



# Sustainability of small scale water and sanitation systems in Cochabamba, Bolivia A case study of the housing cooperatives COVISEP and COVIVIR

Master of Science Thesis in the Master's Programs Industrial Ecology – for a Sustainable Society & Innovative and Sustainable Chemical Engineering

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Department of Civil and Environmental Engineering Division of Water Environment Technology CHALMERS UNIVERSITY OF TECHNOLOGY Gothenburg, Sweden, 2012 Report No. 2012:133

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Cover: Construction of the housing cooperative COVIVIR, Cochabamba

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## Abstract

The research question of this report is; how can the sustainability of small scale water and sanitation systems be assessed. This question is divided into two project goals. It aims to define sustainable development for small scale water and sanitation systems in the context of a case study in Cochabamba, Bolivia. Furthermore, it develops an evaluation framework that can be used to assess the sustainability of small scale water and sanitation systems, by identifying suitable indicators. Additionally, this master thesis is part of a PhD project of 5 years that will use this work for further studies of small scale water and sanitation systems in Cochabamba.

A case study of two housing cooperatives in Cochabamba and their water and sanitation systems was performed. Sustainable development was defined through interviews and group discussions with the concerned stakeholders and in collaboration with local experts. The definition of UN was used, so the questions referred to social, environmental and economic aspects. By using the cutting and sorting technique the empiric data from the interviews was analysed and the themes that the informants brought up were identified, which in this report are referred to as key issues. Together they build up the definition of sustainable development for small scale water and sanitation systems, according to the informants. They are the following; social context, socio-political factors, target group, freshwater resources, economical obstacles, reproducibility, knowledge, management, reliability, water quality and disposal. Furthermore, sub-topics included in each key issue were identified. After this, indicators that evaluate the consideration and fulfillment of all the key issues and associated sub-topics were selected through a literature study. The results of this thesis are limited to the two housing cooperatives that the case study is based on. The applicability might possibly be broader, but further research should be performed to verify this.

The main danger that qualitative research of this kind imply is that you find what you want to find, since you have a limited number of informants and you may have influenced the informants and their answers. This is probably true to some extent in this research; despite the fact that the interviews and group discussions included open-ended questions and that the informants were encouraged to lead the discussion. Additionally, a translator was used, which might have led to misunderstandings and a less fluent and vivid discussion. The analysis procedure also implies reasons to question the results. The cutting and sorting technique is built upon selecting the relevant data and then sorting it into different categories. The fact that this is done by the researcher leaves room for interpretation.

Key words: water and sanitation systems, sustainable development, evaluation framework, indicators, Cochabamba, Bolivia

Hållbar utveckling av småskaliga vatten- och sanitetssystem i Cochabamba, Bolivia En fallstudie av boendekooperativen COVISEP och COVIVIR

Examensarbete vid masterprogrammen Industrial Ecology – for a Sustainable Society & Innovative and Sustainable Chemical Engineering IDA HELGEGREN, HELENA SILTBERG Institutionen för bygg- och miljöteknik Avdelningen för Vatten Miljö Teknik Chalmers Tekniska Högskola

## Sammanfattning

Detta examensprojekt ämnar definiera hållbar utveckling för småskaliga vatten- och sanitetssystem i två boendekooperativ i Cochabamba, Bolivia. Dessutom syftar det till att utveckla ett utvärderingssystem för evaluering av hållbarheten av småskaliga vatten- och sanitetssystem. Detta görs genom att identifiera lämpliga indikatorer. Examensarbetet är en del av ett doktorandprojekt på 5 år, vilket kommer att använda sig av resultaten från det här projektet.

En fallstudie av två boendekooperativ och deras vatten- och sanitetssystem utfördes. Genom intervjuer och gruppdiskussioner med berörda intressenter definierades hållbar utveckling. Grunden för denna lokala definition är FNs definition av hållbarhetskonceptet och frågorna som ställdes under intervjuerna och gruppdiskussionerna gällde därför sociala och ekonomiska aspekter samt miljöaspekter. En klipp- och sorterateknik användes för att identifiera de teman som togs upp av informanterna under intervjuerna och gruppdiskussionerna. Dessa teman bygger tillsammans upp den lokala definitionen av hållbar utveckling och är följande; sociala aspekter, sociopolitiskafaktorer, målgrupp, sötvattensresurser, ekonomiska hinder, reproducerbarhet, kunskap, förvaltning, tillförlitlighet, vattenkvalité och avfallshantering. Genom en litteraturstudie identifierades sedan lämpliga indikatorer för alla teman.

Det finns skäl till att ifrågasätta resultaten. Ett begränsat antal informanter inkluderades. Det är också möjligt att forskarna påverkade deras svar även om öppna frågor användes och forskarna uppmuntrade informanterna att styra samtalet under intervjuerna och gruppdiskussionerna. En översättare användes under intervjuerna, vilket också kan ha påverkat resultaten. Dessutom lämnar analysmetoden utrymme för tolkning.

Nyckelord: vatten- och sanitetssystem, hållbar utveckling, utvärderingssystem, indikatorer, Cochabamba, Bolivia

## **Resumen y Reconocimiento**

Queríamos escribirles una pequeña carta para darles las gracias a ustedes por su manera muy amable y hospitalaria durante nuestra estadía aquí, explicarles en corto que hemos hecho en nuestro proyecto y contarles sobre los resultados del proyecto. Ambos, profesionalmente y personalmente, hemos tenido un tiempo muy bueno aquí, sobre el cual nos hemos alegrado mucho, y el apoyo de ustedes nos ha ayudado mucho en nuestro trabajo.

Para empezar, muchas gracias a la Doctora Carmen Ledo y la Doctora Graciela Landaeta por la oportunidad de realizar nuestra tesis de maestría aquí en Cochabamba! El objetivo de la tesis ha sido desarrollar los indicadores de sostenibilidad que puedan usar para evaluar los sistemas de agua y saneamiento a pequeña escala en Cochabamba porque ahora no hay un marco de evaluación para estos. El proyecto ha sido una colaboración entre PROCASHA, los cooperativas a los que ayudan; COVIVIR, COVISEP y la Universidad Mayor de San Simón (U.M.S.S.). Por eso hemos cumplido un estudio de caso de las dos cooperativas de vivienda en Quillacollo y Sipe Sipe. A través de entrevistas con los actores interesados, a cuales hemos identificado en PROCASHA, los cooperativistas y los financieros Habitad para la Humanidad (HPH) y Centro Cooperativo Sueco (SCC) con expertos en la tema de U.M.S.S. desarrollamos 11 temas claves, los cuales son críticos para un sistema de agua y saneamiento a pequeña escala. Los temas claves son: el contexto social, los factores socio-políticos, el grupo objetivo, los recursos de agua dulce, los obstáculos económicos, el reproducibilidad, el conocimiento, el gestión, el confiabilidad, la calidad del agua y el deposición. Los temas claves son el fundación en nuestra definición de sostenibilidad para los sistemas de agua y saneamiento a pequeña escala.

Después, hemos decidido los indicadores para los temas claves a través de estudios de la literatura y análisis de las entrevistas, para facilitar una evaluación de los sistemas con estos. Nuestra tesis de maestría esta incluida en un proyecto de doctorado el cual evaluará los sistemas de agua y saneamiento en las cooperativas de vivienda COVIVIR y COVISEP, y sugerirá medidas para mejorar los sistemas. Por lo tanto, el desarrollo de los indicadores, los cuales hicimos durante el proyecto de maestría, es la primera parte del proyecto de doctorado para conseguir un marco de evaluación de estos.

El apoyo de PROCASHA ha sido muy importante para nuestro trabajo porque nos dio mucho conocimiento sobre la organización en las cooperativas. Todo el equipo técnico, incluso nuestra supervisora Doctora Graciela Landaeta, nos han ayudado mucho y siempre tuvieron tiempo para contestar nuestras preguntas. Las cooperativas COVIVIR y COVISEP nos han ayudado mucho al contestar a nuestras preguntas y participar en entrevistas y talleres. Los consideramos como informantes claves porque pretendemos hacer un proyecto con mucha participación de los usuarios. Además los cooperativistas han sido muy amables y hospitalarios con nosotras. Hábitat para la Humanidad Bolivia, Centro Cooperativo Sueco, los cuales son los financieros de COVIVIR y COVISEP, y EMAPAQ en Quillacollo han tomado tiempo para contestar a nuestras preguntas.

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Como dijimos antes en la carta, este tiempo en Cochabamba ha sido muy bueno y especial para nosotras, y eso es principalmente gracias a ustedes y por el modo de tratarnos que fue muy cálido, amable y hospitalario. Muchas gracias a todos y esperamos que nos encontremos otra vez en un futuro muy pronto.

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## **1** Introduction

Sustainable development links together development issues and environmental issues and it was first defined in 1987 by the Brundtland report - Our Common Future (Kates, et al., 2005). The report states that *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development, 1987). During the last decades the increased pressure on the world's freshwater resources has gained increased attention. Water is necessary for the protection and health of the environment, as well as for the humanity. Sustainable freshwater management has been argued to be crucial in order to achieve sustainable development (Black & King , 2009).

Water affects the atmospheric and meteorological forces, as well as households and communities. In many parts of the world the water balance is altered locally, due to population growth, new human settlement patterns and changes in lifestyle. The natural flows of rivers and lakes have been artificially altered, and many people have been forced to move, since their homes or livelihoods are dependent on the ecosystems that have been destroyed. Additionally, global warming has water-related effects (Black & King , 2009). It is crucial that the freshwater systems are not further degraded and over-exploited (OECD, 2003).

Improved access to adequate water and sanitation services is a requirement in order to fulfil the concept of sustainable development. Improved water and sanitation services are requirements for life. Despite this, more than 780 million and 2.5 billion people lack access to safe drinking water and improved sanitation facilities, respectively (UNICEF, 2012). Among others, UN's Millennium Development Goals deal with this. They aim to halve the proportion of people that do not have access to safe drinking water and basic sanitation by 2015. It is predicted that the goal regarding drinking water will be met. However, the forecast for the goal of sanitation is not as positive and will probably not be met until 2025 (UN, 2012).

Many scholars, such as Flores et al. (2009), emphasize the importance of small scale water and sanitation systems in developing countries. They argue that they are crucial for achieving increased access to safe water and basic sanitation (Flores, et al., 2009). Through applying the theory of sustainable development on small scale water and sanitation systems in the context of Cochabamba in Bolivia, this report aims to develop a way of assessing the sustainability of small scale water and sanitation systems.

#### 1.1 Gap

A local definition of sustainable development in relation to water and sanitation systems is lacking for the context of Cochabamba. There is not a mutual understanding of what the concept of sustainable development implies. Furthermore, an evaluation framework for small scale water and sanitation systems does not exist. Much research have developed sustainability indicators that can be used for evaluation of water and sanitation systems, but these are not accommodated to the local context of Cochabamba.

#### **1.2 Purpose**

The research question of this thesis is; how can the sustainability of small scale water and sanitation systems be assessed. This is divided into two project goals; defining sustainable development for this context and develop an evaluation framework consisting of indicators applicable on the case study. In the long-run, the vision is to create a framework that can be used by organisations that run small scale water and sanitation systems, such as water cooperatives, private enterprises and municipalities in order to contribute increased sustainable water and sanitation coverage in Cochabamba.

#### 1.4 **Problem description**

The starting point for the thesis is the sustainability definition from UN, which states that social, economic and environmental aspects should be considered (Kates, et al., 2005). This definition makes up the first level of the sustainable development definition. Underlying themes, which make up the three spheres of sustainability, are to be developed to give a context specific definition of sustainability. These themes are referred to as key issues in this thesis. To measure these key issues, suitable qualitative and quantitative indicators will be identified. A visualisation of the structure is given in Figure 1. This way of working was used by Palme (2007) who suggested the structure of a pyramid, since it has the advantage of being clear and perspicuous.



Figure 1 The structure used to define sustainability.

The development of a methodology for identification of key issues and indicators is done by looking at articles from mainly Palme (2007), Mascarenhas et al. (2010) and Wallis (2006), who all has been developing sustainability indicators through a participatory approach accommodated to local conditions.

Like for the researchers Palme, Mascarenhas and Wallis, this thesis starts with a literature study followed by identification of stakeholders, which is a critical step (Wallis, 2006). Indicators are site and context specific (Murray, et al., 2009). This implies that it is crucial to involve decision-makers and stakeholders in the development process (Garfí & Ferrer-Martí, 2011). In this research, the stakeholders do not possess in-depth knowledge about water and sanitation. However, stakeholder participation makes it possible for them to bring about a change and engage themselves into the development process (Wallis, 2006). In this thesis, the stakeholders are not involved in the development of the indicators, rather what they should measure.

To narrow down the scope, a case study of two housing cooperatives COVISEP and COVIVIR in Cochabamba was carried out to gather the empirical data needed. Interviews with the identified stakeholders as well as with local experts from the University of San Simon were held. This information together with group discussions is used to make a first set of key issues. To get input on these, presentations are held with expert groups to make sure that no important areas are neglected as well as finding examples of common practices in Cochabamba and Bolivia. To see if there is validity in the key issues the two main stakeholder groups were asked to prioritise them, in which a high score indicates that the key issue has a big importance for the sustainability. All the methods and motivations to why they are used can be seen in Table 1.

Method	Informant group	Purpose			
Interviews	Stakeholders & local	Gather empirical data			
	experts				
Group discussions	Cooperativistas	Gather empirical data from the cooperatives			
Input presentations	Expert groups	Gather input on missed-out topics and gain			
		information about general practices			
Ranking of key issues	Main stakeholders	Ascertain validity			

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Indicators for each key issue are then developed through a literature study, which is a good way of finding indicators (Wallis, 2006). The whole approach on how to develop the framework can be seen in Figure 2.



Figure 2 Description of the appraoch for reaching the purpose of the thesis.

## 1.5 **Delimitations**

In this report water and sanitation is considered as one system. During the interviews, they were hard to separate without causing confusion, since they are very closely linked to each other.

#### 1.5.1 System boundaries

In the evaluation of sanitation systems, clear system boundaries are crucial (NETSSAF, 2006). In this thesis water is defined as the drinking water, as well as water used for domestic purposes, such as dishes, washing, flushing toilets, showers etc. Sanitation refers to grey water (and dry waste if latrines are used), its treatment, disposal, transportation of sludge and reuse of residuals and water.

## 1.6 Method

To involve the target group in the initial stages of planning and implementation a participatory approach was desired. This makes the users feel responsible and consider themselves as the owners of the water and sanitation solutions that are implemented through developing projects (UNICEF, 1997). The importance of a participatory approach was further emphasized by the fact that this thesis is the initiation of a PhD project. Hence, it was important to involve the stakeholders already in the development of the evaluation framework. This thesis tried to encourage a dynamic dialogue that enhanced mutual understanding and learning early on in the process. This enabled the intended target group, in this case the cooperativistas, to be informed customers, clients and managers instead of receivers (UNICEF, 1999).

The stakeholders were in this thesis used as informants and the approach outlined above is designed to enable a high level of consideration of their opinions and input. The residents of the cooperatives, who are referred to as cooperativistas, were seen as the most important stakeholder group. The empirical data was gathered through interviews with the stakeholder groups and local experts and in order to give the cooperativistas a relative large impact, group discussions were held with them. The group discussions were also seen as a forum where everyone could bring up their opinions and ideas. This was important, since all of the cooperativistas were not interviewed. Furthermore, prioritisation of the key issues was done with them and PROCASHA, which is the organization that is helping them to construct the cooperatives.

However, the users of the systems do not always have the required academic knowledge to independently lay the foundation for the development of sustainability indicators (Murray et al. 2009). Therefore, the opinions of other local stakeholders and experts were also taken into careful consideration. Furthermore, the cooperativistas are dependent on external support, which made the opinions of these external parties very important.

## 2 Background

The water and sanitation coverage in Bolivia has increased during the last decades. However, it is still low, see Table 2 (Bacarreza, et al., 2007). However, the difference in coverage is big between rural and urban areas. The census data defines water access as having water through a reasonable facility, which means from a source less than 1 km away from where it is used and that provides an amount of 20 litres per day and family member. In 1992, the Millennium Goal was set to reduce the percentage of the population without drinking water by half. Hence, the water coverage is targeted to be 78.5% by 2015.

According to the census data, 28% and 43.5% of Bolivia's population had basic sanitation in 1992 and 2005, respectively. (Bacarreza, et al., 2007). The geographical gap between the urban and rural area has remained almost constant since 1992. The national target implies a coverage of 64% until 2015, which was lacking nearly 21 percentage points in 2005. The sanitation coverage information includes the percentage of the population that have sewerage and septic tanks, but in the rural areas it also includes the use of pit latrines. Although basic sanitation systems might be present, the wastewater does not generally get treated. In most cases it is released directly into natural water bodies such as rivers, lakes or to the open air, with environmental degradation as a result (Mercado, 2012).

Year	Water cove	erage		Sanitation coverage			
	Urban	Rural	Total	Urban	Rural	Total	
1992	-	-	57.5%	-	-	28%	
2005	84.5%	51.4%	71.7%	49.7%	32.2%	43.5%	

Table 2 Water and sanitation coverage in Bolivia.

## 2.1 Cochabamba

Cochabamba is the third largest city in Bolivia, which is one of the poorest countries in South America. Around 60% live under the poverty limit and the minimum salary is USD 130 (Jelmini, 2012). The city is located in a valley on 2570 a.m.s.l. (Census, 1992) and the department of Cochabamba is divided into 16 provinces and 45 municipalities (Ledo, 2012). The population of the department of Cochabamba was approximated to be 1 197 072 in 2010, by the means of the official census data from 2001. The municipality of Cochabamba has a popular climate and soil that are suitable for agriculture (Municipality of Cochabamba, 2012), but its topography and climate also makes it sensitive to contamination. Today the municipality faces issues with contamination from traffic, brick production, tanneries and small industry. Air and water pollution are listed as two of the most urgent environmental problems in the region (Municipality of Cochabamba, 2012).

#### 1.2.1 Water and sanitation coverage in Cochabamba

In 2005, the department of Cochabamba presented an upward trend of drinking water coverage with a value of 52.5%, but this is still well below the national average of 71.7% (Table 3). Only the departments Beni and Pando have lower coverage than 50%. This could to some extent be explained by the low population density and dispersion of the population, but this is not a valid explanation for Cochabamba. For the department of Cochabamba to reach the target of 78.5% by the year of 2015, its coverage must increase with 26 percentage points (Bacarreza, et al., 2007).

