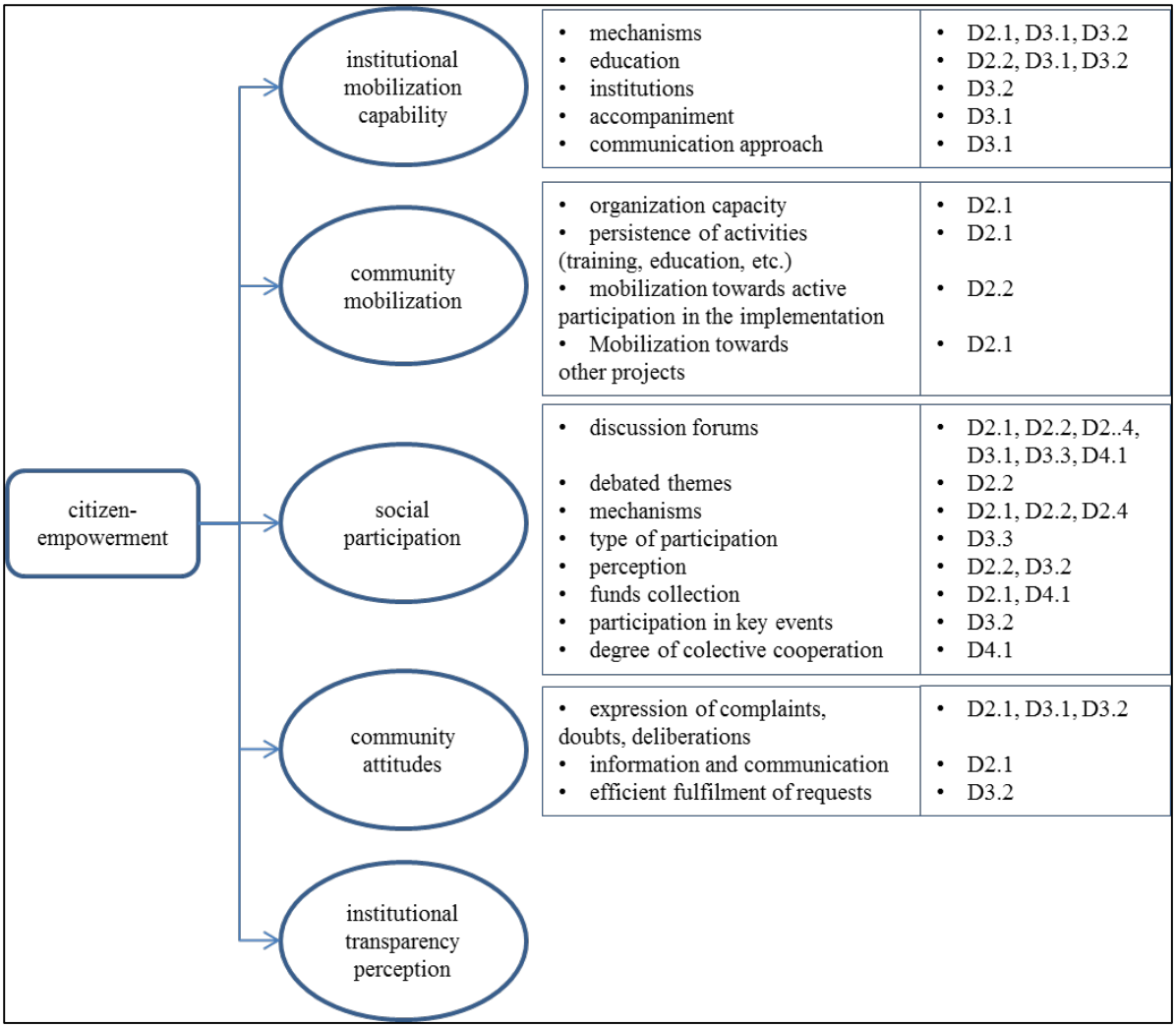


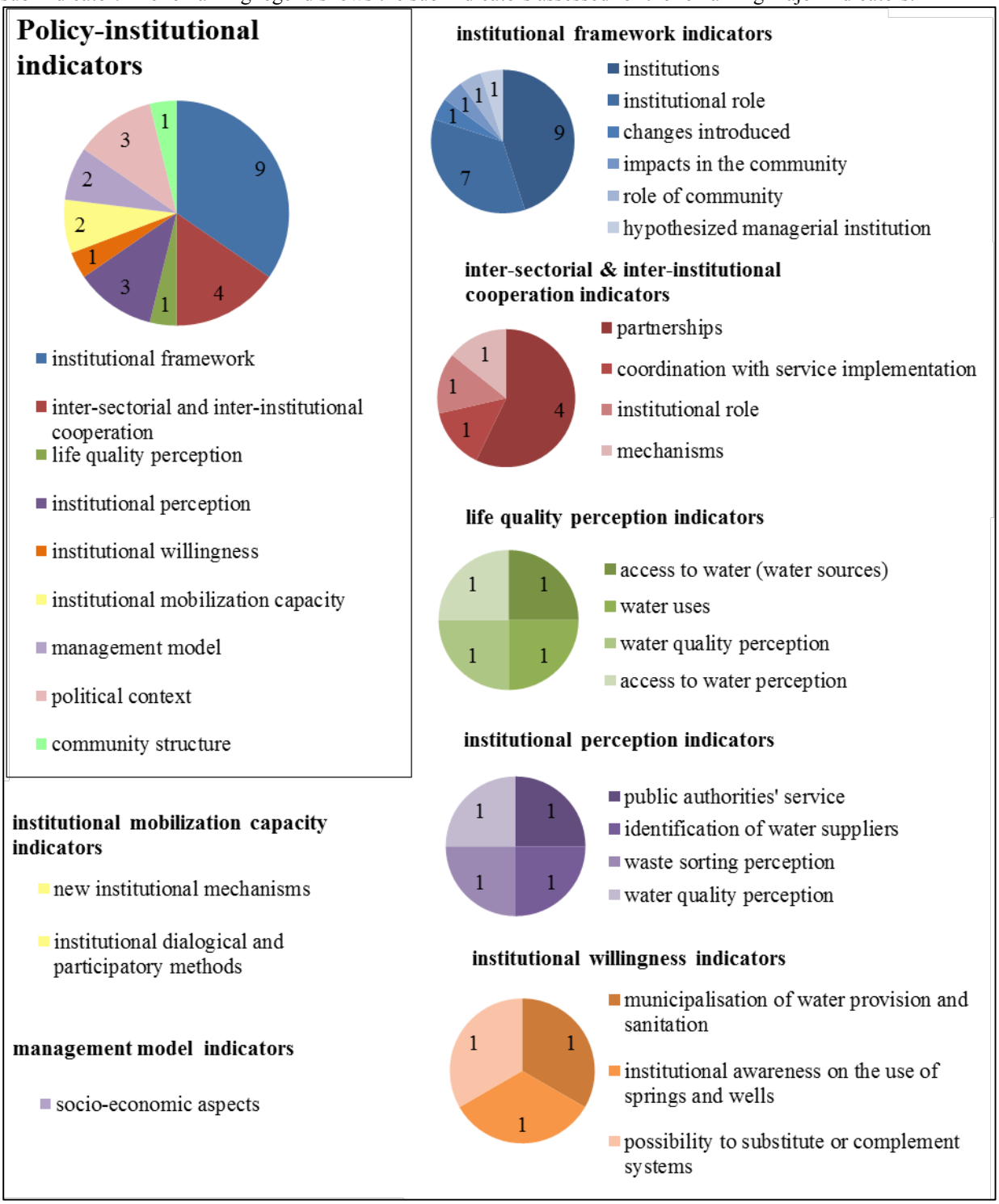
Figure 5. Diagram of the type of indicators for the evaluation of citizen-empowerment, of the socio-political and cultural dimension, per case study. Historical case studies: D2.1-SISAR/CE model; D2.2-Condominial Sanitation System; D2.3-Communal Springs; D2.4-Echo-technological; Current case studies: D3.1- SISAR/CE; D3.2-Integrated Sanitation System; D3.3-Community management; Intervention case studies: D4.1-Participative Water Treatment System; D4.2-SISAR/CE; D4.3-Capacity Building.

Analysing the indicators' table for the assessment of the policy-institutional dimension (Table A4) it stands out that only the Communal Springs' model (D2.3) presents quantitative data and that the information provided evaluates life quality perception and not actual policies and institutional frameworks. The socio-political and cultural is the

dimension with the highest number of indicators assessed (Table A5). From this table, it stands out that different case studies had different metrics to evaluate the same type of information. For instance, the SISAR/CE (D2.1 and D3.1) reported whether the expression of complaints, doubts and deliberations was present in the community, whereas the Community Management model (D3.3) actually measured the number of occurrences per type of expression per year. Regarding the economic-financial indicators (Table A6), it stands out that only the Condominial Sanitation System (D2.2), the Integrated Sanitation System (D3.2) and the Participative Generation of a Water Treatment System (D4.1) feature data regarding intervention costs; that the information regarding the billing system is highly variable and that only two case studies (D2.2 and D4.3) provide information necessary to evaluate whether the costs resulting from water and sanitation facilities are reasonable and affordable to the beneficiaries. It is also observable that the Echo-technological model (D2.4) and the Community Management Model (D3.3) are focused on indicators of community structure whereas the Communal Springs (D2.3) and the SISAR/CE (D4.2) are focused on indicators of life quality perception. The techno-infrastructural/operational dimension is covered by a wide range of indicators (Table A7), from those more obvious that measure implementation, maintenance and operational management, to others that measure community structure, life quality perception, water quality, funds and consumption habits. Another type of indicators, applied by the Participative Generation of a Water Treatment System model (D4.1) measure the feasibility of the solutions over the table to be selected by the communities: indicators of selection and evaluation. Possibly, some of these indicators, though indicated to have been used to assess the techno-infrastructural dimension, would have been more suitable to measure other dimensions. Regarding the indicators for health assessment it stands out that indicators of community structure and life quality perception are again applied (Table A8). This occurs because the Communal Springs' study (D2.3) stated that these indicators were used to evaluate all six dimensions, even though it might not be straightforward their contribution to the assessment of some of the dimensions, as is the case of the health dimension. Notice also, that the Participative Generation of a Water Treatment System study (D4.1) only reported the type of diseases observed in the study area. Finally, the ecological-environmental indicators were essentially focused on environmental commitment, environmental perception and biophysical characterisation. Only the Echo-technological model study (D2.4) took an ecosystem approach and only two intervention case studies, the Participative Generation of a Water Treatment study (D4.1) and the Capacity Building study (D4.3) assessed environmental conditions and problems in the vicinities.

