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IMPACT OF OPERATION AND MAINTENANCE PRACTICES ON SUSTAINABILITY OF RURAL WATER SUPPLY SYSTEMS – CASE DEVCHULI, NEPAL

Master of Science Thesis

Examiners: university researcher Tapio Katko and project manager Pekka Pietilä
Examiners and topic approved by the Faculty Council of the Faculty of Science and Environmental Engineering on 8th June 2016

ABSTRACT

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The purpose of this thesis was to analyze the impact of operation and maintenance practices on the long-term sustainability of the Finnish-funded water supply projects implemented as a part of the Rural Water Supply and Sanitation Project (RWSSP) between 1990 and 2005 in Western Nepal. This thesis explored the water systems' practical technical problems that the communities have been struggling with and the solutions they have developed to tackle them. The availability of technical personnel in the schemes or within the range of the community was studied, too.

Technical problems encountered by the communities in Devchuli, the target area of this case study, included water source depletion, water systems becoming clogged with lime and decreased water quality during the rainy season. Some schemes suffered from yearly landslides but usually the villagers were able to return the scheme to a functioning condition in a week. Population growth and the water scarcity caused by it turned out to be one of the major reasons why the schemes were in need of rehabilitation. Due to increased income and remittances, private taps (as opposed to public taps) had gained some popularity, and the users were demanding upgrading of the schemes.

It was not easy to get technical or financial support from the local government. Often the cost of repairs was too high for the WUSCs to bear on their own and they were dependent on outside funds. As a result of this, some WUSCs had resorted to temporary, cheaper repair solutions such as repairing the pipes with parts of bamboo. Availability of technical personnel in the villages was moderate (75 % of the villages) but their task descriptions and skills varied a lot. In the future, in order to ensure the functionality of the schemes, the WUSCs should be offered post-construction support on a regular basis, which requires developing the capacity of the local government bodies. If suitable, NGOs or private operators could support local bodies in their tasks.

TIIVISTELMÄ

LUKKA, ANNA: Kunnossapitokäytäntöjen vaikutus maaseudun vesihuoltojärjestelmien kestävyyteen - case Devchuli, Nepal
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Tässä diplomityössä tutkittiin kunnossapitokäytäntöjen vaikutusta vesihuoltojärjestelmien pitkän aikavälin kestävyyteen. Työssä tutkittiin Länsi-Nepalissa 1990-2005 toteutetun Suomen osittain rahoittaman Rural Water Supply and Sanitation Project (RWSSP) –hankkeen aikana rakennettuja talousvesijärjestelmiä. Työ käsittelee kyläläisten kohtaamia vesihuoltojärjestelmiin liittyviä käytännön teknisiä ongelmia ja niiden ratkaisuja. Työssä kartoitettiin myös, oliko kylissä koulutettuja työntekijöitä, jotka pystyvät hoitamaan vesijärjestelmän kunnossapitoa, ja oliko kunnossapitoon saatavilla teknistä tukea muualta.

Vesilähteiden kuivuminen, vesijärjestelmien tukkeutuminen kalkilla ja heikentynyt veden laatu sadekauden aikana olivat olleet ongelmana Devchulissa, jossa tämä tapaustutkimus tehtiin. Osa vesihuoltojärjestelmistä vaurioitui joka vuosi maanvyöryn seurauksena, mutta useimmiten kyläläiset pystyivät korjaamaan järjestelmän toimivaksi viikossa. Väestönkasvu ja siitä johtuva veden niukkuus paljastui yhdeksi suurimmista syistä, miksi järjestelmiä ei koettu täysin toimiviksi. Kasvaneen tulotason ja ulkomaisten rahalähetysten yleistymisen ansiosta mahdollisuus saada vesipiste omaan kotitalouteen oli alkanut kiinnostaa kyläläisiä. Monet halusivat, että vesijärjestelmät saneerattaisiin ja yleisistä vesipisteistä siirryttäisiin yksityisiin.