The drinking water coverage has fluctuated in the department of Cochabamba, see Table 3. In 1992 the coverage was 44%, in 2001 65% but in 2005 it was only 52.5%, hence a drop of almost 12 percentage points. This can to some extent be explained by the conflicts and the water war in 2000. According to Deputy Minister of Basic Services (VSB) (Bacarreza, et al., 2007), drinking water coverage in the department of Cochabamba reached its highest levels in smaller towns (2000 to 10 000 inhabitants) with a coverage of 81%, followed by medium-sized cities (10 000-100 000) with 57% coverage. The coverage in major cities (> 100 000) and in rural areas (< 2000) did not exceed 50% in 2005. This was mainly due to the high rates of population growth in peri-urban areas, due to migration from rural areas.

Year	Water coverage	Sanitation coverage
1992	44%	32.8%
2001	65%	-
2005	52.5%	40.6%

Table 3	Water	and	sanitation	coverage	in the	department	of	Cochabamba
Table J	vvalei	anu	Samuation	COVELAGE	III UIC	uepartment	. 01	Cochaballiba

In 2005, the basic sanitation coverage in the department of Cochabamba was of 40.6%. It had increased only 8 percentage points relative to 1992 when the coverage was 32.8% as Table 3 shows above. Hence, Cochabamba does not exceed the national average of 43.5% and is lacking 24 percentage points to reach the national goal of 64%. In 2005, only the departments of La Paz and Tarija had reached rates above 50%, while the other departments had coverage between 30% and 40%, obtaining minor differences compared with 1992. According to data from National Census of Population and Households (CNPV) in 2001, six of Cochabamba's 45 municipalities had very low coverage (less than 13%), while eight reported average coverage (between 13% and 25%) (Bacarreza, et al., 2007). These both groups mainly represent rural areas. 14 municipalities reported superior coverage (over 41%) and are mainly located around the capital of the department (Bacarreza, et al., 2007).

#### 1.2.2 Water and sanitation management in Cochabamba city

The public water distribution system in the town of Cochabamba is run by SEMAPA (*Servivio Municipal de Agua Potable*), but their system reaches far from everyone. The water distribution system is heavily under dimensioned and approximately 50% of the water vanishes through leakage (Ledo, 2012). Furthermore, the water gets contaminated in the bad pipes (Selaya, 2012). SEMAPA has divided the city into different zones according to the standard of the house. The different zones pay different water tariffs, which depend on the standard. Houses of higher standard pay a higher water tariff. However, this system is currently not working well. Some houses are wrongly registered under the lower-standard groups, due to corruption. This enables exploitation of the system and cases of illegal trade exist (Ledo, 2012).

SEMAPA is mainly providing water to the northern parts of the city. Since Cochabamba has grown rapidly over the last years, they are no longer able to provide water to the southern parts, which have had the highest population growth rate. SEMAPA has a central system as well as three smaller independent ones. In the southern parts SEMAPA, as well as other independent organisations, operate to provide the inhabitants with water, but water scarcity in these areas is a big problem. Hence, SEMAPA can only provide water really sporadically to the southern parts, often only two or even one day per week during a few hours each time (Selaya, 2012).

At the moment a big project, which is called Múltiple Misicuni, is carried out. It aims to increase the water supply for the urban populations in the Central Valley of Cochabamba, irrigation water for agriculture in the agricultural area and power generation to the national grid. The water will be taken from the rivers Misicuni, Putucuni and Viscachas, which are located on the other side of the mountain range in Tunari. Improving the availability of water in the Central Valley of Cochabamba will decrease the biggest obstacle to economic, social and cultural development in Cochabamba (Empresa Misicuni, 2012).

The wastewater from the north is treated in the treatment plant of the city. However, the treatment plant of Cochabamba is under dimensioned and the water that passes does not receive enough treatment (Selaya, 2012). There is no sewage system implemented in the southern parts of Cochabamba, so the wastewater from the south is not led to the treatment plant (Selaya, 2012). To some extent sanitation pits exist that have to be emptied regularly. However, this is generally not done and most of the wastewater is not treated at all and directly released into natural water bodies (Mercado, 2012).

#### 1.2.3 Small scale water systems in the municipality of Cochabamba

Municipal water providers exist in some of the municipalities of the department of Cochabamba, for example SEMAPA in Cochabamba and EMAPAQ in Quillacollo. However, these companies are neither able to support all their inhabitants with water nor are they obliged to (Santos, 2012). The other inhabitants are left to organise water for themselves and this is often taken care of by water committees within the OTBs (Organizaciones Territoriales de Base). An OTB does normally exist in every hosing area, since it is a very common way of communities to organise themselves to gain economic and social benefits. If there is water and enough money in the area, the water committee provides water by for example building a well or taking surface water that the inhabitants pay a connection fee and operation tariff to use (Ledo, 2012).

Another example of water organisations in areas where there is not enough water is a group of people that save money and invest in a water truck. This enables them to buy water directly from SEMAPA and avoid the high prices that they otherwise often are exposed to if buying from other private enterprises with water trucks. The latter option is something that for example the poorest parts of Cochabamba city are left to do. Therefore, some have to spend as much as 10 % of their monthly income on water. Furthermore, this water many times is of very bad quality, since it is taken from for examples swimming pools (Ledo, 2012).

Social and environmental problems, such as water shortage, create huge differences between the rich people in the north and the poor in the southern areas. The disease rates are much higher in the south and the life expectancy rates are much lower (Ledo, 2012). Furthermore, the price difference of water is big depending on the source of the water. In the north of the city they pay about USD 0,6 for 1000 litres of water from SEMAPA, but in the south the price can be as much as USD 3,6 for the same quantity when it is bought from a tank truck that is run by private enterprises. However, the OTBs many times have relative low prices and a cubic meter costs about USD 0.4 (Escalera, 2012); (Fernandez, 2012).

The obvious advantage with small scale water systems is that they contribute to increased access to water. However, the water quality is rarely assessed or controlled (Arévalo, 2012). Furthermore, power struggles do often occur within the organisations, since personal benefits can be gained

(Rodriguez, 2012); (Selaya, 2012). The increase of independent systems has increased the dependence on groundwater and contamination of aquifers with health problems as a consequence (Nickson, 2002). Another problem that has been experienced when trying to expand the municipal network is that the people are not used to a municipal system and have therefore opposed themselves to them (Rodriguez, 2012).

The municipality are not obliged to take care of or treat wastewater and sludge (Santos, 2012) and as mentioned above most wastewater is dumped directly into natural water bodies (Bacarreza, et al., 2007). Currently, there are few small scale wastewater treatment plants that function well in Cochabamba. Liliana Arévalo, architect at the urban planning office of Cochabamba, only knows of two. Both of these were constructed with the help of NGOs (Arévalo, 2012). Construction of more small scale treatment plants, which connect sanitation systems of different neighbourhoods, would be one way of improving the sanitation situation. However, the investment cost as well as the operation fees would be high to ensure proper treatment (Mercado, 2012).

## **3** Theory

In this chapter the concept of sustainable development is outlined (3.1), as well as indicators that can be used as an assessment tool. Much focus is also given to summarize the main findings from the literature study regarding small scale water and sanitation systems (3.2). This information is used to give the researchers the background information that is necessary and to enable comparison between the literature and the results of this thesis.

## 3.1 Sustainable development

Sustainable development receives increased attention on all levels in today's society. It is a heavily debated topic and it is argued that progress towards sustainable development is desirable and necessary.

#### 3.1.1 Definition

UN's definition of sustainable development that is quoted in the introduction aims to highlight the needs of the world's poor and the earth's limitations. It is argued that the present and the coming generations have a legitimate right to fulfil their human basic needs, such as food, clothing and shelter. However, this should be achieved without compromising the well-being and the resources of the earth. The Brundtland report tried to deal with the conflict between economic development and the environment (Kates, et al., 2005).

Sustainable development is a concept that has been heavily criticized. The goals have not been challenged, rather praised, but the feasibility of the realization of the concept has been questioned. Sneddon et al. (2006) argue that the main reasons for this are the contradiction between conservation efforts and economic growth, as well as the neglectance of powerful actors in the society (Sneddon, et al., 2006).

Furthermore, it is claimed that the broad definition of sustainable development that is used today has contributed to a relatively free interpretation of the concept although the World Summit on Sustainable Development tried to narrow it down in 2002. This was done by defining the three pillars of environmental, economic and social sustainability that were said to build up the concept. However, this expansion of the definition has been criticized since it is argued that development has to some extent been limited to only include economic development (Kates, et al., 2005). On the other hand, other scholars argue that it is necessary to embrace the plurality of the concept in order to achieve sustainable development and that the broadness of the concept can be an advantage. Sustainable development is not a static concept but should evolve over time and allow inclusion of different actors at all levels and enable an open dialogue between them (Sneddon, et al., 2006).

#### 3.1.2 Indicators

Indicators are often used to measure sustainable development. They summarize important properties, visualizes phenomena of interest, quantify trends and communicate them (Billig, et al., 1999). The main uses are within the following areas; reporting, accounting, benchmarking and planning (Palme, 2007). However, the concept of sustainable development can in itself be difficult to use as a concrete goal, due to its plurality and broad definition (UNHSP, 2004). The three different pillars of sustainable development should be linked through sustainability indicators. However, one of the most common criticisms to indicators is that they do not do this. Many scholars, such as Murray et al. (2009), argue that the compartmentalizing of indicators into the separate

categories of sustainable development contribute to the absence of clear linkages between the different spheres.

If indicators are used as an evaluation tool, the set of indicators should be limited at the same time as comprehensive (Lundin & Morrison, 2002). They should also be easily understood and coupled to the local context (Murray, et al., 2009). Both quantitative and qualitative parameters are important. However, qualitative parameters are more difficult to monitor (Lundin, et al., 1999). If possible, the indicators should have a functional unit in order to allow comparison (Lundin & Morrison, 2002). It is important to bear in mind that indicators have been criticized that they measure what is feasible to measure rather than what is actually aimed to be assessed (McCool, 2004). Azar et al. (1996) argues that indicators should be related to general principles and conditions of sustainability, rather than linked to environmental effects, which all are not known (Azar, et al., 1996). It is important to point out causes, but a common critique is that indicators often rather point out symptoms instead (Cobb & Rixford, 1998), and that they do not include explanatory information (Briassoulis, 2001).

As previously mentioned, indicators are site- and context-specific. This implies that it is crucial to involve decision-makers and stakeholders in the development process (Garfí & Ferrer-Martí, 2011). What that is desirable depends on the local context; the environmental, social and economic characteristics of the area. Furthermore, indicators should be coupled to local benchmarks (Murray, et al., 2009). It is crucial that they assess the resilience of a system, since it is useful to gain information whether the current state of a system can be maintained or improved over time (Milman & Short, 2008). However, indicators are often said to not account for spatial variations to that extent that is desirable. This leads to the questioning whether indicators accounts for the complexity of the reality, which includes multiple pressures and feedback loops (Briassoulis, 2001).

#### 3.2 Small scale water and sanitation systems

There are many factors that affect planning, implementation and operation of small scale water and sanitation systems. This section outlines important aspects regarding this. The information is general for water and sanitation projects in developing countries. The information is valid for Cochabamba, Bolivia, but not specific for this context.

#### 3.2.1 Social

It is absolutely crucial to understand and investigate the local social context in the planning phase, before implementing a system, in order to choose a system that will function well. However, social and behavioural aspects have historically often been neglected in sanitation programs (UNICEF, 1997). In this section, the social factors are divided into the following topics; population, capacity building and health.

#### **Population**

When looking at the population, aspects such as demography, urbanization, migration patterns, housing density and housing characteristics are crucial to consider (UNICEF, 2012). The population size and how it changes is important to know because that affects what system that is suitable. It affects the human-induced pressure on the natural resources in the area (OECD, 2003). Furthermore, living standard is an important factor when implementing water and sanitation solutions (UNICEF, 1997).

Religions and ethnic distribution can also affect the outcome of a water and sanitation project (UNICEF, 1997). Social respect and understanding of the local tradition are crucial components in a water and sanitation project (McConville, 2006). Sanitation can be a matter of prestige and social status (UNICEF, 2012). It is argued that a developing project should aim to preserve the local culture (Garfí & Ferrer-Martí, 2011). Additionally, social problems, such as conflicts regarding water for irrigation between different groups within a society, affect water and sanitation systems (The Water and Sanitation Program, 2011). A system should not exclude inhabitants of the community, due to factors such as physical characteristics, high costs, ethnicity and political association (Hazeltine & Bull, 2003). A water and sanitation project should aim to include everyone on equal terms and avoid creating conflicts between different groups (Garfí & Ferrer-Martí, 2011).

Before initiating a project, it is crucial to carry out a need assessment (Pybus & Schoeman, 2001), which involves the community (Catholic Relief Services, 2005). That the target group has a demand for a specific solution, which a project aims to deliver, is crucial (Jenkins & Scott, 2007). The aim of the project must be a top priority of the community and understood by the target group (Pybus & Schoeman, 2001). Demand for sanitation is expressed by willingness to pay for a solution but also through the willingness to engaging local resources (UNICEF, 1997). Conflicts between groups that have conflicting interests are common, for example between farmers and industry or when commercial interests clash with the water needs of the local people (Black & King , 2009). Additionally, it is important to know how the target group handle new information, challenges and ideas in order to design and implement a solution according to the local characteristics (UNICEF, 1997).

#### **Capacity building**

Community participation is crucial in all steps of a water and sanitation project. The target group should be included and have an active role in the design, management and financing (UNICEF, 1997); (Garfí & Ferrer-Martí, 2011); (The Water and Sanitation Program, 2011). A community that contributes with labour and material, help to develop a sense of community ownership for the project and it enhances local responsibility for the long term operation and reduces project costs (Catholic Relief Services, 2005). An important key factor is to involve women. It has been shown that it is beneficial to have equal men and women in a workforce of a project, especially in areas with clear gender roles (UNICEF, 1997). It is important to identify actors that can support the target group with commitment and resources. People outside of the project can in some cases provide objectivity or specific skills, but as far as possible should local people and skills be used in order to build up local capacity. Social participation is about motivating and engaging the skills of others (UNICEF, 1997). Involving communities in the decisions regarding the characteristics of projects and technical systems is crucial for their independence. It is the first step towards being technologically self-sufficient (Garfí & Ferrer-Martí, 2011).

Knowledge and education are absolutely crucial, since it enables local capacity building (Garfí & Ferrer-Martí, 2011). It is especially important to cover areas that are perceived as constraints and difficulties, since that can hinder and delay preparations and decisions (Jenkins & Scott, 2007). Recommended educational areas are the following; environmental issues, informal and formal training in roles and responsibilities, financial management and personnel management. However, what areas that needs to be covered is context-specific. Before initiating training modules it is important to identify the gap between current knowledge and the degree of knowledge that is

desirable. It is important that education enable active participation, and just not imply passively receiving information (UNICEF, 1997). Workshops and meetings are often recommended working instrument (Garfí & Ferrer-Martí, 2011), as well as collaboration with local schools, non-formal education groups, learning group peers and local leaders. The possibility to learn from each other within an area should not be underestimated. Additionally, there is a great opportunity to learn from the on-going work (UNICEF, 1997). After training and education modules, it is essential to test the outcome of these, to assess how the knowledge level has changed (Pybus & Schoeman, 2001). Furthermore, the importance of revision is highlighted in the literature (UNICEF, 1997).

The Sanitation Handbook (UNICEF, 1997) argues that behavioural change is the ultimate aim of water and sanitation projects. It is mainly affected if the people feel that they have the capacity and willingness to challenge a problem and change their behaviour. It takes a lot of time and effort to bring about change at community level that will be sustained. An important tool for generating sustained behavioural change is to engage and include people in their own progress (UNICEF, 1997).Three factors are argued to be crucial for adopting new behaviours; motivation, opportunity and ability (Rothschild, 1999). It is crucial that the target group is aware of the personal benefits that a specific behavioural change gives rise to in order to encourage and motivate the people (Jenkins & Scott, 2007). Furthermore, it is important that the user feel confident and comfortable in performing the specific chores (Hernandez & Scott, 2010).

#### Health

Access to an improved water source and a sanitation facility are requirements for good community health. The correlation between access to safe water supply and sanitation services and mortality is well grounded in the literature (Catholic Relief Services, 2005). Diarrhoeal diseases are the second leading cause to death among children under 5 years, and lack of improved water and sanitation is the main cause to this (Garfí & Ferrer-Martí, 2011). Characteristics of a high-quality water source are; reliability, plentifulness and proximity to home (Black & King , 2009). It is necessary to assess the water quality both at the source and at the time of use. If the water is stored in an unsafe manner the water quality might be degraded (Hernandez & Scott, 2010). Garfí & Ferrer-Martí (2011) argue that water systems that do not provide water of good quality should not be considered in the decision-making process (Garfí & Ferrer-Martí, 2011). Additionally, organoleptic properties (appearance, taste and odour) are also important to evaluate. These properties do not affect the health implicitly, but due to these factors the users may utilize other unsafe water sources (Garfí & Ferrer-Martí, 2011).

If the water quality does not fulfil the health requirements, water treatment at the household level is crucial (Hazeltine & Bull, 2003). It is important to choose a water treatment method according to the pollutants that have to be removed, since different technologies remove different pollutants (WHO, 2009). A specific water treatment procedure must therefore be evaluated against the site-and context-specific conditions of the concerned area (Garfí & Ferrer-Martí, 2011).

Personal hygiene is the most important connection between water and health (Black & King , 2009). The exposure to faeces is the leading cause to diarrheal diseases, so it is absolutely crucial that human faeces are disposed in a safe way (Hernandez & Scott, 2010). Inadequate sanitation fails to do this and therefore pose a health risk (Tilley , et al., 2008). Children faeces from young children are especially important to consider when assessing hygienic conditions, since they do not use the toilet

facilities. Stools should be emptied in a toilet facility and washable diapers should be cleaned in a safe way. However, in some societies children faeces are considered as harmless, which not is the case (Hernandez & Scott, 2010).