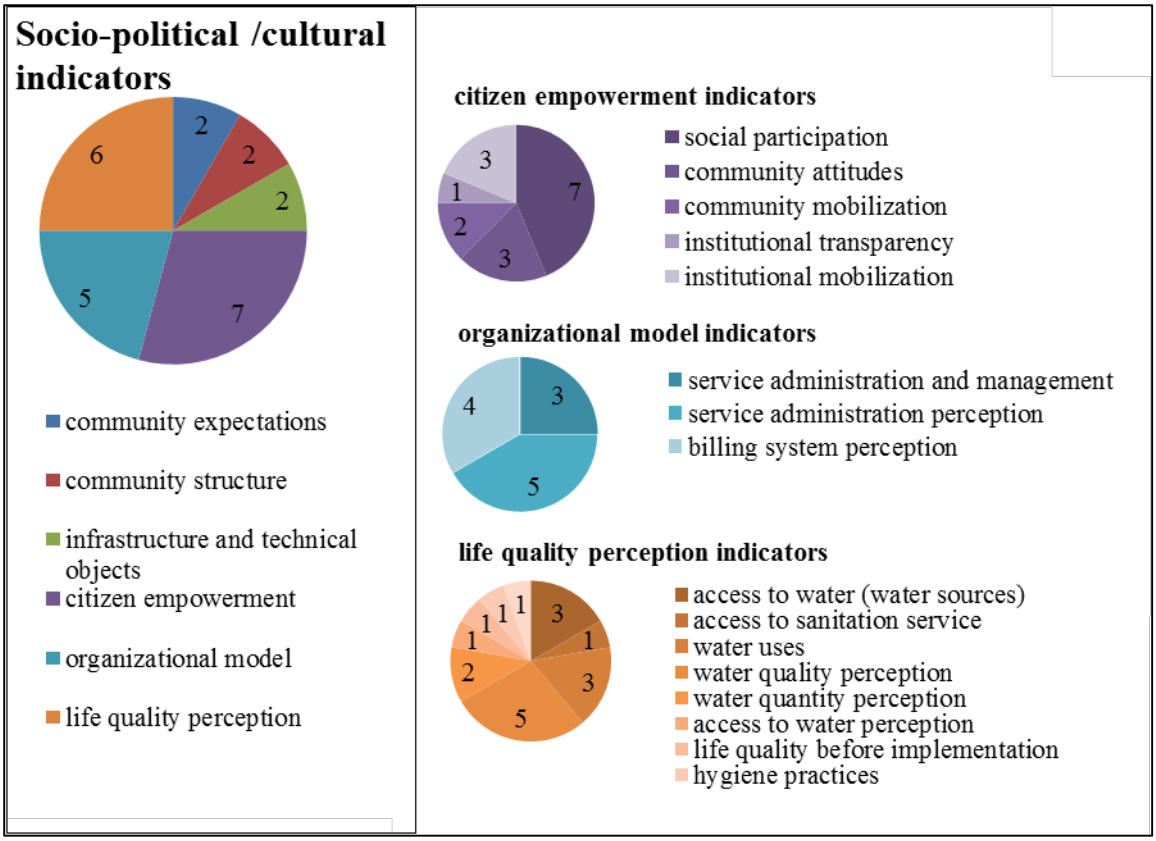
Figures 6 to 11 show the number of case studies per type of indicator for each analytical dimension: policy-institutional (Figure 6), socio-political and cultural (Figure 7), economic-financial (Figure 8), techno-infrastructural/operational (Figure 9), health (Figure 10) and ecological-environmental (Figure 10). Analysing these figures it is possible to perceive the indicators most frequently used. For the policy-institutional dimension, 9 out of 10 case studies describe and/or discuss the institutional framework, while only 1 case study evaluates life quality perception and institutional willingness as indicators for the assessment of the policy-institutional dimension (Figure 6).

Figure 6. Number of case studies per type of policy-institutional indicator. The box in the upper left shows the number of case studies per major indicator. The remaining plots show the number of case studies per sub-indicator. The remaining legend shows the sub-indicators assessed for the remaining major indicators.



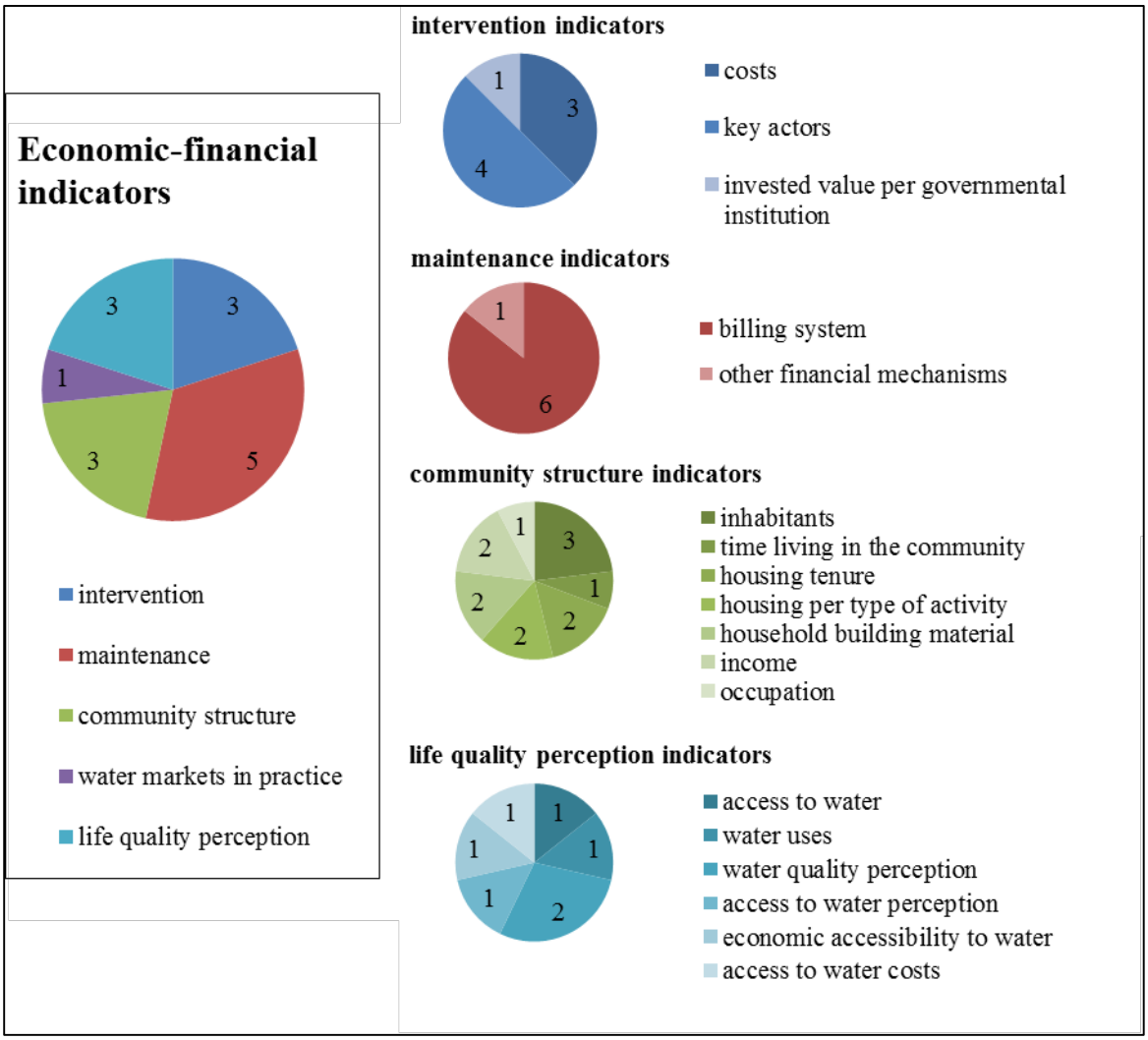
To assess the socio-political and cultural dimension, the indicators most frequently evaluated are citizen-empowerment, organizational model and life quality perception (Figure 7).

Figure 7. Number of case studies per type of social-political and cultural indicator. The box in the left shows the number of case studies per major indicator. The remaining plots show the number of case studies for the sub-indicators most frequently used.



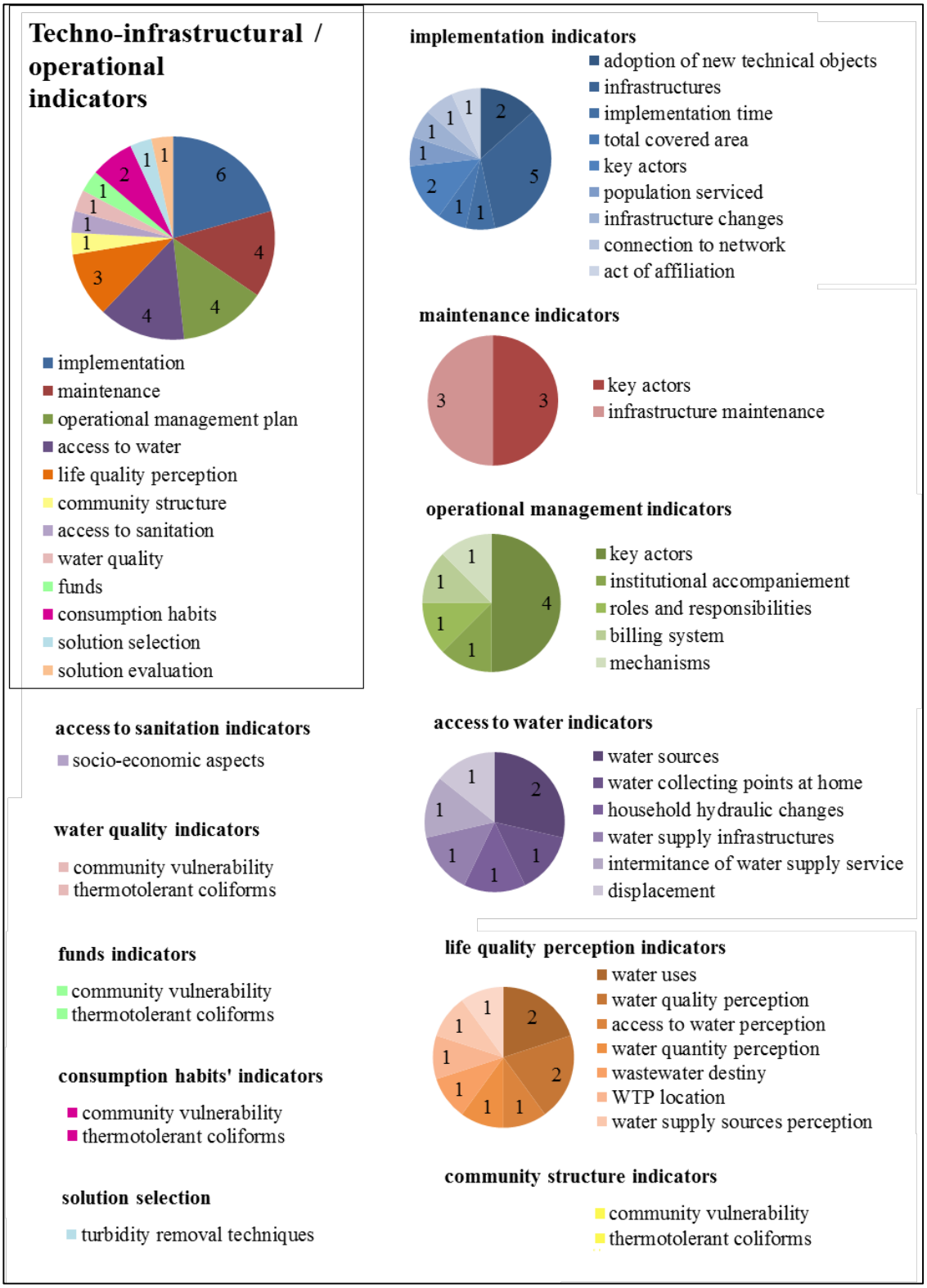
For the economic-financial dimension, the indicators most frequently evaluated are those related to system maintenance, followed by those related to intervention cost values and actors, community structure and life quality perception (Figure 8).