Paikallishallinnolta ei ollut helppoa saada teknistä eikä taloudellista tukea. Usein vesijärjestelmien korjaukset olivat liian kalliita, jotta käyttäjäkomiteat olisivat voineet kattaa niiden kustannukset ilman ulkopuolista rahallista tukea. Osa käyttäjäkomiteoista olikin turvautunut halvempiin teknisiin ratkaisuihin kuten rikkoutuneiden putkien korjaamiseen bambun varren palalla. Kolmessa neljäsosassa kylistä oli kunnossapidosta vastaava työntekijä, mutta heidän työnkuvansa ja osaamistasonsa vaihtelivat paljon. Tulevaisuudessa vesijärjestelmien toiminnan turvaamiseksi paikallishallinnon tulisi tarjota käyttäjäkomiteoille säännöllistä tukea. Tämä edellyttää paikallishallinnon osaamisen ja rakenteiden vahvistamista, jossa myös järjestöillä ja yksityisen sektorin toimijoilla voisi olla jonkinlainen rooli.

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Helsinki, 23 November 2016

Anna Lukka

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LIST OF ABBREVIATIONS

CBM	Community-Based Management
DDC	District Development Committee
DRA	Demand-Responsive Approach
DWSS	Department of Water Supply and Sewerage
DWSSDO	District Water Supply and Sanitation Division Office
GDP	Gross domestic product
HH	Household
LCD	Least developed country
NAPA WASH	Nawalparasi and Palpa Districts Sustainable Water Supply and Sanitation Project
NGO	Non-governmental organization
NPR	Nepalese Rupee
RWSSP-WN	Rural Water Supply and Sanitation Project in Western Nepal
TMS	Total Management Services
UC	User Committee
UN	United Nations
UN-OHRLLS	United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and the Small Island Developing States
VDC	Village Development Committee
VMW	Village Maintenance Worker
VWASHCC	Village Water, Sanitation and Hygiene Coordination Committee
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WUSC	Water User and Sanitation Committee

1. INTRODUCTION

Access to clean, adequate water is one of the most important basic needs of human beings. It is a prerequisite to general poverty and hunger reduction, availability of primary education and disease prevention. (Prasain 2003.) Not surprisingly, access to safe water has also been declared a human right (UN 2010). However, still in 2015, approximately 663 million people in the whole world lacked access to improved source of drinking water (UN 2015). It is mostly the rural population that suffers from the lack of these services (Lockwood & Smits 2011). According to WHO/UNICEF (2010), 84 % of the people without access to improved drinking water sources live in rural areas.

The drinking water supply coverage has increased worldwide significantly over the past decades, from 76 percent to 91 percent between 1990 and 2015 (UN 2015). Since 1990, over 2 billion people worldwide have gained access to an improved drinking water source (WHO/UNICEF 2014). However, achieving sustainable solutions has proven to be difficult. In reality, tens of millions of rural people suffer from problems with prematurely failed systems that are operating below the expected performance level or are not functional at all. The reported coverage numbers tell only of the number of systems built and the number of people served by these systems. Less attention has been given to whether the systems actually continue to work and deliver the expected service over the years. (Lockwood & Smits 2011.)

Barriers to the sustainability of delivering a safe water supply can be difficult to identify. Sustainability is not only about the physical or technical properties of the water system, but also the organizational, financial and managerial capacities of the service producer, whether it is the Water User and Sanitation Committee (WUSC) in the village or some other, for example a private operator. These operate under the local government and should receive support from them which in turn is connected to national policies and regulations and other institutional frameworks. (Lockwood & Smits 2011.)

WHO/UNICEF (2014) reported that the drinking water coverage was 88 % in Nepal in 2014. Yet, the true functional coverage is far lower. In 2011 the Department of Water Supply and Sewerage (DWSS) conducted a study on the status of the drinking water schemes in the country. The results revealed that of the 38 000 constructed gravity flow schemes only 18 % were functioning well, 39 % needed minor repair and 43 % needed major rehabilitation or reconstruction. (HELVETAS Swiss Intercooperation Nepal 2013; Hänninen 2014, 103.)