The occurrence of insects and odour affect the hygienic conditions and health risks with a system. It is crucial to prevent both odour and the presence of insects (Garfí & Ferrer-Martí, 2011). Furthermore, stagnant water can lead to the spread of diseases through hosts or agents that breed on standing water (Black & King , 2009).

#### 3.2.2 Socio-political

Institutional factors are crucial in order to increase the access to improved sanitation (UNICEF, 1997). In this report, socio-political aspects are defined as the issues that are connected to the state and associated policies, as well as the interaction between different stakeholders of the water and sanitation sector. The following areas are found to be influential; legislation, political cohesion and collaboration.

#### Legislation

The first requirement that a water and sanitation system has to fulfil is that it has to be a legal entity and it must have license to operate and extract raw water (The Water and Sanitation Program, 2011). Many small scale water and sanitation providers are generally considered illegal or irregular in the urban setting in developing countries. This leads to lack of information and structure regarding the small scale operators (Solo, 1999).

Property rights are crucial when implementing water and sanitation solutions (UNICEF, 2012). Who that has the right to water is heavily debated on all levels, as well as the responsibility of polluters (Black & King , 2009). Historically, many community-based organizations have operated without considering and following regulations. However, it is important that they do follow the legislation, since that generate many possibilities. It implies protection and it also enable the specific organization to get additional support from external parties. Formality is a way of recognizing an organization (The Water and Sanitation Program, 2011).

#### **Political-cohesion**

It is important to link a project goal with the overall local, regional and national goals (McConville, 2006). Integrating the project with the overall development plan for the whole area can generate synergy effects with surrounding communities (Pybus & Schoeman, 2001). The spread-effect of a project is dependent on this. The individual project should be put in a context that relates to the overall sector. It is beneficial if it is possible to link the project to existing public health priorities, positive behavioural patterns and religious beliefs of the region (UNICEF, 1997). However, it is argued that mixed ownership between the public and the private sector has shown to be unproductive (Solo, 1999).

The current and future status of the municipal infrastructure is important to consider when planning a project, in order to create a long term solution. This is especially true for peri-urban systems (UNICEF, 2012). However, this statement implies that public provision of water and sanitation services is to prefer. Small scale providers are especially seen as an attractive alternative in areas where large scale systems do not satisfy the full population. Different needs and conditions within a city make it difficult for a large scale provider to satisfy the diverse customer needs (Solo, 1999).

Building political will, which has to be built upon what the community wants, can lead to policy changes. Sanitation systems and the people who drive the development of these systems can function as an effective catalyst in policy discussions and the political development. In order to achieve this, building trust and collaboration between different actors is crucial (UNICEF, 1997).

#### **Collaboration**

The collaboration around water and sanitation issues is complex. Water has been debated for centuries, but due to the increased pressure on water resources this debate has been intensified. The challenges are becoming more acute, especially at national and global level. However, despite the many associated challenges, globally there are more success stories than failures (Black & King , 2009).

Collaboration on the local level is crucial for the implementation of water and sanitation. In order to finance large-scale facilities, such as drainage and treatment plants, it is crucial to encourage collaboration and partnerships. Clustering projects can lower the costs, e.g. training, supervision, technical services, and monitoring costs (UNICEF, 1997). An appropriate technology alternative encourages collaboration on equal terms and allows the inclusion of marginalized groups (Garfí & Ferrer-Martí, 2011).

#### 3.2.3 Environmental

It is argued that the following environmental issues are especially important to consider in relation to wastewater systems; adaptability to local conditions, resource conservation, resource recovery and waste minimization. Within these areas, sanitation projects in developing countries often tend to focus on use of locally produced material and water conservation. However, Flores et al. (2009) argues that it is important that the environmental scope is broadened (Flores, et al., 2009). This chapter focuses on following areas; physical characteristics, environmental impact and resource use.

#### **Physical characteristics**

The local climate, including rainfall patterns and water availability affects the type of water and sanitation system that is appropriate (OECD, 2003). Water and sanitation systems are dependent on the water availability (UNICEF, 1997). All potential water sources should be considered and evaluated, since the most suitable alternative depends on the local characteristics (Catholic Relief Services, 2005). However, it is crucial that water and sanitation project depend on renewable water resources (Pybus & Schoeman, 2001). Groundwater sources are generally preferred as drinking water source, since surface water is more likely to be contaminated. However, groundwater can be contaminated as well. Additionally, sources that provide water throughout the whole year and lifetime of the project should be chosen if it is possible (Catholic Relief Services, 2005).

It is important that water supply points are located far from potential pollution sources. They should be located in areas with sanitation services and where pollution from agriculture and industry is controlled, in order to prevent water pollution and decrease the need for treatment (Garfí & Ferrer-Martí, 2011). The location of sanitation systems in relation to groundwater sources and the water table is essential. In most soils decentralized sanitation systems should be located at least 30 meters from a groundwater source and the bottoms of latrines should be at minimum 1.5 meters above the water table. However, the required distances are dependent on the soil type (Garfí & Ferrer-Martí, 2011). The technology selection is dependent on the geology. The permeability and the type of soil are important factors when selecting sanitation system (UNICEF, 1997). Furthermore, wetlands are capable to treat wastewater (Black & King , 2009).

#### **Environmental impact**

Historical pollution levels affect the feasibility of the long-term operation of water and sanitation systems, especially in peri-urban areas (UNICEF, 1997). Many water sources have been degraded and contain water of bad quality as a result, due to bacteria pollutants and other contaminants (Black & King , 2009). It is of uttermost importance that drainage and spillage from defection system do not reach surface water sources or shallow groundwater before it is treated (SCHR, 2004). The environment has an in-built capacity to treat water. However, this cannot cope with the increasing amount of waste, composed of human waste, chemical wastes and industrial spills, which it receives. The regulations in many countries fail to control the waste amounts that end up in the water systems. In developing countries, around 90 per cent all the human waste is released untreated into rivers (Black & King , 2009).

There are several characteristics of water and sanitation systems that are desirable from an environmental point of view. Many scholars, such as Murray (2009), claim that reuse of nutrients, energy and waste water are important characteristics of a sustainable wastewater system. The reuse of different components are an example on active sustainability, since it is a feature that actually have a positive influence on sustainable development (Murray, et al., 2009). However, the implementation of the environmental friendly solutions is not as rapid as preferable. Normally, there is a trade-off between environmental safety and cost. It is common that the users' willingness to pay for a solution that is environmentally safe does not match the cost that this implies (UNICEF, 1997).

#### Natural resource use

Natural resource use is an important aspect of water and sanitation systems. Water and energy use are emphasized as important in much literature, as well as nutrient recovery and land use when designing a sanitation system. Additionally, land availability is an important factor when deciding what system to choose (UNICEF, 1997); (Garfí & Ferrer-Martí, 2011).

The rising water demand is challenging to satisfy at the same time as preserving the environment. The renewable water resources are unlikely to decrease, but the unsustainable use of nonrenewable water resources is a challenge. Furthermore, does global warming affect the hydrological cycle (Black & King , 2009). During the last century the water demand has increased dramatically (OECD, 2003). There are cases of local water shortages where the renewable water sources do not cover the water demand, which leads to unsustainable extraction rates from rivers and underground aquifers. Population growth and increasing middle class are the main reasons to the increased pressure on water resources. It is especially the population with industrialized standards of living that have high water consumption, due to the food diet and high consumption (Black & King, 2009). Water conservation efforts, such as reuse, is an important environmental measure (OECD, 2003), especially in water scarce areas. Furthermore, water conservation decreases material and energy use. Widely accepted uses for treated waste water are mitigation of salinity intrusion, irrigation, industrial applications and ecosystem restoration. However, grey water may often be reused without treatment (Flores, et al., 2009). However, it is important to bear in mind that poor areas rather use too little water than too much, due to that many people in these areas still lack a reliable water source and appropriate sanitation (Black & King, 2009).

Recovery of nutrients is another important feature of a sanitation system, due to the danger of eutrophication. It can especially be beneficial in developing countries where the soil might be affected by erosion and over-farming and artificial fertilizers are relatively expensive. Additionally, energy recovery is beneficial characteristic of sanitation systems, due to concerns associated to global warming. It is possible to utilize the organic matter as an energy source, many times through anaerobic digestion of sludge (Flores, et al., 2009). Furthermore, an alternative that are important for optimizing the resource use is upgrading of the existing systems, which is often an alternative that is not thoroughly considered (UNICEF, 1997).

#### 3.2.4 Economic

Economic aspects are crucial within the water and sanitation sector, especially in developing countries (UNICEF, 1997). The economic pre-conditions and ability to pay, which are presented in more detail below, are important to consider.

#### **Economic pre-conditions**

The development of water and sanitation systems is affected by the business environment (Solo, 1999) and in turn the water and sanitation providers influence the business environment. Overall, it is important that the project benefits the local economy (Garfí & Ferrer-Martí, 2011). Solo (1999) push for free competition. Providers that risk losing their customers if they do not provide a high quality service improve their performance to larger extent relative providers that operate in a restricted market (Solo, 1999). Market-mechanisms, such as pricing, could also be used to steer the development (Black & King , 2009). Furthermore, the providers have to fulfil performance standards that are indirect set by the customers in order to survive in a competitive market. There is a danger with regulations that restrict the profit of the small scale water and sanitation systems, since the providers might not be able to recover their costs, due to factors such as high inflation (Solo, 1999). However, Black and King (2009) argue that unsubsidized water providers in very poor areas imply that the inhabitants are not able to buy water at all. Privatization results in politically unacceptable increases of the price in order to make the operation cost-efficient. Water and sanitation should not be considered as any other product or service (Black & King , 2009). However, the advocates of free competition claim that water can be provided in a competitive business setting in the same way as other basic services, such as electricity and telephone setting (Solo, 1999).

Subsidies for water and sanitation providers are heavily discussed in the literature (UNICEF, 1997); (Solo, 1999). It is argued that governmental investments mainly benefit large scale water companies, which only serve the wealthy areas (Black & King , 2009). This can force small scale providers out of business (Solo, 1999). Despite the critics against the misallocated subsidies to only large-scale systems, subsidies and grants for development of small scale water and sanitation systems should be considered carefully. It can speed up the spreading of improved sanitation and make expensive technologies affordable. However, it is argued that they should be avoided, due to the danger of making communities dependent on external support (UNICEF, 1997). It is absolutely crucial that a project is self-sufficient in the long-run. If a water and sanitation scheme acquires funds from the authorities, it is important that they are able to afford these subsidies for neighbouring communities as well, so that they are sustainable in the long-run (Pybus & Schoeman, 2001). It is also important that the financing strategies are consistent, so they do not confuse the target group. Additionally, self-financed schemes often imply that the wealthier group in a community leads the development

of sanitation systems, which makes the specific sanitation system a status investment (UNICEF, 1997).

In the developing world, many small scale water and sanitation providers are generally considered illegal or irregular in the urban setting. This leads to that small entrepreneurs commonly have difficulties taking loans and therefore invest and upgrade their systems (Solo, 1999).

#### Ability to pay

It is argued that the price is the major reason to that many households lack access to an improved water source. The coverage of piped water and sewage is lower in poor areas, since it is expensive to provide households with high quality water through a piped system (Black & King , 2009). Despite this, people in the poor areas that are connected to small scale providers often pay more than the more wealthy areas that are connected to the public network in many cities in developing countries. Especially the population of poor and informal urban areas pay a high price for unregistered and inadequate water services. However, it is rather the people with an industrial lifestyle that consume a lot of water (Black & King , 2009). Solo (1999) argues that it is impossible for small scale providers to match the subsidized price of the water companies (Solo, 1999).

Need often correlates with demand, but it is interesting to notice that this does not always have to be the case. A certain amount of wealth is a requirement for investing in sanitation. So it is important to consider income when implementing a water and sanitation solution. It is crucial that the systems are affordable for its users both when it comes to capital as well as to maintenance and operation costs (UNICEF, 1997).Traditionally, it is argued that an affordable solution implies that you do not pay more than 5 % of your income for water services (Al-Ghuraiz & Enshassi, 2005). The alternative with the lowest cost might not always be the most appropriate solution, although it is often perceived as that. An economic sustainable alternative rather connects to the affordability and the willingness to pay. The cost of a project should match these two aspects (Garfí & Ferrer-Martí, 2011). The water tariff should be realistic, set with care and allow room for changes as well as include all associated costs (Pybus & Schoeman, 2001). In developing projects, the operation and maintenance costs are generally seen as the users' responsibility (UNICEF, 1997). Therefore, it is crucial that the families take part and approve the costs of a system during the planning phase (Pybus & Schoeman, 2001).

#### 3.2.5 Technical

Technical aspects are important. An appropriate and reliable system design, to which all users have access, is critical. Furthermore, the management and the maintenance affect the reliability and the long-term operation of a certain water and sanitation solution. Below, these aspects are outlined in further detail.

#### Technology

It should not be time-consuming to fetch water (SCHR, 2004). The longer time a family spends on collecting water, the more likely is it that a household do not collect enough water to actually cover their needs (Hernandez & Scott, 2010). It is then likely that the water does not cover the need for personal hygiene, since there are many other more often prioritized uses (Black & King, 2009). The location of a sanitation facility is also of major importance. It is often more used and maintained if it is close to the dwellings (Garfí & Ferrer-Martí, 2011). Furthermore, it is important that the users

safely can use a sanitation system during day and night (SCHR, 2004). Separate systems for men and women can have a positive effect (Garfí & Ferrer-Martí, 2011).

The reliability of water and sanitation systems is absolutely crucial. It is crucial that a water system provides enough water of high quality to cover the needs of the target group (Garfí & Ferrer-Martí, 2011). A water system should provide water throughout the whole day and during all seasons (Hazeltine & Bull, 2003). Furthermore, it is crucial that the water source is protected, and that direct public access to the water source is limited (Garfí & Ferrer-Martí, 2011). If the technical system is shared by several families, consideration should be taken so that not too many people utilize the same facility (SCHR, 2004). In general a private sanitation facility is recommended. If a shared sanitation facility is used maintenance is absolutely crucial. A safe and hygienic sanitation facility encourages sustained use in the long-run (Hernandez & Scott, 2010).

System design is crucial and it is essential that all possible options are assessed during a technology selection process, which should be a dynamic process and evolve with time as the community grows and develop (UNICEF, 1997). Assessment of system capacity in relation to the water need is important (The Water and Sanitation Program, 2011); (Flores, et al., 2009). In peri-urban areas it is especially important to consider the feasibility of long-term operation, which is affected by population density to a large extent (UNICEF, 1997). There are several technical aspects that should be considered when designing a water and sanitation system. For example, Flores et al. (2009) argues that waste flow stream separation is preferable, since it prevents cross-contamination and enables treatment that is appropriate to the waste water quality. Additionally, it facilitates more efficient nutrient recovery (Flores, et al., 2009).

#### Management

An appropriate management structure that is accommodated to the tasks and needs of the organization is essential in the long-run. A project should include a clear goal and problem description and continuously assess and if necessary update these. Management is an instrument that enables a project to meet the goals that it is determined upon. Goals regarding cost, quality and time of completion are especially important (Pybus & Schoeman, 2001). Difficulties can arise due to competing interests (Black & King , 2009). It is absolutely crucial that the community is involved in the management and decision-making (The Water and Sanitation Program, 2011). External actors should not take decisions that the communities can take (UNICEF, 1997). If this is the case it may lead to lack of support from the community, which may lead to difficulties of recruiting and training new leaders (The Water and Sanitation Program, 2011).

What actors that should be involved in a project and what their specific roles should be is important to decide at an early stage. It is often good to use existing community organizations instead of creating new (UNICEF, 1997). Communication is critical, especially in the initial phase of a project. All involved actors must have a clear understanding of the project and all the different agreements that it implies (The Water and Sanitation Program, 2011); (Pybus & Schoeman, 2001). Contracts that specify obligations and rights are advisable, in order to avoid future conflicts. Public consultations can be a way of communicating and enable collaboration between the community and the organization responsible for the water and sanitation system. It is also often beneficial to include local leaders (The Water and Sanitation Program, 2011).

A core team that have the main responsibility is advisable. They should coordinate the work and make sure that the work is executed. Following activities are often included in the work of the core team; strategy and business plan development, budget planning, relationship building between the different actors and performance assessments (The Water and Sanitation Program, 2011). Overall reporting regarding the work of the organization is important. Accounting and transparency of the book keeping are especially important components. Additionally, monitoring is an essential part of the management of a water and sanitation system (Pybus & Schoeman, 2001).

The work of an organization is affected by norms and cultural aspects. This makes it important to develop common values. An important part of this is the development of legal documents, which primarily constitutes of the articles of organization, which includes by-laws. It is also beneficial to establish a clear vision and mission that can guide and motivate the organization to develop. Additionally, it is important that the organization of a water and sanitation system has authority and the ability to decide on convictions for users that do not follow the regulations that are commonly determined (The Water and Sanitation Program, 2011).

#### Maintenance

Regular maintenance and repairs are crucial for the long-term operation of water and sanitation systems. However, in many developing projects the maintenance is often poorly managed and carried out. In order to be able to perform proper maintenance sufficient skills, appropriate spare parts and finances for doing this are necessary (The Water and Sanitation Program, 2011). Locally available materials should be used for construction and maintenance. Central purchasing of imported goods that lower the cost is in many cases counterproductive in the long run (UNICEF, 1997). It is important that the maintenance is in accordance with the instructions from the technical team that have been involved in the construction (Pybus & Schoeman, 2001), but it is preferable if the technical design can be maintained without professionally skilled personnel (UNICEF, 1997). It is important not to underestimate the users' skills and potentials (The Water and Sanitation Program, 2011) and that the users see themselves as competent and have opportunity to carry out the specific tasks (Hernandez & Scott, 2010).

As mentioned, it is important to enable maintenance to function properly in the long-run (The Water and Sanitation Program, 2011). Transfer of knowledge (Solo, 1999) and economic aspects are crucial to achieve this. Maintenance can be very expensive, especially in event of flooding or earthquakes. Due to this, it is often beneficial to set aside savings for this purpose in case of the need for large maintenance funds (The Water and Sanitation Program, 2011). Furthermore, it is important to assess the accessibility of external parties if they are necessary for carrying out the maintenance work. For example, if large quantities of sludge need to be removed or a system needs to be de-sludged frequently it is important to evaluate the accessibility of vans and trucks that can do this (Garfí & Ferrer-Martí, 2011).