Figure 8. Number of case studies per type of economic-financial indicator. The box in the left shows the number of case studies per major indicator. The remaining plots show the number of case studies for the sub-indicators most frequently used.



For the techno-infrastructural/operational dimension, the indicators most frequently evaluated are those related to the implementation process, followed by those related to maintenance, operational management plan and access to water (Figure 9).

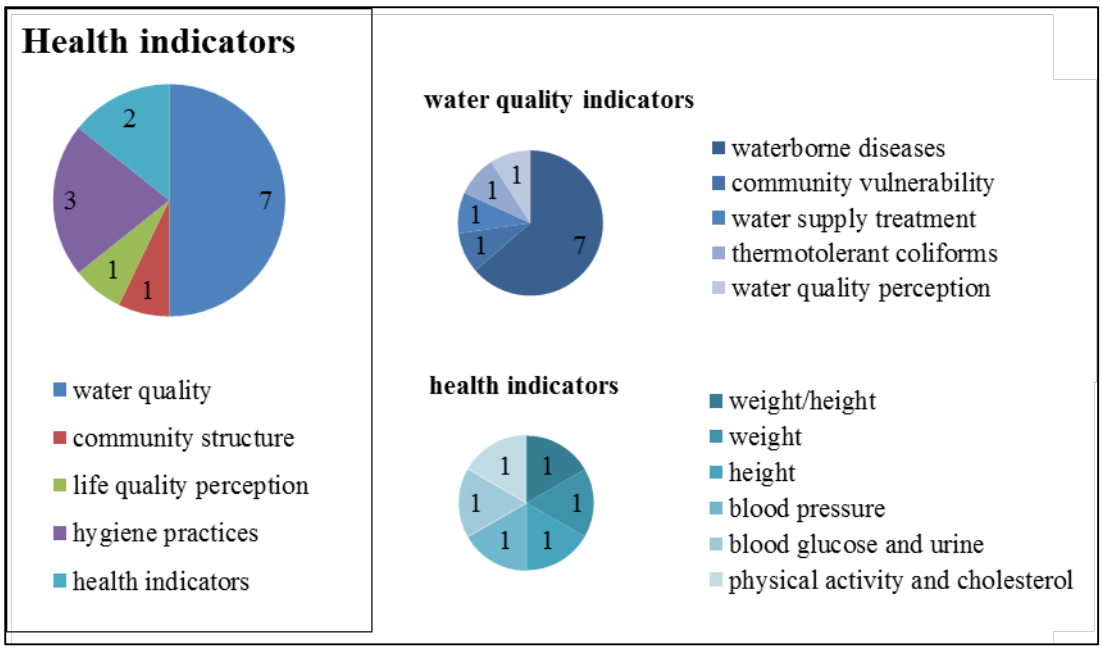
Figure 9. Number of case studies per type of techno-infrastructural/operational indicator. The box in the left shows the number of case studies per major indicator. The plots on the right show the number of case studies for the sub-indicators used by more than one case study. The remaining legend shows the sub-indicators assessed for the remaining major indicators.



The techno-infrastructural dimension shows the widest variety of indicators among all the dimensions evaluated.

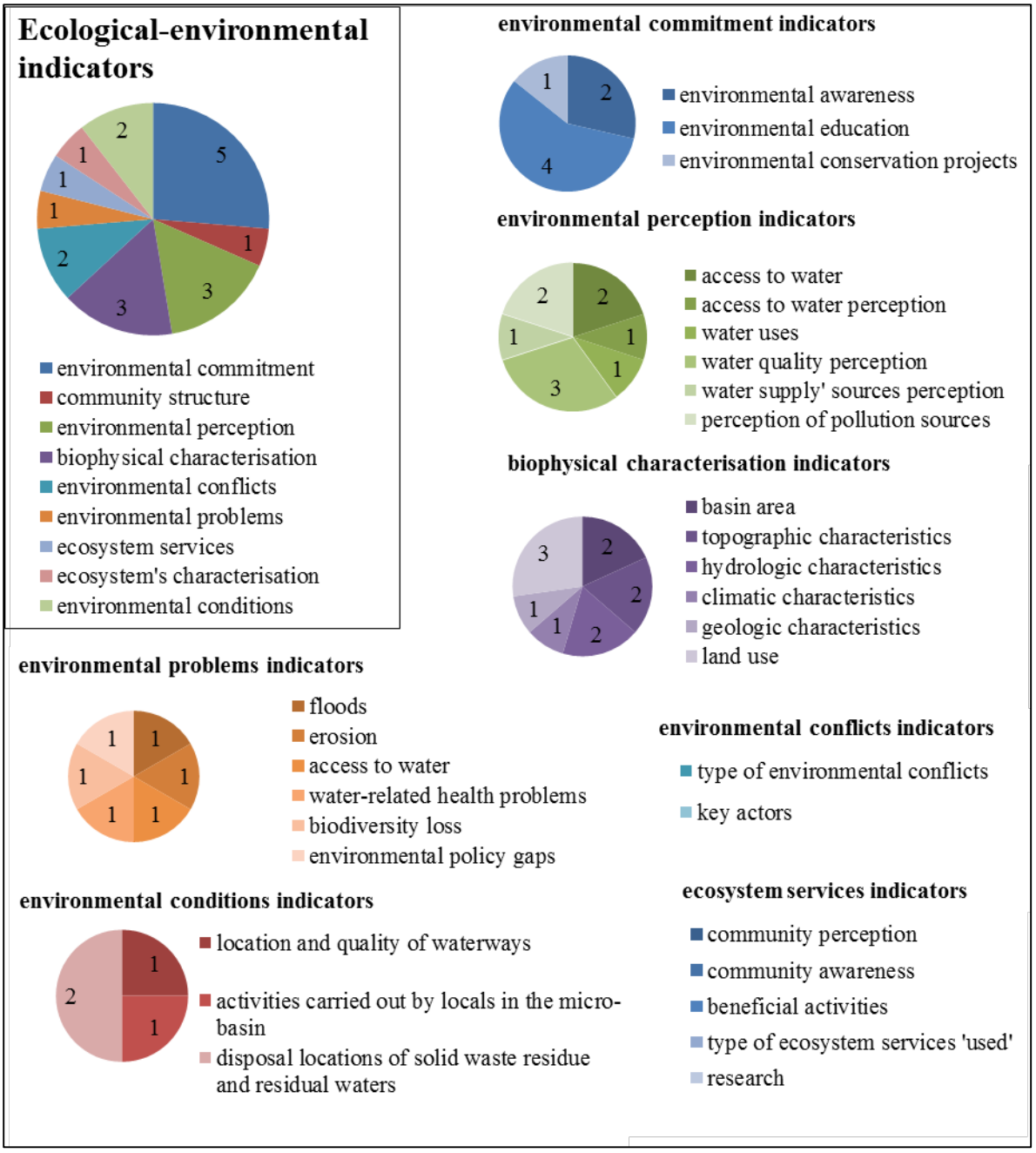
To evaluate the health dimension, the indicator most frequently assessed was water quality, with 7 case studies, followed by the hygiene practices, with 3 case studies, which was evaluated assessing only the type of practices for which water is used (Figure 10).

Figure 10. Number of case studies per type of health indicators. The box in the left shows the number of case studies per major indicator. The plots on the right show the number of case studies for the indicators with more than one sub-indicator and used by more than one case study.



As mentioned before, the ecological-environmental dimension has been poorly characterised and evaluated. This is also reflected in the type of indicators employed (Figure 11). Most of the case studies evaluation was focused on environmental commitment and/or perception and the effective implications of the innovations on the ecological and environmental realms have not been assessed. Frequently, it was only evaluated the relationship between the health and the environmental dimensions, as a mean to describe the environmental sanitation conditions. Likewise, with a few exceptions, it was not clearly assessed whether the ecological-environmental characteristics of the area under study, were taken into account at the time of planning and implementation.

Figure 11. Number of case studies per type of health indicators. The box in the left shows the number of case studies per major indicator. The plots on the right show the number of case studies for the indicators with more than one sub-indicator and used by more than one case study.



4.2. Results

The ultimate goal of the case studies' evaluation was to *assess whether the innovation contributed to increasing access to water and/or sanitation*. To attain this goal, one needs firstly to assess whether there were changes after the implementation of the innovation, either comparing before and after, or comparing with some other control community. Moreover, changes in the access to water can be measured at different levels: water quantity, water quality, availability, economic accessibility and physical accessibility.

The total coverage of the SISAR/CE in the state of the Ceará indicates that the physical access to water has improved. Currently, the SISAR covers a significant portion of the state's rural areas (135 of 182 municipalities) and provides service to an approximate population of 406 000 inhabitants. This includes the communities of Arataca and Andreza – Itapeim Complex- evaluated by the D3.1. Comparing these communities with the community of Cristais, which was recently intervened (D4.2), the results indicate, that though physical and economic accessibility are similar between the Itapeim complex and Cristais, the newly intervened community is still more vulnerable considering the quantity, the quality and availability of water.

The failure of the experience of the Condominial Sanitation System, analysed in the D2.2 report, meant that the poorest sectors of the population remained without access to the basic sanitation, and the living conditions of a large section of the population were appalling. According to studies of the period, the figures of coverage for basic sanitation remained unchanged during the 1990s, and the impact of water-related diseases remained very high. On the contrary, the Integrate Sanitation System (D3.2) implemented in the same area, years after, succeeded in completing a total of 33 projects in the city, among which is included the case study considered in the D3.2 report.

The Communal Springs' model (D2.3) has shown to increase the access to water as these solutions are essentially implemented where formal networks do not exist or are still characterised by high levels of water intermittence. Nevertheless, this solution hardly contributes to the increase of the access to water of good quality and hardly reduces physical accessibility, as the communities spend a considerable amount of time to fetch water.

The Cinara Institute, in Colombia, was at the core of the success of the implementation of socio-technical innovations in two communities analysed by DESAFIO: La Vorágine (D2.4) and Mondomo (D3.3). The increase of water supply coverage and the improvement of the water quality parameters indicate that the access to potable water has increased in both communities. Likewise, the increase of sanitation coverage has shown that the access to sanitation has increased in La Vorágine.

The socio-technical innovation developed by the Participative Generation of a Water Treatment case study (D4.1) is directly related to the treatment of contaminated surface water that is currently used for human consumption without treatment in the Quilombola rural community. Though the final monitoring and evaluation of the treatment system's is still not concluded, the preliminary water quality analysis of the selected solution indicate that the goal of increasing the access to potable water will be attained.