This Master's thesis was written as a part of Nawalparasi and Palpa Districts Sustainable Water Supply and Sanitation (NAPA WASH) Project. The NAPA WASH project was initiated to conduct a long-term sustainability review of Finland-supported rural

water supply projects in Nepal and gather information on the state of the water supply situation in the project area more than 10 years after the intervention. (WaterFinns 2014.) Since the late 1980s, Finland has been supporting the rural water supply sector in Nepal. Rural Water Supply and Sanitation Project (RWSSP) was the first intervention which took place in Western Nepal, the Lumbini zone, between 1990 and 2005. RWSSP has been included in a few assessments and evaluations (Matz et al. 2010, Caldecott et al. 2012) which are based on analyses of a wide variety of documents as well as interviews of primary knowledge holders of different levels, but studies in the actual field sites have not been implemented.

The need for revisiting the schemes and gathering grass-root level information of the practical problems communities are struggling with was recognized by WaterFinns, a Finnish non-governmental organization. As a result, the NAPA WASH project was initiated in 2014. The purpose of the project is to enhance the in-depth understanding of the long-term sustainability factors and identify the good practices of the Water User and Sanitation Committees' which contribute to the sustainability of the scheme. The project includes two main result areas: capacity building at village level and field assessments. The assessments were conducted by a few Finnish and Nepalese students, and this thesis is one of them. (WaterFinns 2014.)

This thesis examines the operation and maintenance (O&M) issues of the water systems and their significance to the long-term sustainability of the systems. O&M is an established concept within the field of rural water supply, even though it wraps up together two quite different kinds of activities (Carter 2009). Operation includes activities linked with the actual running of the service (e.g. general mechanical or water treatment procedures, control of water intake points) whereas maintenance includes activities planned in advance to keep the system in working condition (Brikké 2000). Both are essential to keeping water supply systems performing well and continuously (WHO 2012) and both are addressed in this thesis.

1.1 Research objectives

The objective of this study is to gain better understanding of the impact of the O&M practices on the long-term sustainability of the water supply schemes. The study looks into the variety of problems experienced by the communities with the O&M of gravity flow schemes and the solutions they have developed to tackle them. The aim is as well to understand how the problems have changed from the time of the scheme construction until today, as the living standards and peoples' expectations towards water services have risen. Changes in the number of households using water from the schemes or rehabilitation/expansion of the scheme are connected to these issues. Systems based on other than gravity were left out of the scope of the study due to limited time and other resources. Sanitation and hygiene issues were left out for the same reason.

1.2 Research questions

Based on the previous description, the following three research questions were formulated for this study:

1. What kind of technical, operational or maintenance-related problems has the community experienced with the water supply and how were they solved? How have the problems changed during the years?

2. What kind of technical skills, mainly the Village Maintenance Worker(s), have been available at the community or within the range of the community?

3. How have the communities approached the operation and maintenance of their water scheme?

The thesis starts with introduction of the topic and research questions, followed by a chapter of theoretical framework: literature review of the previous articles, books and other written material in the area of interest. The third chapter presents the context of this case study. The fourth chapter tells about the research methods and why they were chosen for this study. In the fifth chapter, the results are presented and discussed. Finally, the conclusions are drawn in the sixth chapter.

2. LITERATURE REVIEW ON RURAL WATER SUPPLY IN DEVELOPING COUNTRIES

This chapter gives background information how the attitudes behind and the character of the water supply programs, especially regarding sustainability, have changed along the years. This chapter also introduces the fundamentals of gravity flow systems and their operation and maintenance, including the role of village maintenance worker.

2.1 Historical approaches in rural water supply

The character and approaches of the rural water, sanitation and hygiene (WASH) programs have undergone major changes over the years. The first rural WASH programs in Nepal started approximately 50 years ago. (Prasain 2003.) In the 1970s, most rural water programs were delivered and managed by governmental institutions (Harvey & Reed 2006). These approaches were called "top-down" or "supply-driven", as the solutions were decided by technicians based on pre-set guidelines, and the water users were not involved in the decision-making (Prasain 2003). Due to limited capacity and resources, these programs suffered from low sustainability. It was recognized already at that time that more efficient solutions are needed, which triggered interest toward community management (Harvey & Reed 2006).