## 4 Case study description

This thesis is based on a case study of two housing cooperatives. In this chapter the cooperatives and their water and sanitation systems are described, as well as the associated stakeholders (4.1), which are the cooperativistas, PROCASHA, the funders and the municipalities. More detailed information about the two cooperatives COVISEP and COVIVIR are given in chapter (4.2).

## 4.1 The stakeholders

The stakeholders were identified to be four different groups; the residents, PROCASHA, Habitat for Humanity (HPH) and the Swedish Cooperative Centre (SCC) as well as the municipalities in which the cooperatives are located, Quillacollo and Sipe Sipe. In this report the residents of the cooperatives are referred to as the cooperativistas and PROCASHA is the organisation that supports them. HPH and SCC are the two organisations that fund PROCASHA and give loans to the cooperativistas. Further details about the stakeholders and their connections to each other will be explained in this section.

#### 4.1.1 The cooperativistas

Both COVIVIR and COVISEP are cooperatives that have formed themselves to work together to reach a commonly set ambition, to improve their living standard by constructing houses (Arnan, 2012). This correlates very well with the definition of a cooperative that the non-governmental organisation International Co-operative Alliance set in 1995. This is also the definition that PROCASHA uses and it is stated as: *"A cooperative is an independent association in which the people voluntarily organise themselves to satisfy their economic, social and cultural needs through funding an organisation that they put together and run democratically"* (International Co-operative Alliance, 1995).

COVISEP and COVIVIR are non-profit cooperatives with 30 and 12 families, respectively. However, the land bought for COVIVIR is big enough for 26 families; hence 14 more will move there in time. The person in each family that represents them is called a "cooperativista". Hence, there are as many houses as there are cooperativistas. The cooperatives are built upon six values (PROCASHA, 2003):

- Mutual help to reach personal development through working with the others towards a common goal
- Personal responsibility that each cooperativista has to be responsible and act in cohesion with the decisions made by the group
- Democracy that the group works democratically when voting, making decisions and working in the construction site
- Equality that all cooperativistas have the right to be informed, to be heard and take decisions in an equal way without differences between them
- Fairness that the cooperative should treat the members with justice
- Solidarity to stay together and collectively fight for getting an improved life quality

The by-laws of the cooperatives emphasize the need of honouring and respecting the other cooperativistas as well as the crucial necessity of active participation of everyone. All the members of COVISEP and COVIVIR have the same rights and obligations and in decision-making all members have one vote (COVISEP By-laws 2012); (By-laws COVIVIR 2012). Furthermore, the by-laws of

COVIVIR points out the importance of being unattached from politics, religion and ethnicity (By-laws COVIVIR 2012).

Each cooperative is managed by a general assembly which is divided into three committees; committee of education, committee of provision and social assistance and the committee of construction. The latter one is divided into two sub-committees; one for values, purchases and storage and the other for mutual help. The first sub-committee performs all the work associated with purchasing and management of the capital and services that the construction site needs. The other sub-committee organises, executes and controls the support that the cooperativistas and their families give the masons (PROCASHA, 2003).

During the construction phase the cooperativistas have three roles since they are owners of the cooperative, administrators of the construction company and are masons of the construction site, all at the same time. This has sometimes complicated things socially between the cooperativistas, PROCASHA and the masons (Arnan, 2012). However, the fact that the cooperativistas help with the construction has economic benefits and the price is calculated to be 20% less than if the houses were totally constructed by an enterprise. Furthermore, neither the cooperativistas nor PRCASHA aim at luxury but at using their resources in the best way to optimise time, cost and quality in the construction process (PROCASHA, 2003).

#### 4.1.2 PROCASHA

The foundation PROCASHA was founded in 2001 (Landaeta, 2012) with support from SCC. They aim at spreading a housing model of cooperatively living and mutual aid to help low income families in Bolivia (PROCASHA, 2003). Their vision is to improve the life quality of the poor in Bolivia through housing projects and development of public policies (Landaeta, 2012). PROCASHA was initially born in a group of architects who replicated a model from Uruguay (Arnan, 2012) and they are now trying to spread the model by influencing municipal representatives and inspire the current cooperativistas to promote this way of living (Flores, 2012).

SCC is the main funder of PROCASHA and has been so since 2002. During the 10 years PROCASHA has existed, only two cooperatives have been built, but three more are now in their initial stages. A reason for the slow process is that the Bolivian government do not support this kind of housing cooperative (Landaeta, 2012). In Uruguay the model is supported by loans with relatively low interest rates. According to the informants, this is the reason to why this way of living has grown rapidly as a housing alternative there. Therefore, PROCASHA works hard to make their government include housing cooperatives in the housing policies of Cochabamba (Santos, 2012; Arnan, 2012).

Cooperatives and cooperatively owned property also existed in the indigenous cultures of Bolivia and PROCASHA tries to build on these values and on the old tradition of "El Huarake". This means collaboration in the construction as well as provision of the needed material, a process that makes the people feel more as if they are the origin of the house. Furthermore, old tribes shared water, land and forest and this way of living and thinking are still being expressed in the work forms seen in Bolivia today (PROCASHA, 2003).

#### 4.1.3 The funders

There have been two foundations funding PROCASHA and the cooperativistas; Habitat for Humanity (HFH) and the Swedish Cooperative Centre (SCC). Below, they are presented in further detail.

#### Swedish Cooperative Centre

The Swedish Cooperation Centre (SCC) was founded in 1958 and supports its operations by donations, in particular from SIDA, but also from around 60 other Swedish organizations. SCC aims at giving poor people the tools they need to help themselves out of poverty through study circles, micro financing and cooperative collaboration (Swedish Cooperative Center, 2012). They would like to increase the power and the influence that these people have over their own lives to promote equality and thereby create possibilities for them. The values of SCC are the same as those for the International Co-Operative Alliance that are the following; self-help, personal responsibility, democracy, equality, fairness and solidarity (Swedish Cooperative Center, 2012). Furthermore, these values are the same as those PROCASHA and the cooperatives lay their foundation on.

PROCASHA and SCC have worked together since the start of PROCASHA in 2002 and they have an on-going collaboration until next year. SCC always works in this way, with an external supporting partner, such as PROCASHA. Hence, SCC is not involved in any technical or economic advisory of the cooperatives, since this is fully taken care of by PROCASHA (Arébalo, 2012). Although SCC has no expertise or demands on the water and sanitation systems of the cooperatives they are an important stakeholder. The reason for this is that they finance PROCASHA and they have been giving the cooperativistas some of the loans they need to realize the construction of the houses.

SCC will evaluate PROCASHA and the collaboration between them in the end of 2012. In the evaluation of PROCASHA three main aspects will be looked at; that the houses are properly constructed and if they have sufficient technical knowledge, if they work in a way that empowers the people and give them enough education in relevant areas, and finally if they work in a way that can promote cooperatives to be a big movement and spread in the city (Arébalo, 2012).

#### Habitat for Humanity

Habitat for Humanity (HFH) was founded in 1985 in Bolivia and they are a non-governmental international organization. Today there are 5 affiliates in Bolivia with 5 employees in each. The national office is situated in Cochabamba where about 15 people work. The purpose of the non-governmental organization HFH is to lend money to people with small incomes that want to build a house or renovate their current house who get rejected by normal banks. In the end of 2012 they expect to have built 11 000 houses since the start (Numbela, 2012). At the moment there are mainly local businesses in Bolivia who donate money to them as well as some from the USA and Canada. They are not a micro financing institute hence the donors do not get their money back.

The fact that HFH lend money and not give them away is seen as a motivational factor and is also a precondition for the continuation of their work, as they lend out the money they get back to other families. They have recently started to change their vision a bit and are now trying to promote construction of communities instead of single houses to be able to help more people (Numbela, 2012). In this aspiration, COVISEP were their first experience. Normally HFH provide all support functions needed to design and construct a house but in the case of COVISEP, PROCASHA did this. Today HFH give loans for everything that is related to houses. Hence, water and sanitation systems are not their particular aim but they are an important stakeholder for the cooperatives since they enable the construction of the houses. HFH do not give loans to constructions which are bigger than 60 m<sup>2</sup> and therefore they did only give funds for the first floor at COVISEP.

HFH always gives the loans in the form of construction material and not in cash and they include accounting and technical advice, a mason and a supporting architect in the loan (Numbela, 2012). They work after the principals of self-construction which means that the families have to be involved in the process as an assistant and inspector of the mason.

To get a loan from HFH a family should have an income between 1-4 minimum wages (between USD 140 and 560), the family has to own the land on which they want to construct or cover its cost within the USD 6 400 which is the maximum amount they lend out (Numbela, 2012). The smallest amount they lend is USD 700. Furthermore, the loan taker cannot be older than 70 years and HFH require construction of liveable houses hence they e.g. need to have water and bathrooms. Before giving a loan a social worker at HFH evaluates their income and their living standard. In accordance with their criteria they do not aim at helping the poorest people of the society.

The loans are to be paid back in 10-12 years, the interest rate is 8% and the families normally pay back around USD 40-80 USD per month (Numbela, 2012). This rate covers the social worker, education, the architect and administration to some extent as well as the salaries to the employees of HFH. Furthermore, it covers the losses when people are not able to pay back their loans.

#### 4.1.4 The municipalities

COVISEP is located in the municipality Quillacollo in the canton El Paso (Municipality of Quillacollo, 2010) and COVIVIR is in the municipality Sipe Sipe in the canton with the same name (Municipality of Sipe Sipe, 2006-2010). The location of these municipalities is shown in Figure 3. Quillacollo has given the responsibility for water and sanitation to an enterprise called EMAPAQ (Rodriguez, 2012) and Sipe Sipe do not have a municipal system (Efraim, 2012), hence water is provided by self-organized organisations (Huanca, 2012). In this section the water provision systems and the municipalities will be shortly explained.

The composition of sediments in the basin of the Central Valley of Cochabamba differs and the sediment layer varies from 100 m in the southeast to more than 1450 m in the north (Palm, 2010). Hence, aquifers show very different properties within small distances from each other because the sediment layers also vary both horizontally and vertically. The northern parts of the valley consist of coarse materials like blocks and gravel mixed with sand and clayey sand. but the sediment layer turns finer in the south. Here, sandy mud, clayey mud and gravely mud dominates (Palm, 2010). The cooperative COVIVIR is located in the south-western corner of the valley.



Figure 3 To the left: the Department of Cochabamba and the locations of El Paso and Sipe Sipe are highlighted. To the upper right: the location of El Paso and Sipe Sipe in the Department of Cochabamba. To the lower right: the location of the Department of Cochabamba in Bolivia.

#### Quillacollo

Quillacollo is located about 10 km from the centre of Cochabamba and had a population of 104 206 in 2001 (Municipality of Quillacollo, 2010). The area of the municipality is 596 km2 and it is situated 2 460 m.a.s.l. It only has one canton, El Paso, in which COVISEP is located. In the zone the annual average precipitation is 337.2 mm and it mainly rains from November to March.

To some extent the inhabitants of Quillacollo get their water from the municipal provider EMAPAQ, but their coverage is less than 30 % of the inhabitants. There are also over 200 privately owned water systems, which cover 38 % of the citizens. The remaining part of the population does not have a proper water system and therefore buy water from e.g. cisterns and/or trucks. The system of EMAPAQ consists of 9 wells, which are connected to a distribution system and no treatment is carried out by EMAPAQ. In the close future EMAPAQ do not plan on increasing their coverage, since they do not have the required funds. Furthermore, the low water availability and the water quality are other big problems in Quillacollo. Currently, it costs USD 40 to connect to EMAPAQ and all households pay the same independent of water consumption and income (Rodriguez, 2012).

The current sewage system does only cover 40 % of the inhabitants and it is hard to extend this, due to high costs. The cost for sanitation is about twice the cost as for a water distribution system. Currently, there is no wastewater treatment plant in Quillacollo and all the residuals therefore go to the river. EMAPAQ would like to build a plant and one was planned to be built in 2008. However, the project got blown off since the inhabitants of Quillacollo did not want to build one, due to fear of smell and risk of spreading of diseases (Rodriguez, 2012).
### Sipe Sipe

Sipe Sipe is located about 25 km from the centre of Cochabamba (Municipality of Sipe Sipe, 2006-2010), on 2450 m.a.s.l. It had a population of 31 337 in 2001, from which 65% lived in the rural area and 35% in the urban area. The surface of the municipality is 472.1 km2 and the population density is 66.37 per km2. Sipe Sipe is divided into three cantons; Sipe Sipe, Mallco Rancho and Itapuya. COVIVIR is located in Sipe Sipe. The municipality has a large area of soils that are very suitable for different crops and agriculture is therefore the main occupation. This has made Sipe Sipe to one of the richest valleys in Cochabamba.

In contrast to Quillacollo there is no official enterprise which provides water and instead this is often organised by water comities within the OTBs. In 2006 there were 65 OTBs in the municipality (Municipality of Sipe Sipe, 2006-2010) but today there are around 73 OTBs (Efraim, 2012). The access to water sources is rich in Sipe Sipe and the annual average rainfall is 654.05 mm (Municipality of Sipe Sipe, 2006-2010), which mainly fall in the rain period between October and March. Groundwater is the primary source of drinking water (Palm, 2010), but surface water sources are also used. However, surface water is mainly used for irrigation purposes and this water is taken from rivers and from other natural water sources. In the canton of Sipe Sipe, 77% of the inhabitants have access to a river, 59% to other natural water sources and 41% to a well (Municipality of Sipe Sipe, 2006-2010).

The water committee, from which COVIVIR gets its water, has between 170 and 180 members at the moment (Efraim, 2012). However, only about 130 of them are using the water the committee is providing because they live in other places and just own land in Sipe Sipe. The committee has two wells, one that is 110 m deep and the other one is 120 m, but only the shallower one has pipes connected to it at the moment. They have constructed the other well to have more water and also to be able to make a backup tank if something does not work with the first one. All of the users have access to water 24 hours per day. The region has water, but if they dig too deep there is no water to access and the experienced pressure has decreased over the years because more people are using water in the area (Efraim, 2012).

# 4.2 **The housing cooperatives**

Today there are only two housing cooperatives in Cochabamba, COVISEP and COVIVIR, which have been constructed based on the three pillars of mutual aid, collective property and self-maintenance (Santos, 2012); (Arnan, 2012). Currently, the Bolivian legislation includes cooperatives regarding basic services, such as water and sanitation, but it does not include housing cooperatives (Santos, 2012). This creates problems when starting housing cooperatives, since it is a very bureaucratic process and hence is costly for the residents (Landaeta, 2012). Inclusion of housing cooperatives in the Bolivian housing policies would probably make it easier to start housing cooperatives (Arnan, 2012).

The first step of the creation process of a housing cooperative in Bolivia is to make the group of people legal by getting their by-laws approved. Thereafter they have to find and buy a suitable piece of land. When it comes to water and sanitation systems there are not many regulations that the cooperatives have to follow from the municipalities. The only thing that they are required to do is an "environmental chart", which includes a map over the houses and the systems, but overall the

current environmental legislation is not implemented in a strict manner in Cochabamba (Santos, 2012).

The cooperatives provide a better way of living with a higher quality of life for its residents (Landaeta, 2012). Before, many of the residents did not have their own houses and were restricted in basic services. The cooperatives offer a solution that changes this, especially when it comes to water and sanitation (Arnan, 2012). However, water and sanitation is not the main driver behind the creation and development of housing cooperatives, the lack of adequate housing, which includes water and sanitation, rather is (Landaeta, 2012).

### **COVISEP**

COVISEP was the first cooperative that was constructed with the help of PROCASHA. The planning process was initiated in 2002 with meetings, gathering of necessary documents and the search for financing and land (Arnan, 2012). They started the building process in 2009 and they moved into their finished houses in September of 2011. During the construction time, there were periods when they did not build because the cooperative was out of money (Fernandez, 2012).

### **COVIVIR**

In 2004, 150 families contacted PROCASHA and started to have planning meetings in collaboration with them. In 2006 they became a legal cooperative and in 2010, 12 families started the construction of the cooperative COVIVIR. They plan to move into the first floor in the end of 2012 (Arnan, 2012). There were three main reasons for why so many families dropped out. Firstly, the land they finally bought in Sipe Sipe was considered to be too far away from the centre of Cochabamba. Secondly, some had too little money and could not comply with the mandatory requirement of constructing for 8 hours 3 times per week. Finally, some did not agree on the precondition of owning the property cooperatively. However, the land is big enough for 26 families to build on and the present cooperativistas of COVIVIR will soon start the process of letting other families apply to join them (Arnan, 2012); (Arnan, 2012); (Escalera, 2012).

## 4.2.1 The water and sanitation systems

The water and sanitation systems are considered as two separate systems when designed and implemented in the cooperatives, but they are equally important for the construction as a whole (Huanca, 2012). In the cooperatives a water system is defined as provision of drinking water and the water that is used for drinking, showers, washing of clothes etc. However, no analyses of the water quality have been carried out and the residents are therefore recommended to boil the water before drinking it. The sanitation system is considered to begin after usage of the water and include residuals from toilets and wastewater from the kitchen and bathroom. At the moment both cooperatives have water supply systems, but only COVISEP has an implemented sanitation system (Huanca, 2012).

The technical team of PROCASHA investigated different water and sanitation systems that they presented for the cooperativistas. PROCASHA considered environment and health aspects, but the final decision of what system to implement is taken by the cooperativistas (Soto, 2012). Palm (2010) suggests that COVIVIR should construct their own well, install dry toilets and a septic tank followed by preferably a constructed wetland or a sufficiently large leach field (Palm, 2010). PROCASHA considered the proposals as very good, but these solutions would be much more expensive than those that actually were implemented. However, the proposed treatment method for the

wastewater and the residuals would have had been better for the environment (Flores, 2012).

PROCASHA proposed the installation of dry toilets in both COVISEP and COVIVIR, but COVISEP did not accept it and COVIVIR are sceptical. COVISEP wanted conventional water toilets; although this was a more expensive solution. This is probably going to be the case at COVIVIR as well (Huanca, 2012); (Flores, 2012).