Though the preliminary results of the Capacity Building (D4.3) case study indicate that the participative approach applied has been successful, we are not able, by now, to advance on whether the access to non-contaminated water has increased.

4.2.1. Conditions, opportunities and limitations to the socio-technical innovations implementation

4.2.1.A. Opportunities and limitations: Historical case studies

The SISAR/CE model (D2.1) has evolved since its first design in the 1980's, accumulating various experiences and adjusting to the local rural milieu and to the encountered limitations, which were mainly related to the financial self-sustainability of the system and to the communities' participation which tended to decrease once the main goal (water provision) was achieved. Social commitment decrease was in part related to local associations' leadership which, in some cases, was not strong enough to guarantee long-term commitment and avoid communities' demobilisation. In turn, the absence of financial self-sustainability in some SISARs was related to the low purchasing power of the families that did not permit the readjustment of tariffs.

The Condominial Sanitation System (D2.2) was a political experience, based on intense mobilisation of the population in the initial stages of the project. Despite the high level of commitment of local leaders and community, the scale and intensity of participation diminished over time due to the normal attrition of the participative processes and to the lack of financial resources to implement a complete sewerage network. As a result, failures in the implementation, management, operation, and maintenance of the system emerged, condemning the system to failure. The most limiting aspects were related to the lack of agreement with respect to the system's maintenance, to the insufficient capacity of the wastewater lift station and to the lack of funds for urban planning, network extension and monitoring teams.

The Communal Springs' model (D2.3) benefited from a self-motivated community willing to implement and manage a solution for water supply in low-income areas, in a context of lack of political and financial support from public authorities. Though, the number of water sources increased, the informal management and lack of monitoring led to the supply of low quality water with negative consequences within the health and environmental dimensions.

The Echo-technological model (D2.4) benefited from an attitude of respect by the public institutions, which has contributed to a beneficial horizontal relationship between the community and the institutions, favouring the constant access and exchange of information and consequently community empowerment. The implemented model also benefited from the transference of monitoring responsibilities to the community and from the inclusion of builders and works inspectors as team members. The sustainability of this system is nonetheless compromised by land use changes in the middle basin; by the low participation of the community in meetings; the lack of tariffs' equity; the lack of administrative staff and operator overloading. Additionally, the tourists' behaviour may exert more pressure in the city and affect the ecosystem.

4.2.1.B. Opportunities and limitations: Current case studies

The implementation of the SISAR/CE model (D3.1) in the communities of Andreza and Arataca suffered from the same opportunities and limitations as the most of the SISAR/CE implementation processes and mentioned in the previous section of the historical case studies. However, regarding the specific case of these two communities,

the implementation of the SISAR model benefited from the prior existence of local associations, but some limitations were encountered: a) insufficient preparation before the SISAR's arrival; b) lack of continuous proactive accompaniment; c) weak resident attendance at affiliation assemblies; d) lack of training for local actors; e) absence of an official, standardised medium that formally established each actor's responsibilities, as well as the SISAR's model and modus operandi; f) insufficient 'routine' assemblies for community 'accompaniment' per year.

The urgent necessity to solve sanitation problems in low-income areas was a decisive element for the design and implementation of the Integrated Sanitation System (D3.2). This model was set as an alternative to the conventional sewerage system and to the Condominial system which did not considered the urban planning as an object of intervention, nor envisioned the implementation of sanitation as an inter-sectorial process. Due to its holistic characteristics, the model highly depends on political willingness, which as decrease a few years after the first projects' implementation. As a result, recommended partnerships were not established and the role of the municipal government was restricted to network construction in low-income areas, though the responsibility of system regulation and monitoring should have been assigned to the municipal government.

The Community Management model (D3.3) emerged from the necessity to rebuild a highly damaged water supply infrastructure and benefited from a pre-existing echo-technological solution which was locally adapted to a low income and vulnerable population. It also benefited from a prior community-led management model, though informal. Limitations to its implementation are mainly related to vulnerable political decisions, with impact on system's funding.

4.2.1.C. Opportunities and limitations: Intervention case studies

The Participative Generation of a Water Treatment System (D4.1) implemented in a low-income community with specific cultural characteristics successfully invested in community education and training, managing to achieve the goal of selecting the alternative that best suited the community. It was nonetheless affected by financial and managerial problems, as well internal conflicts that have hindered the discussion. Moreover, excluding private companies from the participatory process, capable of implementing the alternatives under scrutiny, revealed implementation difficulties, as some technical limitations were not discussed previous to selection of the solution.

The Capacity Building model (D4.3) benefited from the commitment of both students and teachers involved in the initial phase of model implementation. However, the ability to build original and proper knowledge, and the ability to exercise productive work, might be hindered by two antagonistic social realities: insecure social strata, for one hand, and social strata with privileged monopoly of knowledge production, on the other hand. As the second phase of implementation of the Capacity Building model is yet to accomplish, it is not possible to advance on the further opportunities and/or limitations of this model.

5. Factors, conditions, and processes that help explain the success or failure of the innovations

This section responds to the questions '*what are the critical requirements to make successful socio-technical innovations sustainable and replicable? What are the obstacles to their sustainability and replication?'* Generally speaking, a socio-technical innovation is successful if it remains operational, fulfilling the necessities of the community, for a long-term. This can only be achieved if the socio-technical solution is sustainable at all levels: political, institutional, social, cultural, technical, operational, health and environmental. For cases of top-down implementation and management, political willingness will play a major role as it could chunk the process right before it starts. Lack of inter-sectorial and inter-governmental collaboration could hinder the implementation process or condemn a system to failure as water and sanitation services systems depend on the effectiveness of other sectors of the society, such as urban planning. Lack of social participation also plays a major role, either because the operation and or management are a responsibility of the user-community, or because the control over the service will depend on the community awareness and dynamic attitude. Lack of a suitable economical-financial framework to support both the implementation and the maintenance of the system might in turn condemn a system due to lack of financial sustainability. Technically unsuitable systems, unless fixed in due term, could collapse or could prevent the service to reach the entire community. Regarding the health dimension, unless potable water is supplied to the community, residual water is treated conveniently and the population is aware of the necessary hygiene practices, water-related health issues will always emerge in a community possibly with severe consequences for the population. As for the ecological-environmental dimension, sustainable water and sanitation services are frequently associated to appropriate sanitary conditions, but environmentally sustainability requires taking into consideration other issues such as the biophysical characterisation of the region which plays a crucial role in the construction of the network.

Critical requirements and obstacles to the sustainability and replicability of the socio-technical innovations evaluated in the scope of the DESAFIO project are described in Tables 17 and 18. For each case study, and whenever appropriate, the requirements and obstacles are listed by analytical dimension: policy-institutional, socio-political and cultural, economic-financial, techno-infrastructural/operational, health and ecological-environmental.

Table 17. Critical requirements, by case study and analytical dimension, to make successful socio-technical innovations sustainable and replicable.

Case study			Requirements
Historical	D2.1	SISAR/CE	* Policy-institutional: a) significant state government intervention is needed to guarantee the model's expansion to other locales; b) technological support of state institutions; c) program's institutionalization by the state *Social-political and cultural: a) participation - Charismatic leaderships that guarantee the maintenance of public interest in participation; b) Attitude - involvement of communities in the monitoring of the systems' functioning and quality and consequent report; face-to-face communication; c) Transparency and accountability; d) mobilization * Economic-financial: a) fund raising for the operation and maintenance; b) effective bill payment control and collection; c) public resources distributed equitably * Techno-infrastructural/operational: a) water quality must be guaranteed; b) studies that provide adequate support to the choice of efficient treatment schemes
	D2.2	Condominial Sanitation System	A good technological solution coupled with political commitment to guarantee long-term maintenance which, in turn, guarantee a satisfied and engaged community: * Policy-institutional: a) Political commitment * Social-political and cultural: a) Community organization; b) Participatory planning tool; c) Community awareness * Techno-infrastructural/operational: a) techno teams with experience in participatory approaches; b) construction works provided by public company
	D2.3	Communal Springs	* Policy-institutional: a) recognition from public sectors pertaining to water and sanitation services * Social-political and cultural: a) participatory process of discussion regarding water supply solutions in Queimados; b) in depth knowledge of the existing forms of water provision
	D2.4	Echo-technological	* Social-political and cultural: a) participatory process of discussion; b) suitable training of officials and communities
Current	D3.1	SISAR/CE	(same as D 2.1)
	D3.2	Integrated Sanitation System	* Policy-institutional: Favourable political context; b) political, technical and intellectual commitment with the project and its democratic character
	D3.3	Community management	* Policy-institutional: a) community and institutions involvement in the process: from problem identification, to participatory selection of technology; b) participation of a multidisciplinary and inter-institutional group acting as facilitator * Techno-infrastructural/operational: a) system technologically efficient: with low consumption of energy; b) operationally simple; c) with multi-filters preventing the obstruction of the network; d) technician living nearby the infrastructure facilitating maintenance; e) private-public partnership, guaranteeing initial funding; f) implementation of tariffs for long-term sustainability
Intervention	D4.1	Participative Generation of a Water Treatment	* Policy-institutional: a) reconciliation of all different partners' agendas and engagements, and the latter's ability to understand their role in this process * Social-political and cultural: a) dialogue and knowledge of local reality as prerequisites to the installation of water supply systems in isolated rural communities; b) accompaniment of the solution implemented; c) educated and trained community, facilitators and staff of public authorities

	D4.2	SISAR/CE	* Policy-institutional: a) necessity of advancing public policies oriented towards sanitation in a transversal and cross-sector fashion * Social-political and cultural: a) required action beyond the supply of sanitary services, considering cultural factors that influence household sanitary conditions * Techno-infrastructural and operational: a) introduce a service fee framework that includes reduced fees; b) implantation of hydraulic installations in dwellings that do not yet have them; c) dissemination of information concerning the measurement structure (water meter) and the billing system
	4.3	Capacity Building	* Policy-institutional: a) public entities engagement to guarantee transfer of knowledge * Social-political and cultural: a)full community engagement through students and teachers with the potential to communicate and replicate their experience; b) suitable training * Techno-infrastructural/operational: a) public entities willing to cooperate with water quality analysis

Table 18. Obstacles, by case study and analytical dimension, to the sustainability and replication of socio-technical innovations.