The community-based management (CBM) model started to develop during the International Decade for Water and Sanitation (1981-1990) which brought a strong wave of non-governmental organization (NGO) and donor programs that focused on communities and largely disregarded governmental structures (Lockwood & Smits 2011). The programs differed somewhat from each other but the basic principles of the model implied that the community should have a major role in the development of the improved water supply, own the water system and have overall responsibility of its O&M. The community members must contribute to the initial infrastructure installation costs and cover all the O&M costs by collecting water tariff regularly. (Harvey & Reed 2006.)

The concept of "demand-responsive approach" (DRA) developed in the mid-to-late 1990s. It was supposed to reinforce the community management model by ensuring that the provided water supply service was corresponding to the demands of the community itself. The communities were expected to express their need for improved services more clearly, play a significant role in the project by choosing the service level and technology suitable for them and how they want to manage them. (Lockwood & Smits 2011.) Over ten years, the community management model combined with the demand-

responsive approach became the most popular approach in the rural water programs (Moriarty et al. 2013).

Moriarty et al. (2013) report that these approaches have been successful in increasing the global drinking water supply coverage worldwide significantly, from 76 percent to 91 percent between 1990 and 2015 (UN 2015). Indeed, over 2 billion people worldwide have gained access to an improved drinking water source since 1990 (WHO/UNICEF 2014). Improved drinking water sources include sources such as water piped into a household or yard, public taps, tube wells and boreholes, springs and rainwater collection, whereas unimproved drinking water sources include surface water sources such as rivers, dams, lakes or irrigation channels, unprotected springs and dug wells. (WHO/UNICEF 2015).

However, the access to these services has not stayed permanent. There is widely documented evidence that newly delivered WASH services often perform effectively for a period, and then either fall into disrepair or otherwise fail to provide continuing benefits to their users (Improve International Inc. 2012; Schweizer et al. 2014). The results show that on average 20 to 40 % of water systems are not functional or delivering a sustainable service. For example, the rate for partial functionality or non-functionality for "all India" is more than 30 %, but there are some states where the rate is 60 % or even 70 %. (Lockwood & Smits 2011.)

Regional differences, rural-urban disparities, and differences between the rich and the poor and discriminated groups of people remain. Poorer people living in rural areas are much more likely to be without improved water source and sanitation facilities. This is the reality in Nepal, too. The unequal distribution of water and sanitation services are reflected in caste, ethnic, gender and geographic differences. In 2012, Nepal reported total improved drinking water coverage of 88 %. Of the urban people, 90 % had access to an improved water source and 49 % had piped water on premises. For the rural people the number was 88 % with 16 % pipe on premises. (WHO/UNICEF 2014.)

During the 2000s, views have started to shift towards service delivery thinking. It has been suggested that there are limits to what can be achieved through voluntarism and informality. First-time access to improved water supply services has been granted to many but the service level is fluctuating and unreliable, and the expectations of rural water users are increasing as their level of education and standard of living are increasing. Urbanization leads to faster growth of smaller towns and rural market centers, where higher and a more complex level of service is desired. (Moriarty et al. 2013.) Limitations of CBM are elaborated further in several articles (Harvey & Reed 2006; Lockwood & Smits 2011; Moriarty et al. 2013). The changes in the approaches in the rural water sector are presented in Figure 1.