### The implemented systems

Both the cooperatives chose to buy a connection to the wells of the OTB that they belong to and pay an operation cost every month. The other option they had would have been to build their own well. For the usage of the groundwater, they would not have had to pay anything as long as the well was situated within the borders of their land. However, this solution was not selected, due to the high cost of USD 60 000 (Huanca, 2012), as well as the longer implementation time (Fernandez, 2012).

In COVISEP every house has a grease trap just outside, but they are not installed at the moment and it is not known how well they are going to work (Huanca, 2012). The waste water and residuals are led in pipes to a septic tank, on its way it passes various chambers that are possible to open in order to enable cleaning and maintenance. The septic tank functions as a sedimentation tank and hence the solids are separated from the fluids by gravity. The fluids thereafter continue to a seepage pit, which is a basic solution that can be described as a whole in the ground with filling. It is normally filled with for example rocks, gravels, sand, silt and clay, which the water is allowed to filter through. It takes much less space and is cheaper to construct than constructed wetlands but in many cases the small area does not provide enough treatment (Palm, 2010). Therefore, it should not be placed closer than 50 meters to a drinking water well. In the septic tank the solids are treated anaerobically which decreases its volume. The tank in COVISEP has to be emptied around twice a year and each time it costs around USD 170, due to the long transportation distance. The sludge is to be brought to SEMAPA's treatment plant but if this really will be the case or if it will be dumped somewhere else is uncertain (Huanca, 2012).

The sanitation system at COVIVIR is planned to be of the same type as that in COVISEP. At the moment it only consists of pipes from the community house to a septic tank. However, it is not absolutely determined that they will build a seepage pit since it is dependent on the permeability of the ground, which is not known at the moment. If the earth profile would not provide sufficient treatment for constructing a seepage pit the other option would be to install a filter after the septic tank. If a filter is installed it has to be rinsed and cleaned on a regular basis. In COVISEP they did not do a particular study of the earth profile, but they saw that the earth was permeable when digging and installing the pipes and this is the executive strategy in COVIVIR as well (Huanca, 2012).

### 4.2.2 Financing

The loans that the cooperatives take are a precondition for being able to build the houses, since these families do not have the required funds without them (Flores, 2012; Escalera, 2012). PROCASHA is working on trying to get more support from the government to decrease the dependence of external credit institutions and to make it possible for more people to live in housing cooperatives. At the moment the government is not supporting this movement in any way (Landaeta, 2012); (Arnan, 2012).

The loan is given to the cooperatives and the cooperatives themselves give them to each family and the costs for the loans as well as for operating cost are split equally between everyone. If one family does not pay their cost one month, the other families put pressure on them. However, the other families always consider why a family has not paid and if it is due to for example illness in the family they try to find a solution together (Flores, 2012). See Table 4 for more information regarding the loans.

## **COVISEP**

Each family in COVISEP got USD 6500 from HFH and from SCC each family got USD 500 to buy the land, USD 1 000 to finish the first phase of the construction and USD 1 200 to install water and sanitation systems. The cooperativistas have 6 years to pay back the loans from HFH with an interest rate of 9 % and 12 years to pay back the loans from SCC without interest rate (Flores, 2012).

### **COVIVIR**

COVIVIR has at the moment only taken loans from SCC. One loan was USD 1 154 per family to finance the land for 26 houses and one on USD 5 750 per family to finance the first phase of the construction of the 12 first houses. They have 2 years to pay back the loan for the land with an interest rate of 0% and to pay back the other loan for the first phase they have 20 years with 2% interest rate. At the moment COVIVIR has no money to build the sewage system for but HFH is likely to give them a loan of the rest of the money they need (Flores, 2012).

	COVISEP (30 houses)	COVIVIR (12 houses)
Loan to construct the houses	Habitat for HumanityUSD 6500/familySwedish Cooperative CentreLand USD 500/family1 <sup>ST</sup> construction phase USD1000/family	Swedish Cooperative Centre Land USD 1 154/family (26 houses) 1 <sup>st</sup> construction phase USD 5 750/family (12 houses)
Loan to water systems	Swedish Cooperative Centre Installation of water USD 400/family	Habitat for Humanity Installation of water USD 650/family
Loan to sanitation systems	Swedish Cooperative Centre Installation of sewerage USD 800/family	Have not implemented a sanitation system
Pay-back period	Habitat for Humanity 6 years Swedish Cooperative Centre 12 years	Swedish Cooperative Centre Land 2years 1 <sup>st</sup> construction phase 20 years
Interest rates	Habitat for Humanity 9 % Swedish Cooperative Centre 0%	Habitat for Humanity9 %Swedish Cooperative CentreLand 0%1 <sup>st</sup> construction phase 2 %

#### Table 4 Summary of the loans taken by the cooperatives.

### 3.3.4 The costs of the water and sanitation systems

To get water COVISEP bought 30 accesses from their OTB. The price is USD 0.29 for 1 m<sup>3</sup> and they all pay according to their water meters (Fernandez, 2012). The total cost of the water system was USD 400 per family and for the sanitation system USD 800 per family (Flores, 2012).

COVIVIR has also joined the local water committee of the OTB that they belong to. For this they paid a connection fee of USD 650 per family (Flores, 2012) and a water price of USD 0.43 per m<sup>3</sup> (Escalera, 2012). The sanitation system has not been constructed yet but is approximated to cost USD 570 per family (Soto, 2012).

# 5 Methodology

Interviews with the stakeholders and local experts from the University of San Simon, group discussions and input presentations with the main stakeholder groups, as well as a prioritization of the key issues were carried out to gather the needed empirical knowledge. This chapter describes the process of choosing the research question (5.1.) and the research method (5.2), how the research material was prepared (5.3), how the data was collected (5.4.) and how the data were analysed (5.5.). The information from the data collection was used for analysis but also to the Case Study description (Chapter 3). A complete list of everyone that was interviewed can be found in Appendix 1.

# 5.1 **Choice of the purpose of the research**

If the research is classified according to its purpose, the study can be described as exploratory, descriptive, analytical or predictive. In an exploratory study, the research is more about looking for patterns, ideas or hypothesis, than actually testing and confirming a hypothesis. It is a suitable approach in order to find research designs for an upcoming study and narrowing down a problem that will be further investigated later on (Palgrave Macmillian, 2008). An exploratory approach was therefore chosen in this case, since this thesis makes up the foundation of a PhD-project, which will decide direction according to the findings of this project. This is the overall purpose, if the thesis is put in its context. In itself, this report aims at defining sustainability for small scale water and sanitation systems of housing cooperatives in Cochabamba, as well as developing an evaluation framework.

# 5.2 **Choice of the research method**

A qualitative approach was used to gather the empirical information that was needed to achieve the purpose of this thesis. The main reason for this was that this kind of approach does not aim at obtaining statistical relevance (Malterud, 1998), in contrast to a quantitative approach that includes a large number of people (Riesenhuber, 2006). However, this was neither possible nor needed in this case.

Qualitative interviews with the identified stakeholders and local experts were suitable to learn about their views regarding water and sanitation systems. The qualitative approach enables gathering of in-depth information and the possibility of analysing the gathered information afterwards. Through asking *Why* and *How* questions, a qualitative approach can give knowledge about behaviours and reasons for certain actions (Riesenhuber, 2006). This was the goal of the interviews, through which the informants' opinions about water and sanitation were identified. Furthermore, group discussions were held with the cooperativistas at COVIVR and COVISEP, since not all of them were interviewed and to create an environment that could generate other responses than the ones that are given in a one-to-one interview. Esaiasson et al. (2012) emphasize the importance of giving the opportunity to everyone to give input and share their thoughts. Furthermore, discussions enable concretization of thoughts and opinions in another way relative to one-to-one interviews (Esaiasson, et al., 2012).

Many scholars, such as Wallis (2006) and Mascarenhas et al. (2010), verify their findings through for example input presentations with the stakeholders, to make sure that no important aspects have been left out. Hence, two input presentatios were performed in this research as well, with PROCASHA and the researchers at the Centre of Planning and Management (CEPLAG) at the University of San Simon. In these, the participants were asked to discuss their opinions after having

seen the results of the research so far. Additionally, to know if the identified key issues were important to the stakeholders, a prioritization of them was carried out. This was performed by COVISEP and COVIVIR, as well as with PROCASHA. In this case, a more quantitative approach was chosen because clear patterns were desired, which is preferable when patterns are supposed to be identified, according to Esaiasson et al. (2012). Therefore, a questionnaire, which enabled the participants to give each key issue a score, was prepared.

The search for theory was divided into five main topics; social, socio-political, economic, environmental and technical aspects of small scale water and sanitation systems in Cochabamba. These were chosen, due to being very frequently occurring during the interviews, as well as their coherence with the UN's definition of sustainable development. The literature study was carried out in order to increase the understanding regarding the investigated field and to identify suitable indicators.

# 5.3 Research material

Interview questions and discussion material majorly affect the outcome of interviews and group discussions. Details regarding this, in relation to this thesis are presented below, as well as information about the preparation of the input presentations and the questionnaires.

## 5.3.1 Interview questions

Descriptive answers are necessary to perform a qualitative analysis. Questions that open up for explaining are therefore to prefer. Furthermore, it is good to register unexpected answers, which should be followed up if it is possible. The purpose is not to obtain figures and percentages, rather to visualize how things are instead of looking for a frequency. It is a challenge to allow an open dialogue at the same time as the topics that are discussed should be relevant. This type of interview approach, works better when the researchers have limited knowledge or want to understand how people experience and feel about different phenomena (Esaiasson, et al., 2012).

The interview questions that were used in this thesis work were carefully thought through, in order to give answers, which could lay the foundation for a scientific analysis. Questions opening up for explaining answers, were prepared. During the interviews, these questions were complemented with more detailed questions to gain more explicit information. The questions for the group discussions were designed in a similar way and the aim was to create a discussion within the group. In accordance with Esaiasson et al (2012), the interviews and group discussion started off with easy questions about their work and involvement in small scale water and sanitation systems, followed by more precise questions about their opinions or views regarding certain areas or about their knowledge in their area of expertise. The questions focused on social, environmental and economic aspects.

## 5.3.2 Group discussions

Through a focus group, it is revealed how the group collectively think regarding a specific topic or phenomena. In the ideal case, the group dynamic should enable the participants to reflect on each other's input (Esaiasson, et al., 2012). It is important that the participants realize that there is no right and wrong, and to create an atmosphere that is not judging. Additionally, it is important to consider the power struggles and the social hierarchy that develop within a group, especially if the focus group consists of people that know each other from beforehand.

In this research group discussions were used to understand how the residents value water and sanitation, as well as their opinions in the matter. Questions where prepared beforehand, but since no preparation was required for the cooperativistas the questions where not distributed before the group discussion. The aim was to generate a discussion between the participants, where they reflected and responded on each other's input. This was done by designing open questions and by clearly pointing out that no right or wrong answers existed. The themes were introduced in an open way. It was also kept in mind that the participants can be unwillingly so share sensitive information in between each other. Therefore the discussion leader for each work shop tried to create an atmosphere where all the participants could actively participate.

### 5.3.3 Input presentations

Presentations about the progress of the development of the key issues were held to make sure no important aspects were forgotten or had been left out. The presentations included the work so far and a draft of the key issues, as well as important sub topics and clarifications what was included. Afterwards, each key issue where discussed and input considered.

### 5.3.4 Questionnaire design

The questionnaire in this report refers to the ranking exercise that was performed. It consisted of a big board, cards with the key issues and a description sheet. The board included a grid and a scale from one to ten written on the short side, where 10 represented very important and 1 not important. The cards represented all the key issues and included a short description of the key issues. There were as many cards as key issues. The description sheet consisted of a short summary of all the key issues. This was handed out to give all the participants as similar information about the definitions of the key issues as possible. The stakeholders where then asked to place the cards on the board, on the location that best represented their opinion on the importance of the key issue. Hence, this questionnaire only made it possible to obtain quantitative information, which was desired to ascertain a pattern.

## 5.4 **Data Collection**

It is important that the informants together compose a diverse group of people, which include people of both genders, different ages and backgrounds (Esaiasson, et al., 2012). In general, the sample group in this research aimed to be as diverse as possible, so that the collected data is complete and suitable for analysis. Different tools for data collection were used, which also contribute to a more diversified set of data. The methods that are used are described below and are the following; interviews, group discussions, input presentations and questionnaires.

## 5.4.1 Interviews

The snowball technique is a method that helps to select what informants to include in a study. It implies that the informants get the opportunity to point out other people that they consider as being of use for the project. The informants complement each other and together they create data that is complete (Esaiasson, et al., 2012). This approach was used in this thesis, since the researchers had limited knowledge regarding what stakeholders and experts that existed in Cochabamba. The informants were able to name people that could provide complementary information. The cooperatives and PROCASHA were the only informants that were given from the beginning. These groups pointed at other parties that were of interest for the research. The following people, which made up a diverse group, were suggested and chosen for interviews; the office of urban planning; an

economist, an architect and an engineer at the University of San Simon; the water company EMAPAQ in Quillacollo and the president of the water committee that COVIVIR is connected to in Sipe Sipe.

All interviews laid the foundation for the analysis, except for two interviews that were executed with the director of the urban planning office and the architect of University of San Simon. These interviews were used as an information source about indicators, their development and application. In total, 10 experts, 4 external stakeholders, 2 experts on indicators and the cooperatives were interviewed (Table 5). For a complete list please, see Appendix 1.

Table 5 A summary of the number of people that were interviewed.

Experts	External stakeholders	Experts on indicators	Cooperativistas
4	10	2	2

### 5.4.2 Group discussions

The group discussions were carried out with the two cooperatives. In COVISEP two discussions are performed, one with the cooperativistas and one with the children. Both water and sanitation were discussed in both groups. At COVIVIR two group discussions were executed as well. The twelve cooperativistas were divided into two groups; one of them discussed water and the other one sanitation.

## 5.4.3 Input presentations

The input presentations where held with PROCASHA and the department CEPLAG at the university of San Simon. PROCASHA was chosen because they have a lot of valuable information about the cooperatives, as well as competence in the area of small scale water and sanitation. At CEPLAG, a team of researchers work within the field of water and sanitation, which made them to a suitable expert group that could have valuable input. They were likely to know what aspects that is important to consider, as well as give information on what kind of aspects they include in their own work within this field.

## 5.4.4 Questionnaire

The questionnaires are used for verification of the key issues. The main stakeholders, the cooperativistas and PROCASHA, were therefore chosen for performance of this. They are closest to the systems. The other stakeholders where not selected, since they do not possess specific knowledge about the water and sanitation systems of the housing cooperatives.

# 5.5 Analysis of the data

The analysis procedure is outlined below. The empiric data from the interviews and the group discussions are used for theme identification, which are later on verified through the input presentations and the questionnaire. The key issues are later on said to build up the contextualized sustainability definition, which is complemented with indicators that can be used as an evaluation tool.

## 5.5.1 Identification of themes

The key issues were developed by selecting relevant data from the interviews. This data was then analysed to identify the themes that were brought up. This is a common way of analysing qualitative data. A theme can be found by e.g. asking the question: What is this expression an example of? In

general, there are many different methods and approaches that are used in qualitative research. A combination of them is often used. In this thesis the cutting and sorting technique is used for analysis of the data, since many other methods are dependent on that the interviews are transcribed. Furthermore, it is suitable when the researcher is not a native speaker of the spoken language (Ryan & Russell Bernard, 2003). Spanish is not the researchers' mother tongue, so a translator who summarised the answers of each question was used. No word-for-word translation was applied. Due to this, the informants have not been quoted, but only referred to in the analysis.

The cutting and sorting technique has been outlined by Ryan and Bernard (2003). It implies sorting of relevant quotes and expressions into piles, which represent the different themes or categories that can be found in the data that is selected as relevant. In the initial phase of the analysis it is common to identify a wider range of themes, which later on is narrowed down or weighted. The themes in this report, here referred to as key issues, were developed in accordance with this method by identifying expressions from the interviews that seemed important. The importance was decided upon by looking for repetition, usage of metaphors or analogies. Only expressions from open-end questions were selected for further analysis. Information that considered basic facts about the cooperatives were not included in the analysis but was used for the case study description. The selected expressions were then arranged into piles of expressions, which indicated on the same theme. This was initially done by writing down all important key words from the expressions on individual papers and thereafter sorting them into small piles, which represented the key issues. All the piles were then sorted into different sub-themes, which here are called sub-topics. The analysis was then continued by counting how many cooperativistas, other stakeholders and experts that had been talking about each sub-topic during the interviews and group discussions. Each person was only counted for once per sub-topic, even if the sub topic had been mentioned many times during the interview, since that enabled calculation of the percentages. The interviews were not transcribed and information may therefore be lost. Hence, to count every time someone expressed themselves about a certain sub-topic would have not been accurate.

It is often fruitful that many different people sort the relevant information, since that will generate a longer list of potential themes (Ryan & Russell Bernard, 2003). However, in this report, only the researchers have sorted the data, mainly because field notes have been used and they are more easily understood by the investigators.

### 5.5.2 Verification of themes

The verification of the key issues was done in two ways, by input presentations and weighting of the key issues, which is here referred to as a questionnaire. These kinds of approaches have also been used by Wallis (2006) and Mascarenhas (2010), but with a larger number of workshops and presentations. These authors also used written material that was filled out by the stakeholders to gather data, input and verification of the indicators. In this study verification of the identified key issues were done in a similar way by letting the cooperativistas and PROCASHA weighting them, but no written material was used to gather data or input.

### 5.5.3 Selection of indicators

The indicators were mainly defined by literature studies, since a lot of research has been carried out within this area. Handbooks about water and sanitation projects, written by well-known organisations such as UNICEF, the Water and Sanitation Program (WSP), the World Bank, the Network for the development of Sustainable Approaches for large scale implementation of Sanitation in Africa (NETSSAF) and USAID, were primarily used to find suitable indicators for each sub topic. Additional scientific literature from scientific databases was also used..

# 6 Results

In this chapter the definition of sustainable development for small scale water and sanitation systems is outlined. It is applicable in the context of the performed case study (6.1). Furthermore, associated indicators that can be used to assess the progress towards the contextualized definition are presented (6.2). The final chapter (6.3) shows how the cooperativistas and PROCASHA valued the importance of the identified key issues.