Case study			**Obstacles**
Historical	D2.1	SISAR/CE	* Social-Political and Cultural: a) public demobilization; b) youth withdrawal * Economic-financial: a) self-sustainability (high cost of operation and repairs; increased non-payment bills; insufficient 'unreal' tariff); b) lack of equitable distribution of public resources * Techno-infrastructural/operational: a) lack of studies to support choice of treatment schemes
	D2.2	Condominial Sanitation System	Highly dependent on local conditions and circumstances: *Policy-institutional: a) lack of inter-sectorial dialogue; b) lack of political decision to design institutional frameworks * Social-political and cultural: b) lack of community articulation, long-term engagement and awareness; c) break of Condominial Agreement *Techno-infrastructural/operational: a) lack of resources; b) incomplete implementation; c) system disconnected from other infrastructures; d) lack of suitable management and operation; e) lack of continuity and prioritization over time (lack of agreement with public sanitation company to guarantee maintenance and lack of community capacity to guarantee effective maintenance); f) lack of urban planning * Ecological-environmental: a) lack of environmental education
	D2.3	Communal Springs	* Social-political and cultural: a) conflicts amongst the population ; b) clientelistic culture * Economic-financial: a) lack of funds * Techno-infrastructural/operational: a) difficulties to reach or find water table; b) lack of organised community and/or public administration support; c) change the technological paradigm (centralised macro-system) of water and sanitation services organization * Health and Ecological-environmental: a) contaminated water table
	D2.4	Echo-technological	* Techno-infrastructural/operational: a) unsuitable sewerage system to collect both residual and rainwater; b) unsuitable WWTP
Cu	D3.1	SISAR/CE	* Social-political and cultural: a) population resistance to change (introduction and dissemination of innovations is inevitably a process of

			transgression. Innovations call into question behaviours and attitudes that can often be routine and sources of balance) * Techno-infrastructural/operational: a) ineffective enrolment mechanism; b) obscure existence of progressive price tables; c) lack of clear definition of each actor's responsibilities; d) deficient accompaniment from SISAR's actors
	D3.2	Integrated Sanitation System	*Policy-institutional: a) inertial forces that prevent institutional change, in particular in relation to reforms geared at promoting inter-sector collaboration; b) Policy-institutional instability and fragility: uneasy relationship, tensions, and contradictions between electoral politics and the politics of substantial democratisation * Social-political and cultural: a) public authorities discredit previously built among vulnerable communities
	D3.3	Community management	* Policy-institutional: a) political willingness * Techno-infrastructural/operational: a) suitable only for rural communities from 1000 up to 25000 inhabitants, with endowments ranging from 80-120L / person / day (approximately 35L /s) * Social-Political and Cultural: a) population education with respect to environmental dimension
Intervention	D4.1	Participative Generation of a Water Treatment	*Policy-institutional: a) difficulties in reconciling the different partners' agendas * Techno-infrastructural/operational: a) suitable for small communities
	D4.2	SISAR/CE	* Social-political and cultural: a) rural cultural factors, that prevent the use or correct use of infrastructures; b) low income communities, which prevent the increase of tariffs and may therefore compromise the economic sustainability of the system
	D4.3	Capacity Building	* Social-political and cultural: a) antagonistic social identities: for one hand, helplessness and insecure communities and on the other hand privileged monopoly of knowledge production

6. Lessons learned

Addressing the gaps in current water and sanitation systems can promote the discussion for long-term sustainable socio-technical innovations, especially for vulnerable communities. Aiming to develop sustainable strategies and alternatives that allowed to '*excavate the complex origins of the problems that we face and clearly identify the key factors, drivers, thresholds and processes at work at different scales*', the DESAFIO project considered several types of socio-technical innovations, broadly divided into three main categories: i) focusing only on sanitation issues, ii) focusing only on water supply issues, iii) considering both water supply and sanitation (Figure 12A). Additionally the extent of the performed innovation was also a crucial aspect for its sustainability and reproducibility issues (Figure 12B).

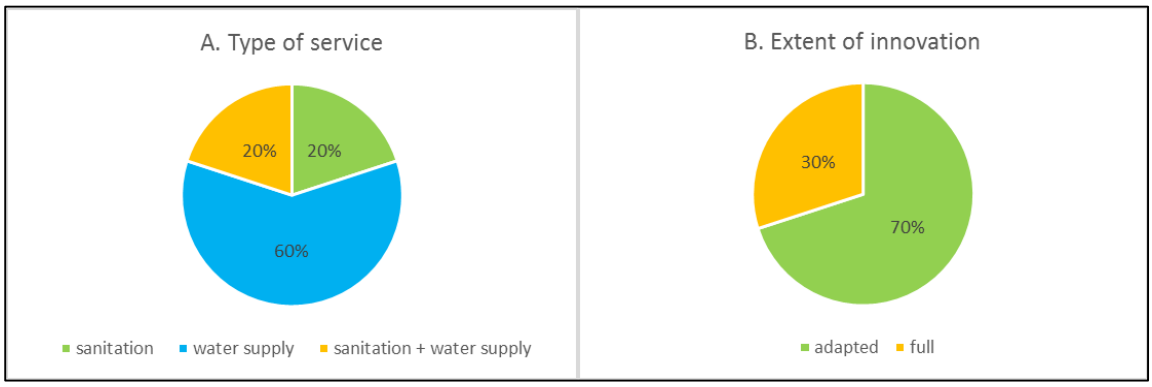


Figure 12. Innovations covered by the case studies: A. type of services considered; B. extent of the innovation undertaken.

Drawing on the DESAFIO 10 case studies, from 3 Latin America countries (Argentina, Brazil, and Colombia), in this section aims to 1) analyse the main promoters and constrains to ensure the sustainability and reproducibility of the analysed innovations to larger scales, while 2) comparing it to other experiences observed in other countries.

Most of the DESAFIO case studies relied on a bottom-up management of water supply and sanitation systems after its implementation, usually led by Governmental institutions. These were, for example, the cases in Colombia, Mustardinha (Recife) or the SISAR model. These studies identified two major needs: 1) the need to empower local communities; while 2) training them to ensure that they had the adequate skills and tools to manage water systems effectively. These findings are in accordance with several experiences and outcomes observed worldwide (e.g. Moriarty et al. 2013). Community Management approaches are characterised by users having control over their systems (Lockwood 2004), after its completion, and have been applied in many countries, especially on rural areas. For instance, in rural areas in Panama there is a clear separation between the implementation of water projects and its effective management. Rural water systems are usually constructed by governmental institutions (e.g. Ministry of Health) but after its completion the management of the systems is from the responsibility of local citizens, normally through a water committee (Braithwaite 2009).

These approaches have been implemented worldwide as a way to ensure the democratisation of water and sanitation systems. However, the implementation approach and the tools given to communities are going to determine the success, or failure, of such experiences. This is particularly evident on rural areas. Often, when a top-down approach is adopted, meaning that a governmental institution implements a water supply or sanitation system in a specific rural area, the risk of failure at the long-term is high. Among the main causes for potential failure of these systems, assuming that they were initially well implemented, are the fact that local communities, which stay in charge for the system maintenance, lack adequate skills, education or even capital to ensure the accurate system functioning (Braithwaite 2009).

In this context, several issues emerge as key aspects to take into consideration when implementing socio-technical innovations related to water and sanitation systems: 1) the scaling issues to be considered; 2) the dimensions (and the accurate indicators) that should be monitored; 3) the viability of innovations; and, finally, 4) the broader political context where these innovations occur.

6.1. Scaling issues

'To ensure an effective transfer of knowledge, at which scale should it be done?' Local and/or at the level of national governments, non-governmental organizations, households (private sector). Or should it rely on an inter-sectorial and inter-institutional coordination at all levels?

A common aspect of all DESAFIO case studies was the spatial scale considered, usually at the local level. Relying on a bottom-up approach from the obtained results/outcomes and trying to extrapolate it to other systems, the implications of the several DESAFIO case studies can be organised when considering the wider spatial scale implementation of these socio-technical innovations. In this context, a core question from a policy perspective is to determine the optimal scale at which the several considered socio-technical innovations might be implemented, from an environmental, health, institutional and cultural perspective. From the several case studies, there were some examples that could not be applicable to all communities or even to wider spatial scales, such as the Communal Springs model on Baixada Fluminense (D2.3), due to a number of limiting factors, among others, availability of hydric resources, or quality of the water supplied. However, there were also some examples that could present a reliable solution for larger populations, like, for example, the Integrated Sanitation System (D3.2) and the SISAR/CE (D2.1, D3.1, D4.2).

Additionally, the temporal scale of the tested socio-technical innovations also play a role when evaluating its effectiveness. Some of the analysed innovations clearly play a short-term solution, in terms of social, economic, environmental or even technical perspective. This was, for example, the case of Communal Springs model on Baixada Fluminense (D2.3). Other innovations present a well-structured approach, designed and implemented with communities, which might ensure its long-term sustainability and possible reproducibility. Among these, the case of the Quilombolas communities (D4.1) can be pointed as an example.

6.2. Dimensions to be analysed: open issues

All six analytical dimensions defined by the DESAFIO project should be taken into consideration when planning and designing a socio-technical solution for the provision of WSS. As the success of the implementation of a WSS system depends on a wide range of factors, it could be counter-productive to neglect one or several dimensions when evaluating the long-term suitability of an alternative. As an example, cultural and educational issues were overlooked when implementing the Participative Generation of a Water Treatment System model (D4.1). It was not expected that residents in the Quilombola community would remain defecating outdoors and in rudimentary pits compromising the success of the installation of the water treatment system. Another example was the implementation of a billing system (economic-financial dimension), by the SISAR/CE model (D2.2), without auxiliary income generating projects and initially without a progressive water price table suitable for the local realm. As a result, residents would not pay for the service and some of the SISARs became financially unsound.

Likewise, evaluating the suitability for replication of socio-technical innovations needs a thorough analysis of all six dimensions. Otherwise, inaccurate conclusions can be drawn. The ecological-environmental dimension was the most neglected throughout the case studies' analysis. In some deliverables this dimension was completely overlooked (D2.2, D2.3) and in others only issues related to environmental sanitation were assessed (D2.1, D3.1, D4.2, D3.2, D4.3). The proper assessment of the analytical dimensions requires a prior and clear definition of the dimension that should be accessible to all project partners and clear ecological-environmental indicators provided beforehand. In face of the scarce ecological-environmental information available, the goals to relate "*i) point (urban) and diffuse (rural) source water pollution to the chemical status of surface waters; ii) the chemical status of surface waters to the ecological status of aquatic ecosystems, and iii) the ecological status of aquatic ecosystems to ecosystem functions, services and values, to assess the environmental, economic and welfare implications of stakeholder-defined WSS scenarios*", are yet to be accomplished as well as the goals to identify which ecosystem services were/will be affected as well as their ecological/economic value.

Methodological issues have also hindered a proper evaluation of the economic-financial constraints and opportunities. This dimension ought to evaluate the "*costs, effectiveness and/or benefits of WSS interventions"*, for which household surveys are highly applied. The 10 case studies gathered economic-financial data at the household level, but the indicators used are a) highly variable between case studies (Table A6), b) some were only qualitatively evaluated and c) a clear baseline situation for each case study is yet to be established. The information gathered so far is more appropriate for a descriptive analysis of the economic and financial characteristics.

An incomplete and/or imprecise set of indicators and an imprecise description of the '*criteria used to define the "zero point", the baseline, to evaluate the functioning and results of the innovation'* hinders the possibility to properly evaluate the innovations under study. The DESAFIO partners were asked to characterise the innovations according to some criteria and to evaluate the results against a baseline, however, seldom this criteria was clearly identified.