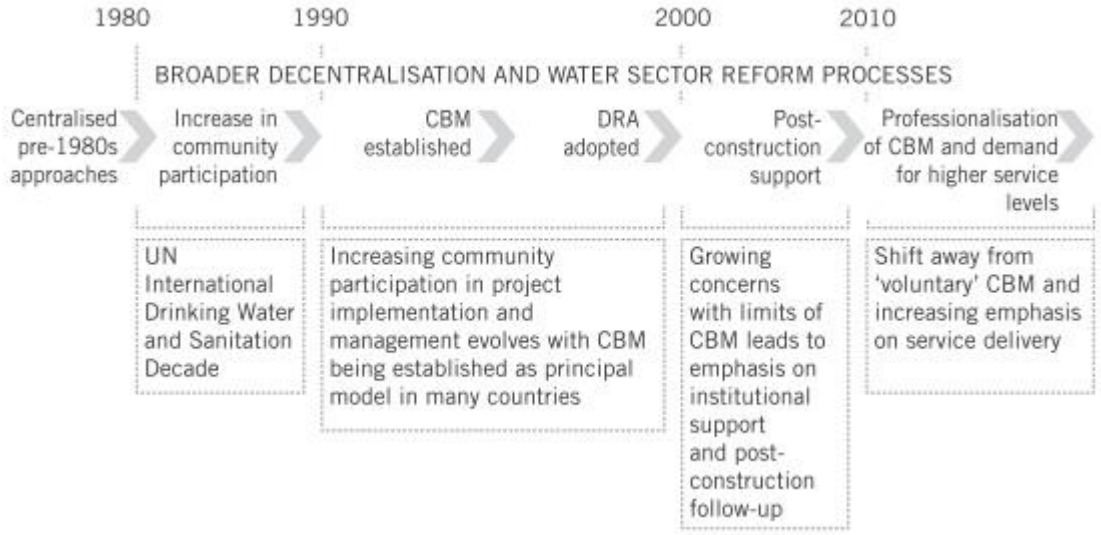

Figure 1. *The rural water sector evolution (Lockwood & Smits 2011).*

Potential solutions to the limitations of CBM include:

1. Professionalization of community management
2. Provision of institutional support to communities
3. Self-supply

Professionalization of community management is needed as the wealth and size of the community increases and water systems become more advanced. This includes business practices such as auditable bookkeeping, billing, customer service and probably hiring of trained and paid staff for e.g. water treatment or plumbing. In some cases, a part or most of the tasks can even be outsourced to private operators. In the end, professionalization is about holding the service providers (whether community-based or private) accountable for their work against known indicators and having an external authority to regulate their work. (Moriarty et al. 2013.)

The communities' need for institutional support started to be recognized in the early 2000s. Most of the community-based service producers are in need of some level of external support without which they are not capable of managing the water supply service. Actually, the majority of them receive some form of support, but often it is provided in a reactive manner. Moriarty et al. (2013) state that the support should be provided on a regular basis, and they suspect that threshold effect applies in this case: below the certain threshold of support, there is no visible effect and only when the threshold has been passed will there be a correlation between efforts and money invested and progress in the level of services.

Self-supply is the best alternative in the most remote areas which are most difficult to serve. Self-supply means people being served by a private household supply, which

includes e.g. dug wells, boreholes or hand pumps. The majority of the rural populations will be served by larger water schemes, but there will be some areas where constructing schemes is not feasible and where people quite often are not able afford or willing to pay for a more advanced service. However, self-supply as an option of service must be recognized and supported by state agencies, too. (Harvey & Reed 2006; Moriarty et al. 2013.)

2.2 Sustainability in rural water supply

There is not a single precise definition for sustainability in rural water supply. Abrams et al. (1998) define sustainability simply as *"whether or not something continues to work over time"* which in the field of water supply means whether water continues to flow or not. Sara & Katz (2005) have defined sustainability as *"the maintenance of an acceptable level of services throughout the design life of the water supply system"*. According to Lockwood & Smits (2011), many organizations have defined sustainability in this context as *"the capacity to continue the flow of perceived benefits of the investment project after its active implementation period has ended"*.

Sustainability is a multidimensional concept, which means that it is affected by the systemic and dynamic interactions of several factors. The factors can be internal or external, and they include issues which are more about the system and the community itself, but also wider sectoral issues such as connections to several stakeholders. (Lockwood & Smits 2011, Peter & Nkambule 2012, Walters & Javernick-Will 2015.) One factor should not be preferred over another (Lockwood et al., n.d.). All of the factors are vital and necessary for sustainability, but none of them is sufficient in itself (Abrams et al. 1998).

Lockwood et al. (n.d.) note that the definitions of sustainability increasingly include demands of distributing the benefits equally for everyone in the society, regardless of gender or other differences. One aspect the definitions do not yet fully recognize is that some level of external support is needed at the community level, as the awareness of the need for follow-up and post-construction support for the communities started to increase in the early 2000s (Verhoeven & Smits 2011). It is, however, challenging to analyze and measure sustainability (Peter & Nkambule 2012). This is why it has posed such a challenge to the WASH sector, too (WaterAid 2011).