# 6.1 Sustainable development

The contextualized definition of sustainable development is built upon UN's definition of sustainable development. The three pillars are in turn dependent on eleven themes that are called key issues, which need to be considered if a system is to contribute to sustainable development in the long run in the context of the case study. Each key issue consists of sub-topics. The different key issues are not categorized according to the three pillars of sustainability, since they are seen as dependent of each other. The results from the analysis are shown in Figure 4.



Figure 4 Visualisation of the definition of sustainable development.

The eleven key issues are presented below together with the comments that have been made about them during the interviews. For each key issue, a related table showing how many supporting expressions that were made is presented. These results are shown in percentages and divided between cooperativistas, external stakeholders (everyone but the cooperativistas) and experts. The percentage represents how many stakeholders and experts in the interviews and the group discussions that brought up the certain sub-topic. In total each sub-topic can get 4 votes from the cooperativistas, 10 from the external stakeholders and 4 from the experts.

### Social context

The social context is absolutely crucial to consider when planning, implementing and running a water and sanitation system in order to be used and function well in the long-run (Rodriguez, 2012); (Mercado, 2012). The service that is provided should be sufficient for the population size and not create disunion and conflicts (Mercado, 2012); (Soto, 2012). This key issue includes the sub-topics demographic characteristics and social respect. The supporting expressions that support each sub-topic are presented in Table 6.

Maria-Ester Soto emphasizes that the capacity of a water and sanitation system must be sufficient in order to function satisfactory. This implies the importance of considering how many households there are in a specific area, as well as the average number of people in each household (Soto, 2012). Furthermore, the population growth should be considered. In Cochabamba the population growth has contributed to deficient coverage of water and sanitation (Selaya, 2012); (Ledo, 2012).

In this report social respect refers to consideration of cultural norms and traditions, which are the major factors that determine whether a community will accept a certain water and sanitation solution or not (Rodriguez, 2012); (Soto, 2012). Perceptions are very difficult to change and dry toilets are mentioned as an example of this (Landaeta, 2012). The technical team proposed these for COVIVIR and COVISEP, but none of the cooperatives wanted to implement them. It is further argued that Cochabamba does not have any experience of dry toilets and that traditions and norms contribute to unwillingness to implement this solution (Huanca, 2012); (Arnan, 2012). Additionally, it is absolutely crucial that a water and sanitation solution is not seen as a solution for poor people (Landaeta, 2012). An important aspect to keep in mind in relation to social respect is that the cultural background of the population may differ. The inhabitants of Cochabamba have migrated from many different parts of Bolivia, which has led to a very diverse city. The population has very different backgrounds and cultures. This can affect the collaboration around water and sanitation within the neighbourhoods and lead to conflicts (Soto, 2012); (Mercado, 2012); (Ledo, 2012).

Key Issue	Sub-topic	Supporting expres	sions	
		Cooperativistas	External stakeholders	Experts
Social	Demographic characteristics	0%	20%	75%
context	Social respect	25%	60%	50%

#### Table 6 The identified sub-topics for the key issue Social context.

## Socio-political factors

The intense lobbying of the cooperative model that PROCASHA performs (Arnan, 2012); (Landaeta, 2012), indicates that political cohesion is important. The following sub-topics build up this key issue; legislation, political structure of water organizations and municipal support (Table 7).

It is absolutely crucial to comply with the legislation (Arnan, 2012); (COVIVIR, 2012); (Santos, 2012). Legislation can offer support and PROCASHA requires that the cooperatives follow the regulations (Arnan, 2012); (Soto, 2012); (Flores, 2012); (Fernandez, 2012). Furthermore, it can be beneficial to consider future changes in the legislation that probably will occur (Santos, 2012). However, in general the legal enforcement is weak in Bolivia, since the government lack capacity (Santos, 2012); (Huanca, 2012); (Mercado, 2012); (Rodriguez, 2012). Most of the water and sanitation systems in Cochabamba do not live up to the requirements of the state (Mercado, 2012); (Huanca, 2012).

Furthermore, property rights are a problem (Santos, 2012). Many housing areas are informal, which makes it difficult to find suitable land to which you can acquire the property rights. As a consequence, many of the existing water and sanitation systems are informal (Santos, 2012); (Mercado, 2012); (Flores, 2012).

How small scale water systems are organized and structured affect the overall access to improved water sources (Landaeta, 2012). Currently, small scale water organizations have much power and they have a high influence on local politics. In Cochabamba, there are many people that organize small scale water systems, due to self-interest (Rodriguez, 2012). The cooperativistas of COVISEP felt that they were only socially accepted as neighbours after they had joined the local water committee (Landaeta, 2012).

During the interviews, the importance of increased financial support from the government and the municipalities has been emphasized (Villarroel, 2012); (Arnan, 2012); (Soto, 2012); (Landaeta, 2012). The role that the municipalities have in the provision of water and sanitation has been highlighted (Rodriguez, 2012); (Mercado, 2012); (Fernandez, 2012); (Escalera, 2012); (Ledo, 2012); (COVIVIR, 2012). Both the cooperatives want to be connected to the municipal sewage system (COVISEP, 2012); (COVIVIR, 2012). However, the municipality is not obliged to provide water (Santos, 2012). Victor Rodriguez, former director of EMAPAQ, partly agrees with the idea that the municipalities are responsible for water and sanitation. Especially he agrees that sanitation systems should be provided by the municipalities due to their high costs. However, this is difficult to realise. The municipalities have limited economic resources and it is argued that the inhabitants of Quillacollo are difficult to collaborate with (Rodriguez, 2012).

Key Issue	Sub-topic	Supporting expres	sions	
		Cooperativistas	External stakeholders	Experts
Social-	Legislation	50%	80%	25%
political factors	Political structure of water organizations	25%	20%	0%
	Municipal support	75%	40%	50%

#### Table 7 The identified sub-topics for the key issue Social-political factors.

### Target group

A suitable target group is important for a well-functioning water and sanitation system. Need and demand are the two sub-topics that are included in this key issue (Table 8). The need the target group has, as well as their demand of the solution, should be high.

PROCASHA aims to support poor people that do not own an adequate house and thereby contribute to an increased life quality of the cooperativistas and their families (Arnan, 2012); (Villarroel, 2012). Water and sanitation are really important issues in order to achieve this (Landaeta, 2012). The access to these services has improved for most of the cooperativistas in comparison to their previous situation (COVISEP, 2012); (COVIVIR, 2012); (Arnan, 2012).

A high demand for the cooperative model is necessary for it to function. During the planning phase of the cooperatives there has been a high dropout rate (Arnan, 2012); (Fernandez, 2012); (Escalera, 2012). The causes to this are unknown. However, it is argued that commitment is absolutely crucial. In the case of the cooperatives, the demand is highly affected by the requirements that PROCASHA

has on the cooperativistas (Arnan, 2012). For example, the cooperativistas have to have a stable income, since they have to be able to pay back the loans (Villarroel, 2012); (Arnan, 2012); (Numbela, 2012). PROCASHA and Habitat for Humanity also require that the cooperatives implement a sanitation system (Arnan, 2012); (Numbela, 2012).

Key Issue	Sub-topic	Supporting expressions			
		Cooperativistas	External stakeholders	Experts	
Target group	Need	50%	50%	0%	
	Demand	75%	30%	25%	

Table 8 The identified sub-topics for the key issue Target group.

### **Freshwater resources**

Freshwater resources are of course a requirement for water and sanitation solutions. Water availability and water use are the sub-topics of this key issue (Table 9). The long-term feasibility of a water and sanitation system depends on these factors.

Water availability is important to assess. Especially in the case of Cochabamba, since some parts are suffering from water scarcity (Mercado, 2012); (Selaya, 2012); (Efraim, 2012). PROCASHA has water availability as an important criterion for the search of land for the cooperatives. They have rejected land options, due to lack of sufficient amount of water (Arévalo, 2012).

The water use should not be too low, but neither too high. A system should provide sufficient amount of water. If a system provides too little water, it might lead to that the users utilize unsafe water sources (Mercado, 2012); (Rodriguez, 2012). However, at the same time a system should encourage water conservation. Alvaro Mercado points out that the wastewater production is dependent on water use (Mercado, 2012). Water reuse is a desirable feature of water and sanitation systems, according to PROCASHA (Landaeta, 2012).

### Table 9 The identified sub-topics for the key issue Freshwater resources.

Key Issue	Sub-topic	Supporting express	Supporting expressions			
		Cooperativistas	External stakeholders	Experts		
Freshwater	Water availability	0%	20%	75%		
resources	Water use	25%	40%	50%		

## Economic obstacles

The economic factors are said to be the most important aspect of a sustainable water and sanitation system during many of the interviews (Landaeta, 2012); (Flores, 2012); (Mercado, 2012); (Fernandez, 2012); (COVISEP, 2012); (COVIVIR, 2012). This key issue are divided in two sub-topics; affordability and willingness to pay, see Table 10. Bolivia is a poor country, so the affordability of water and sanitation system is crucial, as well as the willingness to pay. These two factors have to match each other in order to achieve a sustainable water and sanitation system.

Cost affects the feasibility of a water and sanitation solution, especially sanitation systems, since those are more expensive (Rodriguez, 2012). In Bolivia low-cost is a requirement for a water and sanitation system (Flores, 2012). It is common that the maintenance of water and sanitation systems is inadequate, due to lack of money. This implies the importance of looking at the cost during the whole life cycle of a system (Mercado, 2012). Income, as well as cost, affects the affordability,

especially since the cooperativistas have relative low incomes (Fernandez, 2012); (COVIVIR, 2012); (Flores, 2012); (Escalera, 2012). The implementation cost is especially perceived as important, according to the cooperativistas (COVISEP, 2012). Loans are a pre-condition for the implementation of adequate water and sanitation systems in this case (Fernandez, 2012); (COVIVIR, 2012); (Flores, 2012); (Escalera, 2012). The importance of considering the income levels in this kind of projects is further emphasized by the fact that the construction work of COVISEP and COVIVIR was delayed due to economic issues (Arnan, 2012); (Fernandez, 2012). The cooperativistas have had difficulties to fulfil their 3 workdays per week at the construction site, since they cannot afford to lose income at their ordinary workplace (Arnan, 2012); (Escalera, 2012). Furthermore, implementation time was discussed in relation to cost during the interviews (Landaeta, 2012).

The willingness to pay is very important for the implementation of water and sanitation systems. The cooperativistas consider it too expensive to connect to the local water committees (Fernandez, 2012); (Escalera, 2012). The construction of the sanitation system is perceived as very expensive, especially since most of the neighbours do not have a proper sanitation system (Villarroel, 2012); (COVISEP, 2012). In the interviews with Alvaro Mercado and Victor Rodriguez, it is argued that the Bolivian population are not used to pay for their basic services, especially not for sanitation services (Mercado, 2012); (Rodriguez, 2012).

Key Issue	Sub-topic	Supporting expressions			
		Cooperativistas	External stakeholders	Experts	
Economic	Affordability	100%	60%	75%	
obstacles	Willingness to pay	50%	20%	25%	

 Table 10 The identified sub-topics for the key issue Economic obstacles.

## Reproducibility

Reproducibility refers to the spread-effect of a project. It is a requirement for a project that aims to have an overall impact on the water and sanitation coverage. External support and collaboration are the two sub-topics that are included in this key issue, see Table 11. The sub-topic collaboration refers to collaboration between non-stakeholder groups and stakeholders.

SCC and PROCASHA argue that the aim of the cooperative model, which they have initiated in Bolivia, is to start a movement that will spread and be a part of the solution to the housing issues in Cochabamba and Bolivia (Landaeta, 2012); (Arébalo, 2012). The external support has been critical for the formation of the cooperatives (Villarroel, 2012); (Fernandez, 2012); (COVIVIR, 2012). The external parties must have adequate knowledge for performing the work that they are doing. They should offer professional high-qualitative support that empowers the target group, so that they can help themselves (Arébalo, 2012). The importance of soft skills is emphasized during the interviews, in order to achieve well-functioning collaboration between the target group and the other stakeholders (Arnan, 2012); (Landaeta, 2012). Furthermore, the financial capacity and the exit strategy of the external parties are discussed. The number of cooperatives that PROCASHA have the possibility to support is not known and no clear exit strategy is in place (Soto, 2012); (Arébalo, 2012).

The cooperatives need to become independent and be fully responsible for the operation and maintenance of the cooperatives, including the water and sanitation systems (Huanca, 2012). In the interviews, it has been argued that the whole process that COVISEP and COVIVIR undergo and still

experiences makes them that (Villarroel, 2012). The whole idea behind the cooperative movement is built on the concept of self-help. The idea is that the cooperativistas take loans and through them they are able to finance the construction of their homes (Landaeta, 2012); (Numbela, 2012). However, this is not completely true. PROCASHA subsidizes the process. The cooperativistas do not pay for the support from PROCASHA, neither for the professional construction workers (Arnan, 2012); (Soto, 2012). However, in the future PROCASHA plans that the cooperativistas will pay for the professional construction workers and partly the cost for PROCASHA (Arnan, 2012).

Collaboration empowers people and makes solutions possible. A group is able to do things that individuals cannot do on their own (Mercado, 2012); (Villarroel, 2012); (Flores, 2012). The cooperatives are an example of this since they would not be able to build the houses as individuals. This is also true for water and sanitation, collaboration makes the construction of an adequate water and sanitation system possible (Villarroel, 2012). The cooperativistas are positive towards the idea of building a sanitation system together with the neighbours (COVISEP, 2012); (COVIVIR, 2012).

Key Issue	Sub-topic	Supporting expres	ssions	
		Cooperativistas	External stakeholders	Experts
Reproducibility	External support	50%	80%	50%
	Collaboration	50 %	20%	50%

#### Table 11 The identified sub-topics for the key issue Reproducibility.

### Knowledge

During almost all the interviews knowledge are mentioned as essential for the implementation of a water and sanitation system and for its operation in the long-run. This key issue includes the following sub-topics; general awareness and associated knowledge (Table 12). General awareness and associated knowledge refer to knowledge regarding the society, including water and sanitation, and the technical systems, respectively.

General awareness is critical in order to achieve increased access to improved water and sanitation (Rodriguez, 2012). The population of Cochabamba do not demand improved basic services, since they are used to bad conditions and not aware of anything else (Mercado, 2012). Furthermore, the wastewater treatment plant that was planned to be built in Quillacollo was not constructed, due to the belief that it would not function satisfactory and pollute the area, which is the case for the plant that is run by SEMAPA. According to Victor Rodriguez, the former director for EMAPAQ, lack of awareness was the main reason to the resistance, they did not see the benefits he argues (Rodriguez, 2012). It is crucial that the people perceive the problem as possible to solve and overcome (Landaeta, 2012). PROCASHA aims to increase the general awareness regarding sustainability issues among the cooperativistas, as well as about the cooperative model and associated issues (Landaeta, 2012); (Villarroel, 2012); (Santos, 2012). They further argue that it is important to include everyone in the education; women, men and children (Landaeta, 2012). Lack of awareness about legal issues and formal procedures have been a source to arguments between the cooperativistas and PROCASHA (Santos, 2012).

It is crucial to have knowledge about the structure of water and sanitation organizations and how the technical systems function among the users (Rodriguez, 2012); (Mercado, 2012); (Arévalo, 2012); (COVISEP, 2012); (COVIVIR, 2012); (Selaya, 2012); (Escalera, 2012). Transfer of knowledge is sometimes not achieved, but it is absolutely vital (Mercado, 2012). PROCASHA claims that they have

provided the cooperatives with the necessary training (Santos, 2012). However, the cooperativistas argue that they have not achieved the amount of education that is necessary for proper maintenance (COVISEP, 2012); (COVIVIR, 2012).

Key Issue	Sub-topic	Supporting expre	ssions	
		Cooperativistas	External stakeholders	Experts
Knowledge	General awareness	25%	40%	25%
	Associated knowledge	75%	50%	75%

Table 12	The	identified	sub-tor	nics for	the ke	ev issue	Knowledge
	ille	luentineu	Sup-top	102 101	THE KC	y 133UC	Kilowieuge.

### Management

The management of a water and sanitation system is crucial. The sub-topics that build up this key issue are organization and community participation (Table 13).

The structure of the organization of a water and sanitation system is important (Selaya, 2012); (Arévalo, 2012). Competition for the power over a system can occur and corruption is often a problem in Cochabamba (Ledo, 2012); (Selaya, 2012); (Mercado, 2012). Transparency is desirable (Ledo, 2012). Ownership has been discussed frequently during the interviews. Almost all the stakeholders have mentioned collective property as a challenge and that there is a lack of understanding of the concept among the cooperativistas (Escalera, 2012); (Flores, 2012); (Landaeta, 2012); (Villarroel, 2012); (Arnan, 2012); (Huanca, 2012).

It is important that a water and sanitation project allow community participation. The cooperativistas are involved in the whole process and they have the authority to take all the final decisions (Flores, 2012); (Villarroel, 2012). During the interviews the importance of an easy and straight-forward decision-making process is emphasized (Landaeta, 2012); (COVISEP, 2012). Furthermore, clear roles and responsibilities are highlighted in many of the interviews, as well as the possibility to take measures against those who are not fulfilling their obligations. The cooperativistas are obliged to work 3 days a week at the building site during the construction time. However, some of the cooperativistas do not fulfil their responsibilities, which have been a source to argumentations (Huanca, 2012); (Arnan, 2012). The collaboration between the cooperativistas themselves, but also between the cooperatives and the other stakeholders, is important for a well-functioning water and sanitation project. This kind of project creates close bonds between the cooperativistas, but it also leads to situations that challenge the collaboration between them (Villarroel, 2012); (Numbela, 2012); (Arnan, 2012); (COVISEP, 2012).

Key Issue	Sub-topic	Supporting express	ions	
		Cooperativistas	External stakeholders	Experts
Management	Organization	25%	60%	100%
	Community participation	100%	40%	0%

Table 13 The identified sub-topics for the key issue Management.

## **Reliability**

The reliability of a water and sanitation system is crucial. It is important that a system provide reliable service in the long-run. This key issue is divided into the following sub-topics; system design, access and maintenance (Table 14).