Regarding the comparison within studies, the DESAFIO Project suggested to compare the before and after implementation and/or compare the evaluated community with a control. Of the 10 case studies, 2 used control communities to evaluate the implementation: the SISAR/CE model (D4.2) and the Communal Springs model (D2.3). The Capacity Building model (D4.3) also proposes to compare communities within different types of water supply frameworks, but comparison is yet to be performed. Likewise, though the Integrated Sanitation System (D3.2) was implemented after the failure of the Condominial Sanitation System (D2.2) a straightforward comparison between the two models still needs further assessment. On a totally different approach, the Participative Generation of a Water Treatment System (D4.1) compared the "*participatory and dialogical process utilised in this study with that which is used by government institutions*", focusing the comparison at the policy-institutional level only. A good example of a comparison before and after the implementation is provided by the Echo-technological model (D2.4) which clearly presents results for the same indicators before and after.

Another issue that needs further discussion is the concept of vulnerability. A community might be vulnerable for a number of reasons: socially and culturally vulnerable, for instance, as a result of low education levels; economically vulnerable due to low average income; politically vulnerable as a result of institutional instability; ecological-environmentally vulnerable if, for instance, the region is exposed to environmental problems such as floods or even exposed to high levels of water contamination; and a community might even be vulnerable due to systematic health issues as a result, for instance, of low hygiene practices. Determining the vulnerability degree of a community is a vital departing issue to evaluate the key dimensions to be taken into account when designing and implementing alternative WSS solutions.

6.3. Viability of socio-technical innovations implementation

When considering the main factors that determine, or undermine, the success of socio-technical innovations it is fundamental to evaluate the underlying conditions where those innovations are going to be implemented. From the DESAFIO case studies it was possible to highlight three main key factors: social skills and/or awareness, political willingness and suitable economic-financial framework.

It is expected that an empowered community, through education and participation mechanisms, will take responsibility for the system and will be mobilised to find the optimal solutions for their region and to guarantee its long-term sustainability. The Capacity Building intervention case study (D4.3), in Argentina, was designed based on these principles, oriented to "*promote and strength the participation of the community and the social actors on the base of reinforcing the civil society to be the real agents changing their life quality*". Likewise, the Participative Generation of a Water Treatment case study (D4.1) was concerned in implementing a process where social groups were stimulated to "*actively participate in the research process*". These are successful examples. On the contrary, the Condominial Sanitation System (D2.2), which was based on the idea of sharing responsibilities between the State and the beneficiary, suffered from lack of proper articulation between the community and the public authorities and lack of user community awareness.

The political will to support the implementation of a WSS also plays a crucial role, even for bottom-up innovations. The Communal Springs' model (D2.3) is a good example. Though the community took total responsibility for system implementation and maintenance, serious health and environmental problems emerged. The community was not aware of the consequences of implementing such a technically vulnerable solution, and even when they were, the necessity for water supply overlapped the necessity to avoid possible negative consequences. Institutional support, either technical, educational, etc., could have prevented key problems. Top-down innovations, in turn, might become highly dependent on institutional stability and on the capacity for inter-sectorial and inter-institutional coordination. One of the obstacles to the success of the Condominial Sanitation System (D2.2) was the lack of inter-sectorial dialog, preventing the proper maintenance of the system.

A suitable economic-financial framework is also mandatory for all situations. For top-down implementations, the public authorities, or private-public partnerships, must guarantee that the necessary intervention funds are available, even if the community is

expected to contribute in some manner. For cases where financial sustainability depends on the implementation of a billing system, it must be guaranteed that all sectors of the community are capable of supporting the implemented tariffs. The SISAR/CE model, implemented in Ceará, Brazil, is an example of struggle to attain a feasible financial structure for system self-sustainability. Quite the reverse, was the attitude of the water supplier in Brazil responsible for the implementation of the Condominial Sanitation System (D2.2) which started charging for water tariffs before the system was completed.

6.4. Policy issues

The DESAFIO project used the social learning and empowerment as the conceptual driver to explore the potential for innovative and effective socio-technical systems to trigger a collaborative process between governmental institutions and local communities, which could contribute to the improvement of populations' well-being, especially on vulnerable communities. The question that arises in this scenario, and foreseen in the DESAFIO proposal, is actually '*how these can be harnessed to change policies, to develop new strategies and practical interventions, and to enhance policy learning'*, allowing for its translation into regional, state or even national politics.

The way these findings can be integrated into wider policies is the upcoming challenge that requires further investigation. The outcomes from the DESAFIO project have highlighted two main issues that have the power to drive decisions:

a) Political willingness
b) Broad approach focused on societal management

a) <u>Political willingness</u>

A key factor for the long-term sustainability of the socio-technical innovations, and especially for peri-urban or rural communities, is the capacity and interest for local or national institutions to continue providing support, even after the intervention is finalised (the so-called 'political willingness' covered in section 6.3). In some of the case studies covered by the DESAFIO project, there was a positive intention to guarantee the accompaniment of the innovations management (D2.1, D2.4, D3.1, D 3.2, D3.3, D4.2), mainly in cases where those interventions were aligned with broader national politics or programs for improving populations well-being. Conversely, there were also some situations that present a high risk for lack of interest in supporting some interventions, leaving their management to the local communities (D2.2, D2.3, D4.1), regardless it is a rural, peri-urban or urban system. This lack of support may be related to the inability of authorities to control the processes and management of the interventions. Among the reasons that can lead to these events can be pointed: the weak decentralised capacity (D2.3), difficulty to reach the communities (D4.1), or even the poor urban planning (D2.2).

b) Broad approach focused on societal management

The involvement and participation of local communities has emerged, also in line with previous experiences in other countries, like Panama (Braithwaite 2009), Bangladesh (Rahman and Jahan 1997), or Kenya (Harvey and Reed 2007), as a crucial issue that can determine the success or failure of the analysed socio-technical innovations. Community management systems have been faced as the predominant approach to be adopted to ensure sustainable water and sanitation system services and the MDGs attainment, especially to rural communities (Lockwood 2004). However, and as discussed in section 6.3, a number of factors can contribute to the fail of fully involvement of communities, which can consequently lead to the failure of the interventions (e.g. Moriarty et al. 2013). To guarantee its success, an accompaniment of the interventions has to be done, using flexible procedures and demonstrating the importance of the system maintenance, if necessary, creating an ownership sense. The next step would be to 'scaling up' the successful cases, ensuring the provision of services to a wider population.

7. Conclusions

Due to the nature and characteristics of the socio-technical innovations considered and to the socio-political situations in which each case study was embedded on, like system studied (rural, urban, peri-urban) or even democratisation processes stage, making of cross-comparisons among case studies can be a difficult and hard task. Even so, from the several case studies' methodological approach it was possible to find common issues that help to tackle the difficulties in ensuring the democratisation of water and sanitation services.

Firstly, the outcomes from most of the case studies suggest that the approach selected has been well designed, yet its implementation still demanded for further investments, especially for some of the dimensions covered by the DESAFIO project (e.g. the ecological-environmental dimension was sparsely covered in most of the case studies).

Secondly, there should be a consistent approach among case studies, ensuring that the selected indicators and metrics for the several dimensions are uniform among innovations evaluation. Recognising the need for specific indicators depending on the type, and extent, of innovation, an additional effort has to be done to ensure a common framework among case studies to enable cross comparisons and wider generalisations of results.

Thirdly, to guarantee a comprehensive evaluation of the innovations, a set of indicators, metrics and data should be available to allow sound cross-comparative assessments.

From these findings two major conclusions can be drawn: 1) the DESAFIO project can be regarded as a pilot project, which can be used as a starting point for further investigation and collaboration among innovations and teams; while 2) ensuring that a more consistent approach is applied to the case studies.

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9. Appendix

Table A 1. Main features of recent (Historical) case studies.

DESAFIO systems	Case study			
	Historical			
	SISAR - Politico-Institucional Evaluation	Condominial Sanitation System (CS)	Communal Springs	Ecothecnological System
	D2.1	**D2.2**	**D2.3**	**D2.4**
Location	Brazil / Ceará	Brazil / Recife / Mustardinha (ZSSI)	Brazil / Rio Janeiro / Baixada Fluminense / Queimados - Jardim da fonte and Vila do Rosário	Colombia / Santiago de Cali / La Vorágine
Type of System				
Rural	X			
Peri-Urban			X	
Urban		X		X
Source of innovation	from above	from above	from below	from above
Extent of innovation	adapted	adapted	full	full
Management type				
Public companies	X	X		
Cooperatives				
Communities	X	X		X
Informal management			X	
Type of service	Water supply	Sanitation	Water supply	Water supply and sanitation
Type of actors	* public authority (SISAR/CAGECE's offices) * financial institution: KfW Bank (German) * local communities (community associations / resident operator / population)	* municipal authorities * local communities	* local communities	* public institutions * local communities
Served Population (no.)				
municipalities	2013: 130	1	1	1
communities	2013: 1 1	1 (ZSSI)	2	1
area		57 ha		
inhabitants	2013	1991: 13 000 2000: 19 000	Queimados: 5 000	1994: Residents: 240 Floating: between 3 600 and 4 700 per day
systems / dwellings / households	2013		2010: 21 springs identified	1994 households: 37
users	2013	1991: 13 000 2000: 19 000	Not known. Formal and informal water supply systems coexist	1994: Residents: 240 Floating: between 3 600 and 4 700 per day
users under analysis	36	1991: 13 000 2000: 19 000	Jardim da Fonte Spring - 300 Vila do Rosário Spring - ?	1994: Residents: 240 Floating: between 3 600 and 4 700 per day
Temporal scale of design and implementation of the innovation				
design	1980s	late 1980s	-----	1993
implementation	phase1: 1990s phase2: 2005 phase3:2011 phase4: under discussion	1993-1994	responds to needs	1995-1996

analysed time interval		1993-2000	2009-2010	1993-1997
Temporal scale(s) of the impact sought through the innovation				
long-term	X	X		X
medium-term				
short-term			X	
Key Agents				
planning	Public administration	Public administration	none	Municipal public institutions and R&D Institution
implementation	Public administration and Community	Community	Community	Community with financial support from municipal institutions
operation	Community	Community	Community	Public administration and Community
maintenance	Community	Public administration and Community	Community	Regional public entity and Community

Table A 2. Main features of current case studies.

DESAFIO systems	Case study: Current		
	SISAR-BME - Ethnographic Assessment	Integrated Sanitation System (IS)	Community Management
	D3.1	**D3.2**	**D3.3**
Location	Brazil / Ceará / Andreza and Arataca	Brazil / Recife / Mustardinha (ZSSI)	Colombia / Cauca / Sanatander de Quilichao / Mondomo
Type of System			
Rural	X		X
Peri-Urban			
Urban		X	
Source of innovation	from above	from above	from above
Extent of innovation	adapted	adapted	adapted
Management type			
Public companies	X	X	
Cooperatives			
Communities	X		X
Informal management			
Type of service	Water supply	Sanitation	Water supply
Type of actors	* public authority (SISAR/CAGECE's offices) * local communities (community associations / resident operator / population)	* public authority (all levels of government: municipal, provincial and federal and public service provider: CAMPESA) * local communities	* Private company * national and international NGOs * international cooperation organisms * national, departmental and municipal governments * Community: Board Administration Aqueduct, community leaders, educational institution, community support groups and Users * University (CINARA)
Served Population (no.)			
municipalities			1
communities	2		1
area		38 ha	
inhabitants	Andreza: 685 Arataca: 470	11093	3 400
systems / dwellings / households	Dwellings with SISAR accounts: Andreza: 245 Arataca: 144	Households: 3149	
users	Andreza: 685 Arataca: 470	11093	3 400
users under analysis	Andreza: 685 Arataca: 470	11093	3 400
Temporal scale of design and implementation of the innovation			
design	1980s	2000-2001	1991 - 1994
implementation	2013	2002	1995

analysed time interval	2013	2001-2004	1994-1995 2014
Temporal scale(s) of the impact sought through the innovation			
long-term	X	X	X
medium-term			
short-term			
Key Agents			
planning	Public administration and Community	Public administration and Community	Community, NGOs, associations; federal government, University
implementation	Public administration and Community	Public administration and Community	Community, NGOs, associations; federal government, University
operation	Community	Public administration and Community	Community, NGOs, associations; federal government, University
maintenance	Community	Public administration and Community	Municipal administration; Community

Table A. 3 Main features of intervention case studies.