It is essential that the system design is accommodated to the local characteristics (Mercado, 2012); (Huanca, 2012). Land use is emphasized as a very important characteristic to consider (Huanca, 2012); (COVIVIR, 2012). The cooperativistas want a system that requires as little land as possible (COVIVIR, 2012). Additionally, proper design, adequate construction work and high quality building materials are highlighted as important for a sustainable water and sanitation system (Escalera, 2012); (Fernandez, 2012); (COVIVIR, 2012). User satisfaction is desirable and the cooperativistas therefore make the final decisions regarding what system to implement (Landaeta 2012); (Soto, 2012)

Independent access is a requirement for a water and sanitation system (Arévalo, 2012); (Huanca, 2012). The whole target group should have access and the service should be available during the whole day. Currently, COVISEP has water between 6 am and 11 pm. However, they would like to extend their service a bit in the evening (COVISEP, 2012).

Maintenance is crucial for the long-term operation of a water and sanitation system (Rodriguez, 2012); (Huanca, 2012); (Mercado, 2012). However, In Cochabamba it rarely functions satisfactory, especially not for sanitation systems. They usually work in the initial phase, but stop to function due to lack of maintenance (Mercado, 2012). It is argued that one reason to why dry toilets were not chosen is that they required more regular maintenance than water closets (Soto, 2012); (COVISEP, 2012).

Key Issue	Sub-topic	Supporting expressions		
		Cooperativistas	External stakeholders	Experts
Reliability	System design	100%	10%	75%
	Access	75%	10%	25%
	Maintenance	100%	20%	25%

### Table 14 The identified sub-topics for the key issue Reliability.

## Water quality

Water quality is emphasized as absolutely crucial during the interviews (Arévalo, 2012); (Efraim, 2012); (Fernandez, 2012); (Huanca, 2012); (COVISEP, 2012); (COVIVIR, 2012); (Mercado, 2012). This key issue is divided into the following sub-topics; present state, treatment and risk of contamination (Table 15).

It is important to evaluate the water quality (Selaya, 2012); (Huanca, 2012). However, a study of the water quality has not been performed at either COVISEP or COVIVIR (Fernandez, 2012); (Huanca, 2012). The water system of COVIVIR provides water that is salty (Efraim, 2012); (COVIVIR, 2012), which concern the cooperativistas (COVIVIR, 2012). High salinity of the water limits its potential uses (Mercado, 2012).

Water treatment is desirable (Rodriguez, 2012; Huanca 2012) but currently the cooperatives do not have any water treatment in place (Huanca, 2012). Therefore, the cooperativistas are advised to boil the water before drinking it (Arnan, 2012).

Risk of pollution is also important to consider, when it comes to providing safe drinking water (Soto 2012). Microbiological pollution is of great concern in Cochabamba, due to lack of adequate sanitation systems (Mercado, 2012); (Efraim, 2012). The cooperativistas are worried that their

drinking water will get polluted. They are especially concerned regarding animal farming and butcheries nearby their properties (COVISEP, 2012); (COVIVIR, 2012). Additionally, the brick factories that are situated in the same area as COVIVIR are worrying for the cooperativistas of COVIVIR (COVIVIR, 2012).

Key Issue	Sub-topic	Supporting expressions		
		Cooperativistas	External stakeholders	Experts
Water quality	Present state	75%	30%	75%
	Treatment	25%	40%	0%
	Risk of contamination	50%	20%	25%

### Table 15 The identified sub-topics for the key issue Water quality.

### Disposal

The importance of proper sanitation systems and disposal were brought up in many of the interviews. Many people in Cochabamba lack access to adequate sanitation systems (Efraim, 2012). This key issue include the following sub-topics; hygiene and emissions, which refer to the emissions that are associated to disposal of human waste and wastewater (Table 16).

The health benefits that a proper sanitation system generates are highlighted in the interviews (Mercado, 2012); (Selaya, 2012); (COVIVIR, 2012). The cooperatives contribute to improved hygiene for the cooperativistas (Soto, 2012).

The connection between environmental degradation and lack of proper sanitation systems was emphasized during many of the interviews (Escalera, 2012); (Arévalo, 2012); (Arnan, 2012); (COVIVIR, 2012). It is crucial to have a sanitation system that allow for treatment (Escalera, 2012). The lack of proper sanitation systems in Cochabamba contaminates the environment (Arévalo, 2012).

#### Table 16 The identified sub-topics for the key issue Disposal.

Key Issue	Sub-topic	Supporting expressions		
		Cooperativistas	External stakeholders	Experts
Disposal	Hygiene	50%	10%	50%
	Emissions	50%	30%	25%

# 6.2 Indicator framework

The indicator framework, which consists of key issues and associated indicators, will enable the evaluation of the sustainability of small scale water and sanitation systems (Figure 5). The key issues that build up the sustainable development definition are divided into sub-topics and indicators are identified for each sub-topic. The literature is used as a way of finding suitable indicators, which measures if a system fulfil all the different key issues that a sustainable water and sanitation system should do.



Figure 5 Visualisation of the Sustainability pyramid with indicators.

Below, chosen indicators are presented (Table 17). They aim to be comprehensive at the same time as the number is minimized. All the indicators presented in this section are presented together with further information in Appendix 1.

#### Table 17 List of indicators.

Key-issue	Sub-topic	Indicator	Variable
Social context	Demographic	Demographic	-Population
	characteristics	characteristics	-Population density
			-Population growth
			-Residence pattern
			-Household size
			-Household composition
	Social respect	Acceptance	- Appropriateness to current
			local cultural context
			-Appropriateness of the
			project to the local culture of
			men and women
			-Violation, omission,
			Ignorance
		Cultural background	-Ethnicity
		<b>.</b>	-Religion
Socio-political	Legislation	Framework	-Legal framework
issues			-Law enforcement
			standards
		Property rights	-House and land ownership
	Political structure of		-Political pressures
	water organizations		r ontical pressures
	Municipal support	Municipal support	-Municipality spending
		maneipar support	-Number of projects and
			initiatives at the municipality
			level
			-Plans for infrastructure
Target group	Need	Need	- Use of an improved drinking
			water source
			- Access to an improved
			sanitation facility
	Demand	Motivation	-Dissatisfaction with current
			defecation place
			-Awareness of sanitation
			options
		Intention	-Priority of change among
			competing goals
			-Absence of permanent
Freeburgton	Matar availability		constraints
reshwater	water availability	Physical availability	-Annual freshwater
resources			volume
	Wateruse	Wateruse	-Water consumption
		Water use	-Beuse of water
Economic	Affordability	User ability to pay	-Operation and maintenance
obstacles			cost
			-Investment cost

			-Average household income
			-Bank/saving facilities
		Return on investment	-Decreased costs
			-Financial benefits from reuse
			-Potential for local
			development business and
			income generation effects
	M/illingnoog to nov		Morte
	winingness to pay	winingness to pay	-Money
Reproducibility	External support	Independent users	-Percentage of local materials
. ,		•	and resources used
			-Availability of required
			products and materials
			compositions for operation
			competence for operation
			and maintenance
			-Complexity of construction
			and O&M
			-Usage of generally accepted
			construction practices
		Suitable external	-Adequately trained
		actors	external partners
			-Support of local structures
			-Transparency
			-Exit strategy
	Collaboration	Requirements	-Possibility of avoiding conflict
			among different groups
			-Availability of land for central
			treatment
Knowledge	General awareness	Awareness about	-Ability to address awareness
		water and sanitation	and information needs
			-Percentage of people trained
			in water sanitation and
			hygione
			Education
	Associated knowledge	Knowledge about the	-Demonstrated understanding
		system	through testing
			-System perception
			-Easy to understand the
			system
			-Type of performed
			education
			-Reinforcement and revision
Management	Organization	Administrative	-Representative of the
		organization	community
			-Constitution
			-Transparency
			-Monitoring plan
			-Authority (sanctions)
			-Pricing strategy

			(water meters etc.)
		Ownership	-Property rights
	Community	Involvement	-Percentage of local
	participation		population involved
			-Local capacity for
			management
			-Responsibility distribution
			-Communication
		Equality	-Percentage of potential
			beneficiaries
			-Positive/negative impact to
			women, children and elderly
Reliability	System design	Performance	-Out-leakage
-			-In-leakage
		Technical structure	-Robustness (against
			overflow, non-access to clean
			water, sewer stoppage,
			flooding of basements)
			-Flexibility
		User satisfaction	-Proper usage
	Access	Water	-User friendliness
			Shared source:
			-Distance to water source
			-Collection time per day
			-Number of people per water
			source
			-Queuing time
		Sanitation	-User friendliness
			Shared source
			-Time households spend on
			travelling to public or shared
			facilities
			-Safety
			-People per facility
			-Privacy
			-Facility cleaning
	Maintenance	Organization	-Community plan to support
			and carry out routine
			maintenance and repairs.
			-Local capacity for
			maintenance
			-Clear roles and responsibility
		Physical structure	-Overall facility maintenance
			-Cost of materials
			-Time
			-Availability of spare parts,
			parts for maintenance etc.
			- Possibility to use local
			competence for O&M
Water quality	Present state	At the source	-Type of water source
			-Users that agree that their

			water needs treatment
			-Microbiological quality
			(faecal coliform)
			-Chemical quality
			(Salinity phosphorus)
			-Organolentic properties
			(Appearance taste odour)
		At the point of use	Storage containers
		At the point of use	Lisers that agree that their
			-Osers that agree that then
			Microbiological quality
			-iviicrobiological quality
			(laecal collorm)
			-Chemical quality
			(Salinity, phosphorus)
			-Organoleptic properties
			(Appearance, taste, odour)
	Treatment	Appropriate	-Degree of treatment
		treatment method	required
			-Flexibility (use of different
			types depending on the types
			of contaminations)
	Risk of pollution	Risk of pollution	Protocol from CASA
Disposal	Hygiene	Safe disposal of faeces	-Use of sanitation facility
			-Safe disposal of children's
			faeces
		Personal hygiene	-Safe disposal of children's faeces -Hand washing
	Emissions	Personal hygiene Atmospheric	-Safe disposal of children's faeces -Hand washing -Acidification potential
	Emissions	Personal hygiene Atmospheric emissions	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global
	Emissions	Personal hygiene Atmospheric emissions	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv)
	Emissions	Personal hygiene Atmospheric emissions	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances
	Emissions	Personal hygiene Atmospheric emissions Water pollution	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication
	Emissions	Personal hygiene Atmospheric emissions Water pollution	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic
	Emissions	Personal hygiene Atmospheric emissions Water pollution	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil
	Emissions	Personal hygiene Atmospheric emissions Water pollution	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts
	Emissions	Personal hygiene Atmospheric emissions Water pollution	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids
	Emissions	Personal hygiene Atmospheric emissions Water pollution	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances -Sludge to landfill
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances -Sludge to landfill -Sludge used as fertilizer
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances -Sludge to landfill -Sludge used as fertilizer -Organic material (in the
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances -Sludge to landfill -Sludge used as fertilizer -Organic material (in the
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances -Sludge to landfill -Sludge used as fertilizer -Organic material (in the wastewater used for
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances -Sludge to landfill -Sludge used as fertilizer -Organic material (in the wastewater used for irrigation) -Quality of recyclod products
	Emissions	Personal hygiene Atmospheric emissions Water pollution Land discharges	-Safe disposal of children's faeces -Hand washing -Acidification potential -Contribution to global warming (CO2-eqv) -Hazardous substances -Eutrophication -Spreading of toxic compounds to water and soil -Salts -Total suspended solids -Dumping of hazardous substances -Sludge to landfill -Sludge used as fertilizer -Organic material (in the wastewater used for irrigation) -Quality of recycled products

# 6.3 **Questionnaire**

Figure 6 shows the average score that the different key issues gained after the ranking that PROCASHA and the cooperativistas of COVIVIR and COVISEP performed. The cooperativistas are presented as one group. Each key issue was given a score between 1 and 10 by all the participants in the ranking exercise. All the key issues got a score well above the middle score and are therefore all interpreted as important for the sustainability definition.



Figure 6 The mean values from the prioritisations of the kwy issues done by the cooperatives and PROCASHA.

The opinion between the cooperatives and PROCASHA varied regarding how important they think each key issue is. All values can be found in Table 18.

Cooperatives		PROCASHA	
Target group	9,5	Water quality	9,7
Management	9,3	Disposal	9,3
Reliability	9,3	Target group	8,8
Knowledge		Freshwater resources	8,7
Water quality	8,8	Economic obstacles	
Social context	8,6	Knowledge	
Socio-political factors		Reliability	8,2
Freshwater resources	8,5	Social context	7,8
Disposal	7,8	Socio-political factors	
Economic obstacles		Reproducibility	
		Management	
Reproducibility	7,2		

Table 19 The different	moon scores from the	prioritisation of the ke	v issues done by th	a cooperatives and PPOCASHA
Table to the unferent	. mean scores from the	prioritisation of the ke	y issues done by th	le cooperatives and Procasha.



The standard diviation was quite big, both when the cooperatives as well as PROCASHA carried out the prioritisation. This is shown in the boxplots below in Figure 7 and Figure 8.

Figure 7 Boxplot over the prioritisation done by the cooperatives.



Figure 8 Boxplot over the prioritisation done by PROCASHA.

# 7 Discussion

The discussion has been divided into three sub-parts. Firstly, the results are discussed and compared with previous written literature and field observations done during the data collection. Secondly, a discussion regarding advantages and disadvantages with the chosen methodology is outlined. Finally, the experimental uncertainty depending on the research design is discussed

## The results

Eleven key issues were identified in this thesis. Together they make up the definition of sustainability for small scale water and sanitation systems in Cochabamba. The ranking exercise, which is referred to as a questionnaire in the methodology section, generated high average scores for all key issues. This is interpreted as if all the developed key issues have a big importance for the sustainability of small scale water and sanitation systems in the context of this case study. Furthermore, the key issues are confirmed by much literature. There are many similarities between the key issues and highlighted aspects in literature regarding water and sanitation projects.

The importance of considering social aspects is emphasized in literature, as well as in the results of this thesis. This result can be further supported by the fact that Cochabamba is the home for a population from a vast variety of origins and social classes. Socio-political aspects and management have also been emphasized as especially important during the interviews and group discussions. This is also supported by the literature. The importance of a good management structure and knowledge among the users and external organisations are frequently mentioned in both literature and results. The importance of a suitable target group is especially emphasized by the cooperativistas. This might be due to the fact that the collaboration within the cooperatives is sometimes challenged by conflicts and different views and opinions, especially since the cooperatives are built upon the concept of collective property. Freshwater resources have been emphasized as important by the experts, but not to a high extent by the cooperativistas and the external stakeholder. This is probably due to lack of knowledge among the cooperativistas and the external stakeholders, since they do not have a formal education within this field.

Economic aspects were thought to be heavily emphasised in the interviews, but so was not the case. They were mentioned as important by almost all stakeholders, especially the experts, but the cooperativistas themselves did not emphasize them as much as expected. Reproducibility was discussed much during the interviews with the external stakeholders. It was emphasized as desirable. The spread-effect is absolutely crucial for sustainable developing work. Knowledge was emphasized by all the different stakeholder groups, as well as by the experts. The long-term sustainability is dependent on this key issue. It was especially discussed in relation to maintenance and the willingness to implement sanitation solutions. As expected, reliability was emphasized by the cooperativistas and the experts. The cooperativistas prefer a system that they can depend on in the long-run, and do think about this much, since they use the systems each day. However, it was not mentioned as much by the external stakeholders. The present state of the water quality and disposal are highlighted by all the informants. Pollution sources are seen as a threat to future water supply. This is also expected, since microbiological pollution is a great problem in Cochabamba. In relation to this disposal was also emphasized.

The results reflect the informants' education and professional background to some extent. The majority of the external stakeholders do not have an education within the field of technology and

engineering but within sociology, economics and architecture. This might have led to that social aspects have been emphasized more than technical and environmental. Furthermore, the different stakeholders interpreted the questions and used terms differently. The questions and terms that were used were aimed to be as straight-forward as possible. However, if broad terms, such as economic aspects, were interpreted differently, this might have affected the results. Additionally, there might be areas that have not been mentioned, due to lack of knowledge or the perception that the informant considered it as irrelevant or the belief that the researchers already knew about it. Furthermore, it sometimes felt like if the informants answered in a way that they thought was expected of them. This was probably enhanced by the fact that both the researchers are Swedish and SCC is the financier of PROCASHA, as well as of the cooperatives.

There are some interesting differences between the results of this thesis and relevant literature. Many scholars mention aspects associated to health and hygiene as critical, but they do not seem to be a direct concern for the informants in the area of water and sanitation in this case. Furthermore, the researchers perceived that environmental aspects in regard to water and sanitation systems were crucial. However, this is not the case in this thesis, where the informants have not emphasized environmental concerns as absolutely crucial. One reason for this might be that it is difficult for the informants to have academic knowledge about this, since they have not worked or are educated within this field. Only emissions and contamination were mentioned as environmental concerns during the interviews, but nothing about resource and energy usage or landscape effects were mentioned. These are all aspects that are frequently mentioned in literature.

The set of key issues are mainly constructed to be used in the evaluation of different systems, but they could also be further developed to enable assessment of different project phases. The identified indicators are good examples of ways of measuring the key issues. It was aimed to choose indicators that represented the key issues and not the point of view of the researches. Those that are listed in this report are found in the literature, so they have been used before. They have been chosen in order to guarantee their accuracy and usefulness. However, the selected indicators are not all fixed and it is possible to add and take away depending on the intended usage. It is aimed at keeping the indicators as easy to use as possible, so the underlying workload of gathering the needed data will not be too high for the evaluator. However, this is a fine line of what data that is actually needed to prevent the evaluation of becoming superficial as well as too time consuming. The indicators that are chosen are dependent on the knowledge and expertise of the researchers. This leaves room for subjectivity, so the indicators need to be verified before they are used. During the expert interviews, the Delphi-method is suggested as suitable for this purpose.

#### The methodology

The purpose of the project has changed over time, since the delimitations of the project were difficult to make. This caused problems since it created a vague purpose with the research and made the methodology choice difficult. It was difficult to know what method to use for analysing the data. The vague purpose in the initial phase resulted in the search of appropriate indicators, but instead one of the major findings showed to be the definition of sustainability through identification of key issues. It is hard to say if the outcome might have differed if the focus would have been to define sustainability by defining the key issues from the beginning. The data collection step would have been performed differently if the purpose was known from the beginning, since the analysis procedure that was used in this thesis is dependent on data that is consistent. The same questions

and interview material should be used for all the interviews. However, this was not completely the case in this research. Furthermore, a clear understanding of the purpose might enable more adequate input in the different data collection methods. Since, the purpose was changed along the way, it was impossible for the stakeholders to gain a complete understanding about the research. This made their role a bit unclear, which might have affected their answers.

It is impossible to overlook the fact that the researchers' choice of method to collect data, analyse the data and their interpretation of what the informants said has influenced the results. How many people that were interviewed, whom that were chosen and how the interviews were conducted have had a major impact on the results. In general, more people could have been interviewed. It was difficult to know when the number of interviews was sufficient for fulfilling the purpose of the thesis. The cooperativistas and PROCASHA had major roles in the data collection process. The experts have of course influenced the results to a large extent as well, but the number of experts that were included could have been more. Furthermore, the questions and how the researchers led the discussion have influenced the answers. To some extent it can be argued that you get the answer that you want. In order to avoid this, open questions were used to a large extent, but since it was difficult to get the informants to speak freely about the topic, the content of the interviews were influenced by the researchers.

The researchers did all the analysis themselves, but it might have had been better to let someone outside the project select and sort the relevant information from the interviews and group discussions. This approach would have given more objectivity, but since the interviews were done together with a translator and no word-for-word documents of the interviews existed. Therefore, the notes from the interviews were probably better understood by the researchers. Hence, it was argued that the researchers were most suitable to do the analysis.

The method was chosen to enable continuous input from the stakeholders, but the feedback on the key issues during the input presentations was quite weak. This indicates that the chosen key issues cover the most important aspects of a sustainable water and sanitation system. However, the lack of input can also be a sign of inadequate knowledge regarding the investigated area, as well as lack of understanding of their important role in the development process. It is also worth reflecting around how the input presentations were conducted. They were carried out in quite large groups, which might have led to that the participants were not as active as they could have been. The most critical aspects that were mentioned during these input presentations were health and knowledge. Because of that knowledge and health got prominent roles.

The report aims to focus on water and sanitation by doing a case study of COVIVIR and COVISEP. However, it can be questioned if this really is the ideal case study. This is due to the fact that they have organised themselves into a cooperative to improve their housing conditions and not to primarily create improved water and sanitation solutions. It was therefore often difficult to discuss water and sanitation topics without drifting into discussions about the housing form. In the analysis it is assumed that aspects that were stressed as important for well-functioning housing cooperatives are also valid for water and sanitation organizations. For example, if management is mentioned as crucial for a housing cooperative, it is assumed that it is important for water and sanitation organizations as well. However, if this is an appropriate assumption is not known. The thesis used a qualitative approach, which does not aim at achieving statistical relevance. Statistical relevance is therefore not obtained. However, there are parts of the analysis that can be argued to be more of a quantitative character. The tables that show the percentage of the informants that support the different sub-topics within the key issues is a way of quantifying the support for the different key issues. However, the tables should be seen as indications of the different informants' opinions and trends, more than precise data. This is also valid for the ranking of the key issues that is a quantitative approach.

The methodology behind the prioritisation can be questioned. The data collection process regarding this was difficult, since the researchers got the impression that the informants started to evaluate their own systems rather than giving their opinion on the importance of the key issues. From the beginning, this exercise intended to generate potential weighting values for the different indicators associated to a certain key issue. However, due to the misunderstandings and the difference in how people defined the different key issues, it is rather used as a verification tool. Not too much attention should be given to the difference between the average scores that different key issues obtained.

### The experimental uncertainty

Before we started with the data collection a literature study was performed, which continued throughout the whole process. This has affected the results indirectly, since this gave the researchers an idea of what aspects that were important and possibly was going to be brought up. If this is an advantage or disadvantage is not known. It has the potential of functioning as a sort of verification that the interviews touched upon all factors that might have a large importance. However, it also might lead to overestimating the significance of certain factors and that the researchers have influenced the results in a certain direction.

The water and sanitation systems that are included in this case study have not been used for long or are under construction. COVISEP has used their water and sanitation for about half a year and COVIVIR has connected to a water system, but they have not built the sanitation system yet. This might also have had an effect on the results. The main informants, who are the cooperativistas and PROCASHA, do not have much experience of water and sanitation systems. Their opinions regarding these systems will probably change when they get more experience.

Another aspect that might have affected the results is that the researchers do not have a thorough understanding of Bolivia's culture or the local conditions in Cochabamba. Important aspects might have been lost due to this. The fact that a translator was used might also have contributed to misunderstandings. However, it can also be an advantage to have little pre-knowledge regarding the area when performing qualitative studies since it minimises influences from the researcher's prejudices, opinions and own ideas.

In general, it was difficult to obtain exhaustive information without asking direct questions during the interviews, the group discussions and the input presentations. Possible causes to this are inadequate interview and discussion material and that the informants did not realize their importance for the study. It was a challenge to enable an open and fluid discussion during the different data collection exercises.

# 8 Outlook

In the next phase of the PhD, there is a need for inclusion of reference groups. The project ultimately aims to develop a handbook for small-scale water and sanitation systems in Cochabamba. This includes two project goals. First, an assessment of the current systems within COVIVIR and COVISEP will be performed. Secondly, new systems will be designed and implemented in a housing cooperative, which is ought to be built in the future. However, the use of a handbook that only is valid for housing cooperatives in Cochabamba can be questioned, since they represent a small proportion of Cochabamba's population. Hence, there is a need to broaden the scope. The inclusion of reference groups is necessary to increase the use of the handbook, which is supposed to be written. OTB's are interesting to look into. In Quillacollo and Sipe Sipe these neighbourhood organizations are water providers. Both COVIVIR and COVISEP are connected to their local water committees within their OTB's. This makes these groups of people suitable to target for further investigation. The lack of organization and control around the existing small scale systems is challenging. The informants argued that the lack of control is a problem and overuse of water resources is one example of this. Assessment of these systems might lead to that important knowledge and information is shared.

Despite an overhanging health and environmental risk, appropriate sanitation systems are not maintained and implemented to the extent that is necessary in Cochabamba. The neighbourhoods collaborate around water, but not sanitation. In the next phase of this project, it would be interesting to look into the causes to this. The municipality of Quillacollo was not able to implement a treatment plant, due to resistance among the inhabitants. They are now investigating the reasons to why the implementation of a treatment plant was not possible in 2008. This study might be useful in this project and would be interesting to take part of. Could sustainable small scale sanitation systems be a potential solution to this? What would inspire and motivate the people to implement these solutions? One of the main findings of this thesis is that the views and opinions of the different stakeholders and experts regarding small scale water and sanitation systems differ. They consider different aspects to be important, especially the relative importance of different aspects. It would be interesting to investigate the effects of this. Do this affect the implementation of water and sanitation systems and their spread-effect?

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## Appendix 1

The informants are listed in the table below as well as what kind of role they played in the research. Additionally, what kind of data collection process that was used for each informant is listed.

Informant	Position	Empiric data collection
Cooperativistas	Stakeholder	
Roberto Fernandez	President of COVISEP	-Interview
Marcela Escalera	President of COVIVIR	
COVISEP		-Group discussion
COVIVIR		-Prioritisation
Support organisation to the	External stakeholder	
cooperatives		
Roxana Villarroel	Employee at comitee de	-Interview
	articulador	
Technical team of PROCASHA	External stakeholder	
Graciela Landaeta	President, PhD in Architecture	-Interview
Hernan Arnan	Social worker	-Prioritisation
Freddy Huanca	Engineer	-Input presentation
Maria Ester Soto	Architect	
Marcela Santos	Solicitor	
Lucy Flores	Economist	
University of San Simon	Experts	
Marco Quiroga	PhD student	-Interview about indicators
Carmen Ledo	Head of CEPLAG,	-Interview
	PhD in Economics	-Input presentation
Alvaro Mercado	M.Sc. in Engineering	-Interview
Researchers at CEPLAG	B.Sc. in economy and	-Input presentation
	architecture	
Urban pacification office in	Experts	
	Engineer	Interview
	Lingineer Architect	-Interview
	Architect	
Isaac Maldonado Sanabria	Director	-Interview about indicators
Funder	External stakeholder	Interview
Martha Arébalo	Coordinator for SCC in Bloivia	-
Daniel Numbela	Volunteer responsible at HFH	
Water provider	External stakeholder	-Interview
Efraim	President of the OTB in Sipe Sipe	
Victor Abel Rodriguez Medina	Former director of EMAPAQ	

## Appendix 2

In this appendix indicators that can be used to evaluate water and sanitation systems are presented in alphabetic order.

Indicator	Notes	Unit	Potential evaluation	Reference
Ability to address			Qualitative	(NETSSAF, 2006)
awareness and				
information needs				
Access to an	This is developed by		Improved sanitation	(Hernandez &
improved	the United Nations		includes;	Scott, 2010); (Garfí
sanitation facility	in order to assess		-Flush or pour/flush	& Ferrer-Martí,
	the Millennium		facilities connected to	2011)
	Development Goals;		a: piped sewer system,	
			septic system or pit	
			latrine Bit latrings with slab	
			-Pit latrines with slap	
			-Composing tonets	
			nit latrines	
Access to water	-User friendliness		piciacinics	(Garfí & Ferrer-
source	Shared source:			Martí, 2011)
	-Distance to water			
	source			
	-Time per day			
	(children, elderly			
	etc.)			
	-Number of people			
	per water source			
	-Queuing time			
Adequately				CSR
trained				
external partners				
Administrative	-Representative of			CSR
organization	the community			
	-Constitution (By-			
	laws, accounting			
	etc.)			
	-Transparency Monitoring plan			
	(sanctions)			
	-Pricing strategy			
	(water meters etc.)			
Appropriateness	Acceptable to use		Qualitative	(Kvarnström & af
to current local	and maintain			Petersens, 2004);
cultural context;				(Garfí & Ferrer-
Respect for local				Martí, 2011)
culture				
Appropriateness of				(Garfí & Ferrer-
the project to the				Martí, 2011)
local culture of				
men				
Availability of land	Is there space for			(NETSSAF, 2007)
for central	semi-central			
treatment	treatment			

Availability of required products and materials				(Hernandez & Scott, 2010)
Bank/saving facilities	To know potential to have access to credit			(NETSSAF, 2007)
Capital cost				(Flores, et al., 2009)
Clear roles and responsibility				CSR
Construction cost		Input of own resources and labour in construction & Initial costs, total and annual costs.		(NETSSAF, 2006)
Changing regulatory standards				(Milman & Short, 2008)
Community plan to support and carry out routine maintenance and repairs.				CSR
Convenience	-comfort -personal security -privacy/dignity -smell -noise - attractiveness/statu s -adaptability to needs of age and handicapped, gender and income groups -location and availability		Qualitative	(NETSSAF, 2006)
Current legal acceptability			Qualitative	(Kvarnström & af Petersens, 2004); (NETSSAF, 2006)
Current and legal acceptability and institutional capacity				(Flores, et al., 2009)
Current and foreseen legal acceptability and institutional capacity			Qualitative	(NETSSAF, 2006)
Compatibility with existing system				(NETSSAF, 2006)
Complexity of construction and O&M work				(Bracken , et al., 2005); (Hellström, et al., 2000)

demand				
Demonstrated	It will be necessary	%		(Pybus &
knowledge	to test all the			Schoeman, 2001)
through testing	members of the			, ,
	steering committee			
Drinking water				(Nader . et al
quality index				2008)
Fasy to				(Hellström et al
understand				2000)
Education	To know how	No. of years in		(NETSSAE 2007)
Luucation	information will be	school		(NE135AI, 2007)
	discominated	301001		
Employment of	uisseminateu			(Carfí & Forror
				(Gaill & Feller-
IUCal Stall	Llala ta idantifu	Dranaution of		(NETECAE 2007)
Ethnicity	Help to identify	Proportion of		(NETSSAF, 2007)
	potential social	ethnic group		
	conflicts that may			
<b>E</b> 10 11	occur			
External financial				(ivader , et al.,
contributions to				2008)
environmental				
issues				
Exit strategy				CSR
Financial benefits				(Flores, et al.,
from reuse				2009)
Flexibility				(Hellström, et al.,
				2000)
House and land	The value of the			(NETSSAF, 2007)
ownership	house increases if			
	you have the legal			
	right to the			
	property			
Household		Age structure		(NETSSAF, 2007)
composition				
Household income	Affect the ability to			(NETSSAF, 2007)
	рау			
Household size	Enable prediction of	No./household		(NETSSAF, 2007)
	load from each			
	household			
Implementation of				(Nader , et al.,
environmental				2008)
laws at the				
municipal level				
Intention	-Priority of change			(Jenkins & Scott,
	among competing			2007)
	goals			
	-Absence of			
	permanent			
	constraints to			
	acquiring sanitation			
Legal framework	Consideration of		Relevant legal	(NETSSAF. 2007)
-0	legal requirements		documents	, , ,
Level of	0			(NETSSAF. 2007)
decentralisation				, , ,
Law enforcement	Who that enforce			(NETSSAF, 2007)
	hygiene and			(

	sanitation		
Literacy level	To know how information will be disseminated	% of population	(NETSSAF, 2007)
Local capacity for management, operation and maintenance			(Garfí & Ferrer- Martí, 2011)
Motivation	-Dissatisfaction with		(Jenkins & Scott,
(preference)	current defecation place -Awareness of sanitation options		2007)
Municipality			(Nader , et al.,
spending on			2008)
environmental			,
issues			
Number of locals			(Garfí & Ferrer-
employed			(Garri a rener Martí 2011)
Number of			(Nador ot al
number of			(Nauer, et al.,
projects and			2008)
municipality loval			
			(Neslaw, et al.
Number of			(Nader, et al.,
sustainable			2008)
development			
plans/agendas			
adopted and			
implemented by			
the municipality		(0)	·
Operation and		cost; cost/flow	(Flores, et al.,
maintenance (O &		rate; annual cost	2009); (Marques &
M) cost; O & M		& input of own	Monteiro, 2001)
cost per water		resources and	
produced; O & M		labour in	
		operation and	
		maintenance	
Percentage of local	Affects the		(Garfí & Ferrer-
materials and	reproducibility		Martí, 2011)
resources used in			
water technology			
Percentage of			(Garfí & Ferrer-
people trained in			Martí, 2011)
water, sanitation			
and hygiene			
Percentage of			(Garfí & Ferrer-
potential			Martí, 2011)
beneficiaries			
Performance	-Out-leakage		(Hellström, et al.,
	-In-leakage		2000)
Residence pattern	Helps to create	No./house or	(NETSSAF, 2007)
	structured for	compound	
	decision-making		
	processes		
Religion	Affects practices	Proportion of	(NETSSAF, 2007)
	regarding hygiene	religious group	

	and sanitation			
Robustness	Against:			(Hellström, et al.,
	-overflow			2000)
	-non-access to clean			
	water			
	-sewer stoppage			
	-flooding of			
	basements			
Percentage of local				(Garfí & Ferrer-
population				Martí, 2011)
involved				
Physical		-Annual		(Milman & Short,
availability ;		freshwater		2008); (Lundin, et
Withdrawal		withdrawal/annu		al., 1999)
		al available		
		amount		
Plans for				(NETSSAF, 2007)
infrastructure				
Political pressure				(Milman & Short,
				2008)
Population	Aid planning of	No.		(NETSSAF, 2007);
	sanitation			
Population density	Enables estimations	No. of		(NETSSAF, 2007);
	of steam flows that	people/km <sup>2</sup>		(Nader , et al.,
	need to be treated,			2008)
	as well as the			
	availability of land			
Population growth	Enables to estimate	%		(NETSSAF, 2007)
	future requirements			
Projects				(Nader , et al.,
undergoing				2008)
environmental				
impact assessment				
Positive/negative			Qualitative	(NETSSAF, 2006)
impact to women,				
children and				
elderly				
Possibility to use				(NETSSAF, 2006)
local competence				
for operation and				
maintenance				
Possibility to use				(NETSSAF, 2006)
local competence				
for construction				
Possibility of				(Garfí & Ferrer-
avoiding conflict				Martí, 2011)
among different				
groups				
Potential for local				(Flores, et al.,
development,				2009)
business and				
income generation				
effects				
Responsibility				(Kvarnström & af
distribution				Petersens, 2004)

Responsibility for	Helps to understand			(NETSSAF, 2007)
advocacy and	who the power			
promotion at	structures of the			
community level	community			
Responsibility for	Helps to identify			(NETSSAF, 2007)
sanitation policy	who that represents			
and strategy	the community, and			
formulation	appropriate			
	stakeholders to			
	involve.			
Surface water				(Nader , et al.,
Quality index				2008)
structures				CSN
Sustam parcontion	comployity			
System perception	-complexity			
	including aspects of			
	reuse			
Transparency	Teuse			CSR
Type of education				(UNICEF, 1997)
Type of	-OTB			Questionnaire.
organization	-Committee			CEPLAG
	-Cooperative etc.			
Reinforcement				(UNICEF, 1997)
and revision				
Reuse of water		Reused		(Lundin, et al.,
		water/water		1999)
		consumption		
Usage of generally				CSR
accepted				
construction				
practices				(
User ability to pay		Annualized cost		(Flores, et al.,
	• ···	as % of income		2009)
User acceptability	Compatibility with			(Flores, et al.,
	user habits and			2009)
	preferences;			
	convenience;			
	control , personal			
	attractiveness			
lise of an	Developed by the	%	According to IMP	(Hernandez &
improved drinking	United Nations in	70	improved source	Scott 2010)
water source	order to assess the		includes the following:	5000, 2010)
Water Source	Millennium		-Pined water into	
	Development Goals		dwelling plot or yard	
	Development douis		-Public tan/standnine	
			-Tube well/borehole	
			-Protected dug well	
			-Protected spring	
			-Rainwater collection	
Violation,	Indicates if a system			(Hellström, et al.,
omission,	is accepted or not			2000)
ignorance				
Water		Use per capita per	- Minimum water	(Garfí & Ferrer-

consumption	day (l/p/d)	amount is 20 litres (UNHCR, 2006)	Martí, 2011); (Lundin, et al., 1999); (Cronin, et al., 2008)
Willingness to contribute through work and/or money for sanitation services		Qualitative	(NETSSAF, 2006)