DESAFIO systems	Case study		
	Intervention		
	Participative Generation of a Water Treatment	SISAR/CE - Community oriented water and sanitation services	Capacity Building for Monitoring Water Quality in Vulnerable Communities
	D4.1.	**D4.2**	**D4.3**
Location	Brazil / Minas Gerais / Lagedo / Quilombola territory	Brazil / Ceará / Cristais and Itapeim Complex (IC) (Itapeim, Andreza and Arataca)	Argentina / Santa Fé Province / Carcaraña (city), Coronda (city), La Chispa (town), San Francisco (town), Cañada de Gómez (city)
Type of System			
Rural	X	X	X
Peri-Urban			
Urban			X
Source of innovation	from above	from above	from above
Extent of innovation	adapted	adapted	full
Management type			
Public companies		X	X
Cooperatives			X
Communities	X	X	
Informal management			X
Type of service	Water supply	Water supply and sanitation	Water quality
Type of actors	* Social Movements, NGOs * federal government institutions * University * Community:	Integrated Rural Sanitation System of the state of Ceará (SISAR/CE) Community	* Researchers * Students * School teachers
Served Population (nr.)			
municipalities	1		4
communities	1	2	5
area	60 000 ha		
inhabitants	16 sociocultural communities		Carcaraña: 17 000 Coronda: 18 000 La Chispa: 352 San Francisco: 300 Cañada de Gómez: 30 000
systems / dwellings / households		Dwellings: Cristais- 235 and 36 infants ICx: 344 and 31 infants	
users		Dwellings: Cristais- 235 and 36 infants ICx: 344 and 31 infants	Public Water Company (ASSA): 60% of pop of 15 towns Water Supply Providers (Communes, Cooperatives and Associations): ? Private wells: ? Carcaraña: 17 000 (Cooperative) Coronda: 18 000 (Cooperative) La Chispa: 352 (Private Wells) San Francisco: 300 (Private Wells) Cañada de Gómez: 30 000 (ASSA)
users under analysis	Quilombola nuclei: 38 families	Dwellings: Cristais- 235 and 36 infants ICx: 344 and 31 infants	Initial Sampling - Students + Teachers: Carcaraña: 32 + 6; Coronda: 44+4; La Chispa & San Francisco: 29+3; Cañada de Gómez: 47+2
Temporal scale of design and implementation of the innovation			
design	2013	SISAR: 1995	2014 ?

implementation	2013-2015	Cristais: host to installation IC: 2013	2014 ?
analysed time interval	2013-2015	2013-2015	2014 ?
Temporal scale(s) of the impact sought through the innovation			
long-term	X	X	X
medium-term			
short-term			
Key Agents			
planning	Community, NGOs, associations; federal government, University	Public administration and Community	DESAFIO Researchers
implementation	Community, NGOs, associations; federal government, University	Public administration and Community	DESAFIO Researchers and School Community
operation	Community	SISAR/CE and Community	DESAFIO Researchers and School Community
maintenance	Community	SISAR/CE and Community	Community

Table A4. Indicators applied for political-institutional assessment per case-study.

indicators			metric	case-studies
institutional framework	institutions	current		D2.1, D2.2, D2.4, D3.1, D3.2, D3.3, D4.1, D4.2
		hypothesised		D2.3
	institutional role	current		D2.1, D2.4, D3.1, D3.2, D3.3, D4.1, D4.2
		hypothesised		D2.3
	changes introduced			D2.2
	impacts in the community			D2.2
	role of community	hypothesised		D2.3
political context				D2.1, D2.2, D3.2
inter-sectorial and inter-institutional cooperation	partnerships	public-private		D2.1, D2.2, D2.4, D3.2
		other partnerships		D2.2
	coordination with other essential services			D2.2
	institutional role			D2.4
	mechanisms			D3.2
community structure	inhabitants		inhabitants per dwelling	D2.3
life quality perception	access to water (water sources)	dwellings with network connection	% of answers / category	D2.3
		dwellings with artesian well	% of answers / category	D2.3
		no. of travels to fetch water / day or week	% of answers / category	D2.3
	water uses	type of use	% of answers / category	D2.3
	water quality perception	water quality	% of answers / category	D2.3
		water source preference		D2.3
	access to water perception	existent problems		D2.3
		most vulnerable areas/populations		D2.3
institutional perception	public authorities' service	community opinion		D2.3
	identification of water suppliers	infrastructure, equipment, water quality monitoring		D4.1
	waste sorting perception	responsible institutions		D4.3
	water quality perception	responsible institutions		D4.3
institutional willingness	municipalisation of water provision and sanitation	is it possible?		D2.3
		how, with which sources?		D2.3

	institutional awareness	use of springs and wells		D2.3
	possibility to substitute or complement systems			D2.3
institutional mobilization capability	new institutional mechanisms			D3.2
	institutional dialogical and participatory methods	meetings	presence/absence of public authorities	D4.1
		professionals training	presence/absence	D4.1
management model	guidelines			D3.3
	activities and organization	method used for infrastructure installation		D4.1
		community participation		D4.1

Table A5. Indicators applied for socio-political and cultural assessment per case-study.

indicators			**metric**	**case studies**
citizen-empowerment	institutional mobilization capability	mechanisms		D2.1, D3.1, D3.2, D4.1
			presence/absence	D2.1, D2.2, D3.1
			invitation to education activities	D3.2
		institutions		D3.2
		accompaniment	presence/absence	D3.1
		communication approach		D3.1
	community mobilization	organization capacity		D2.1
		persistence of activities (training, education, ...)		D2.1
		mobilization towards active participation in the implementation		D2.2
		mobilization towards other projects		D2.1
	social participation	discussion forums	attendees participation	D2.1
			% of attendees	D2.2, D2.4, D3.3
			no. of attendees	D3.1
			% of active participants	D2.4
			presence/absence	D3.1
			frequency	D3.1
			participatory appraisal activities	D4.1
		debated themes		D2.1, D2.2
		mechanisms		D2.1, D2.2, D2.4
		type of participation	% answers/ category	D3.3
		perception	mechanisms	D2.2, D3.2
			changes observed	D3.2
		funds collection		D2.1, D4.1
		participation in key events		D4.1
		degree of collective cooperation		D4.1
	community attitudes	expression of complaints, doubts and deliberations	presence/absence	D2.1, D3.1
			number of occurrences / type * year	D3.2
		information and communication		D2.1
		efficient fulfilment of requests	number of days to respond	D3.2
	institutional transparency perception			D2.1
community expectations	life quality			D2.2
		improvements	% of households / category	D4.2
	health			D2.2
	environment			D2.2
	economic-financial aspects			D2.2

	institutional aspects			D2.2
	social participation			D2.2
community structure	inhabitants		no. of inhabitants (per genre; total)	D2.2, D3.1
			average age	D3.1
life quality perception	access to water (water sources)	dwellings with network connection	% of answers / category	D2.3
			no. of dwellings with SISAR accounts	D3.1
		dwellings with artesian well	% of answers / category	D2.3
		no. of travels to fetch water / day or week (6 categories)	% of answers / category	D2.3
		type of water sources		D3.1
		water sources before the implementation		D3.2
		water market a part from the innovation model		D3.1
		access before the implementation (quality perception)		D3.2
		changes observed after implementation		D3.2
	access to sanitation	access before the implementation		D3.2
		changes observed after implementation		D3.2
		sanitation problems identification		D3.2
	water uses	type of use	% of answers / category	D2.3, D3.3, D4.2
			% of households / use	D4.2
	water quality perception	water quality	% of answers / category	D2.3, D3.3, D4.2
			% of category/source	D4.2
		water source preference	(descriptive)	D2.3, D3.1
			% of households/source	D4.2
			% answers / source	D4.3
		water related concerns	(descriptive)	D4.3
		water related concerns by each interviewed user and institution	% answers / category	D4.3
	water quantity perception	water quantity	% of answers / category	D3.3
		water consumption habits: quantity of water consumed per day	% answers / volume of water range group	D4.3
	access to water perception	existent problems	(descriptive)	D2.3
		most vulnerable areas/populations	(descriptive)	D2.3

	life quality before implementation		(descriptive)	D3.2
	hygiene practices	perception	% answers/ category	D3.2
		changes observed		D3.2
	public services' quality perception before implementation	urban cleaning services before		D3.2
		urban cleaning services changes		D3.2
		waste disposal services before		D3.2
		waste disposal services changes		D3.2
		urban drainage before		D3.2
		urban drainage changes		D3.2
		urban paving before		D3.2
		urban paving changes		D3.2
		health services before		D3.2
		health services changes		D3.2
		sanitation services before		D3.2
		sanitation services changes		D3.2
		sanitation maintenance before		D3.2
		sanitation maintenance changes		D3.2
organizational model	service administration and management	key actors		D2.4
		services per key actors		D2.4
		type of water supply infrastructures built		D3.1
		type of modifications to water supply structure		D3.1
		legal / illegal modifications to structure		D3.1
	service administration perception	service administration (water supply, sanitation, WWT, maintenance..)	% of answers / category	D2.4, D3.3
			(descriptive)	D3.1, D3.2, D4.2
		institutional structure		D3.3
		users	number	D3.3
		actors		D3.3
		quality of water supply service		D3.1
		identification of water supplier	% answers per water supplier	D4.3
		waste disposal management :: garbage collection	% answers / no. of times.week	D4.3
		waste disposal management :: solid waste disposal location within the city	% answers / type of site	D4.3

		jobs related to waste sorting and sell in the city	% answers / category	D4.3
		available information (official, non-official mediums)	sufficient / non-sufficient	D3.1
	billing system perception	water supply	% of answers / category	D2.4
		water sanitation	% of answers / category	D2.4
		water supply tariffs	tariff / user category (cost/month; cost/m^3)	D2.4
			quality	D4.2
			tariffs suitability	D3.3
			interference with family total income	D4.2
		electricity	% of answers / category	D2.4
		billing information	sufficient / non-sufficient	D3.1
		progressive water price table knows how to use / does not know		D4.2
infrastructure and technical objects	available information and training			D3.1
	users' intervention	type of illicit interventions		D3.1
		hydrometer functioning (knows how to use / does not know)		D4.2

Table A6. Indicators applied for economic-financial assessment per case study

indicators			**metric**	**case studies**
intervention	costs		difference between the adapted and the original model (%)	D2.2
		damages		D3.2
		relocations		D3.2
		infrastructures built		D3.2, D4.1
		total		D3.2
		total per inhabitant		D3.2
	key actors		key actors	D2.1, D2.2, D3.1, D3.3
	invested value per governmental institution			D3.2
maintenance	billing system			D2.2
		water price table	criteria	D2.4
			presence/absence of progressive table	D3.1
		tariffs	% supported by the community	D2.2
			% answers / average cost of water per month range	D4.3
		payment	regular / non-regular	D3.1
		coercive mechanisms		D3.1
		payment model		D3.2, D3.3
		fines		D3.3
		responsible institution for electricity bills' payment		D3.1
	other financial mechanisms	type	(descriptive)	D2.2
community structure	inhabitants		inhabitants per dwelling	D2.2
			% no. of residents / household	D2.4, D3.3
	time living in the community		% of residents per time interval	D2.4
	housing tenure	rented, owned, other	% of households	D2.4, D3.3
	housing per type of activity	residential, commercial, service, etc.	% of households / type of activity	D2.4, D3.3
	household building material		% households / type of material	D2.4, D3.3
	income		% households / average income category	D2.4, D3.3
	occupation			D3.3
life quality perception	access to water (water sources)	dwellings with network connection	% of responses / category	D2.3
		dwellings with artesian well	% of responses / category	D2.3

		no. of travels to fetch water / day or week (6 categories)	% of responses / category	D2.3
	water uses	type of use	% of responses / category	D2.3
	water quality perception	water quality	% of responses / category	D2.3
		water source preference		D2.3
			% answers / source	D4.3
	access to water perception	existent problems		D2.3
		most vulnerable areas/populations		D2.3
	economic accessbility to water perception	cheap, reasonable, expensive	% of households / category	D4.2
			% of households / category / income	D4.2
	access to water costs		% of households with costs associated with water supply	D4.2
			% of households with costs / income	D4.2
			amount paid per cubic meter of water (R $ / m^3)	D4.2
			amount paid per inhabitant per month (R $ / inhab.month)	D4.2
water markets	shipments, water supply network	before implementation		D3.1

Table A7. Indicators applied for techno-infrastructural/operational assessment per case study.

indicators			metric	case studies
implementation	adoption of new technical objects	water meter, monthly bill		D2.1, D3.1
	infrastructure	model incorporated all the simplified elements of the original model		D2.2
		type		D2.4, D3.1, D3.3
		coverage	Total number of connections	D2.1
			area	D2.2, D2.4
			% of population	D3.2
		changes		D2.4
	connection to network		% of households connected	D2.4
			% of households with rainwater connection to network	D2.4
	implementation time			D2.2
	key actors			D2.2, D2.4
	population served		% of households with service	D2.2
			difference between population with sanitation before and after the implementation (%)	D2.2
	act of affiliation		presence/absence	D3.1
		key actors		D3.1
		information provided		D3.1
maintenance	key actors			D2.1, D2.2, D2.4
	indicators of infrastructure maintenance	garbage, rocks, etc. blocking the network		D2.2
		waste disposal	% of households / type of waste.destiny	D2.4
			% of population that separates solid waste disposal	D3.3
			% of solid waste per type of destiny	D3.3
			% households / type of waste.type of destiny	D2.4
			% households / type of disposal	D4.3
			% households / type of location	D4.3
		sewage	% of population per type of sewage disposal	D3.3
			% of community perception per type of water destiny	D3.3
	key actors			D2.1, D2.4, D3.1, D3.3

operational management plan	institutional support			D2.1
	roles and responsibilities			D2.4
	billing system	water price table criteria		D2.4
	mechanisms			D3.1
community structure	inhabitants		inhabitants per dwelling	D2.3
life quality perception	access to water (water sources)	dwellings with network connection	% of answers / category	D2.3
		dwellings with artesian well	% of answers / category	D2.3
		no. of travels to fetch water / day or week (6 categories)	% of answers / category	D2.3
		types of water sources in use		D3.1, D3.3
			% answers / water source	D4.1, D4.3
		water collecting points at home	% of households with water collecting points	D4.2
		household hydraulic changes	% of households with hydraulic changes after the innovation implementation	D4.2
		water supply infrastructures	presence/absence	D4.2
		intermittence of water supply service	% of interviewed users / category / source	D4.2
			% of occurrences / category	D4.2
		time spent fetching water (with and without displacement)	% of households	D4.2
		time spent fetching water (< 5 min, 5 to 10 min, 11 to 30 min, more than 30 min)	% of households	D4.2
		family member (Women, Men, Young, Toddlers)	% of households / family member	D4.2
	water uses	type of use	% of answers / category	D2.3
		type of domestic uses per water source	% use / source	D2.4
		type of domestic use per type wastewater system	% households / use.system	D2.4
	water quality perception	water quality	% of answers / category	D2.3, D2.4
		water source preference		D2.3
	water quantity perception	water quantity	% of answers / category	D2.4
		existent problems		D2.3

	access to water perception	most vulnerable areas/populations		D2.3
	knowledge regarding wastewater destiny		% of population	D2.4
	knowledge regarding WTP location		% of population	D2.4
	access to sanitation	bathroom	% of households / category	D4.2
			% of category in use / income	D4.2
			% of category in use / education level	D4.2
			% of category in use / age of household head	D4.2
			% of category in use / professional occupation	D4.2
water quality	community vulnerability	Water Quality for human consumption Risk index(IRCA)		D2.4
		Supply Risk Index (IRABA)		D2.4
	thermotolerant coliforms		presence -absence / 100 ml	D4.2
funds	fund raising	mechanisms		D2.4
		institutions		D2.4
consumption habits	water quantity		% of accounts with monthly water consumptions higher than 10 m^3	D3.1
			average monthly consumption per dwelling (m^3)	D3.1
		water consumption per capita	L/ inhab.day	D4.2
Solution selection	turbidity removal techniques	pH, turbidity, colour, hardness, alkalinity, temperature, total coliforms and *E. coli*		D4.1
	disinfection processes	total coliforms, *E. coli*	NMP/100 mL	D4.1
Solution evaluation	impacts	positive and negative impacts, foreseen and unforeseen, direct and indirect	(Discussion forums: Impact flowcharts)	D4.1
	changes observed	changes that occur during the period analysed	(Discussion forums: Seasonal calendars)	D4.1
	attitudes and degree of cooperation changes	qualitative measurements of less tangible changes	efficiency of meetings, amount of resources mobilised, internal communication etc. (Discussion forums: Scales)	D4.1

Table A8. Indicators applied for health assessment per case study

indicators			**metric**	**case studies**
water quality	waterborne diseases	before implementation	presence/absence	D2.2
		after implementation	presence/absence	D2.2
community structure	inhabitants		inhabitants per dwelling	D2.3
life quality perception	access to water (water sources)	dwellings with network connection	% of answers / category	D2.3
		dwellings with artesian well	% of answers / category	D2.3
		no. of travels to fetch water / day or week (6 categories)	% of answers / category	D2.3
	water uses	type of use	% of answers / category	D2.3
	water quality perception	water quality	% of answers / category	D2.3
		water source preference		D2.3
			% answers / source	D4.3
	access to water perception	existent problems		D2.3
		most vulnerable areas/populations		D2.3
water quality	waterborne diseases		no. of cases / year	D2.4
		before implementation	presence/absence	D3.2
		eradication approach		D3.2
		type		D3.3, D4.1
		prevalence of diarrhoea	% of children under 5 years old	D4.2
		intestinal parasites	% of children under 5 years old / parasite	D4.2
			% of answers / type of disease	D4.3
			% of answers / no. of known diseases	D4.3
	thermotolerant coliforms		average of CFU/100 ml per analysis	D4.2
			% of water analyses with *E. coli* out of standard	D4.2
			presence-absence / source / community	D4.2
	community vulnerability	Water quality risk index for water consumption (IRCA)		D2.4
		Supply risk index (IRABA)		D2.4
	water supply treatment		presence/absence	D3.3
hygiene practices	water usage		% of residents / hygiene practice	D2.4
		bath, laundry, dishwash	% answers / category	D3.3

			average volume water (m^3/month)	D4.2
			average no. of baths / day	D4.2
		hands wash		D3.3
		drink, cook	average volume water per category (l/per capita/day)	D4.2
health indicators	weight / height		comparison with WHO targets for children under 5 (per sex, per age)	D4.2
	weight, height, blood pressure, blood glucose and urine, physical activity and cholesterol			D4.3

Table A9. Indicators applied for ecological-environmental assessment per case study.

indicators			**metric**	**case studies**
environmental commitment	environmental education		presence/absence	D2.1, D2.2, D3.1, D3.2
	environmental awareness		presence/absence	D2.2, D3.2
	environmental conservation projects			D3.3
community structure	inhabitants		inhabitants per dwelling	D2.3
life quality perception	access to water (water sources)	dwellings with network connection	% of answers / category	D2.3, D3.3
		dwellings with artesian well	% of answers / category	D2.3
		no. of travels to fetch water / day or week (6 categories)	% of answers / category	D2.3
	water uses	type of use	% of answers / category	D2.3
	access to water perception	existent problems		D2.3
		most vulnerable areas/populations		D2.3
	water supply sources ' perception	community awareness	% of population that acknowledges the aqueduct as a water source	D3.3
biophysical characterisation	basin area			D2.4, D4.3
	topographic characteristics			D2.4, D4.3
	hydrologic characteristics			D2.4, D4.3
	climatic characteristics			D4.3
	geologic characteristics			D4.3
	land use		% area / type of land use	D2.4
			type of land use	D3.3, D4.3
			land use change	D3.3

ecosystems' characterisation	type of ecosystem		area / type of ecosystem	D2.4
ecosystem services	community perception			D2.4
	community awareness			D2.4
	beneficial activities			D2.4
	type of ecosystem services 'used'			D2.4
	research		no. of research documents / type of publication	D2.4
			no. of research documents / institution	D2.4
environmental perception	perception of pollution sources	solid waste, tourism, etc. / Very high, high, total	% answers / type of impact.category	D2.4
				D3.3
	water quality perception	current river status (good, regular, bad)	% answers / category	D2.4
		in ten years (better, without change, worse)	% answers / category	D2.4
		water quality	% of answers / category	D2.3
		water quality perception (upstream basin)	in the coming years	D3.3
		water source preference		D2.3
	water supply sources ' perception	source status		D3.3, D4.2
		community awareness		D4.2
environmental conflicts	type of environmental conflicts		type of press articles (1980-2014)	D2.4
			no. of press articles (1980-2014)	D2.4
	key actors			D3.3
environmental conditions	location and quality of waterways			D4.1
	activities carried out by locals in the micro-basin			D4.1
	disposal locations of solid waste residue and residual waters			D4.1
		garbage collection	no. of times / week	D4.3
environmental problems	floods			D4.3
	erosion			D4.3
	access to water			D4.3
	water-related health problems			D4.3
	biodiversity loss			D4.3
	environmental policy gaps			D4.3