There are many frameworks to assess the sustainability of services. Le Gouais & Wach (2013) analyzed policy and strategy documents published around 2008 by a diverse set of eleven development partners in the rural water sector and found that frameworks could be divided roughly in two categories: *"those developed to monitor or assess the degree of sustainability for particular projects; and conceptual principle-based frameworks designed to orient the development of sustainability measures prior to project or program development"*.

The first set of frameworks (for example in Peter & Nkambule (2012) and Sara & Katz (2005)) is mostly being used in providing accountability of sustainability for donors and improving the projects, but for research purposes, too. The majority of these frameworks include some institutional, financial, social, technical and managerial factors. The second set of frameworks (including for example those by WaterAid (2011) and Lockwood & Smits (2011)) goes less into specific detail but lists and discusses issues that need to be taken into account for every community-managed rural water supply service.

In the first set of frameworks, the institutional or managerial factors deal with the daily management of the water system and assigning it to some committee or organization. Technical factors are about designing and constructing the system in a proper and suitable manner. Some of the aspects to be considered include a difficult terrain for laying the pipes, sources yielding less water than expected or even drying up, or possibility of landslides (Jordan 1980). Construction quality, efficiency of skilled labor and the quality of materials affect the durability of the system substantially. Technical human resources have to be considered, which means that there should be a trained water system operator present and working in the community. Financial factors are about cost recovery, tariff setting and collection and maintaining of the O&M fund. (Sara & Katz 2005.)

Social factors are related to the capacity of the communities to make the water systems sustainable. The wealth, ethnic composition or the unity of the community and other socio-economic factors such as a real community demand for the water system affect the capacity. (Sara & Katz 2005; WaterAid 2011.) Some kind of economic or political disputes are often bound to arise. Such arguments can include the water tariff structure, rights to the water sources, tap stand locations and division of labor. Other "human problems" that might come unexpectedly are curious adults or children abusing or playing with the system, or deliberately sabotaging the system with the intent of punishing other villagers or making illegal connections to get more water or avoid paying for it. These kind of problems should not be underestimated as they have effectively destroyed many water systems. (Jordan 1980.)

One example from second set of frameworks is shown here: Triple-S (Sustainable Services at Scale) building blocks (see Table 1). Triple-S is a six-year learning initiative with the goal of contributing to increased sustainability of rural water services and driving the transformation of the approaches towards providing indefinite and reliable service delivery in the sector. Triple-S is managed by IRC International Water and Sanitation Centre in the Netherlands and collaborates with partners on international, national and local levels in its focus countries. A series of case studies from 13 countries which were selected to represent a continuum of socio-economic contexts, aid relations and overall development of the water sector was done as a part of the initiative. The building blocks have been identified and draw from these studies. (Lockwood & Smits 2011.)

Table 1. *Triple-S building blocks for sustainability of rural water supply systems (Lockwood & Smits 2011; Le Gouais & Wach 2013).*

1. Professionalisation of community management	Community management entities supported to move away from voluntary arrangements towards more professional service provision that is embedded in local and national policy, legal, and regulatory frameworks.
2. Recognition and promotion of alternative service provider options	A range of management options beyond community management, such as self-supply and public-private partnerships, formally recognised and supported in sector policy.
3. Monitoring service delivery and sustainability	Monitoring systems track indicators of infrastructure functionality, service provider performance, and levels of service delivered against nationally agreed norms and standards.
4. Harmonisation and coordination	Improved harmonisation and coordination among donors and government, and alignment of all actors (both government and non-government) with national policies and systems.
5. Support to service providers	Structured system of direct (post-construction) support provided to back up and monitor community management entities and other service providers.
6. Capacity support to local government	Ongoing capacity support provided to service authorities (typically local government) to enable them to fulfil their role (planning, monitoring, regulation, etc) in sustaining rural water services.
7. Learning and adaptive management	Learning and knowledge management supported at national and decentralised levels to enable the sector to adapt based on experience.
8. Asset management	Systematic planning, inventory updates, and financial forecasting for assets carried out, and asset ownership clearly defined.
9. Regulation of rural services and service providers	Regulation of the services delivered and service provider performance through mechanisms appropriate for small rural operators.
10. Financing to cover all life-cycle costs	Financial frameworks account for all life-cycle costs, especially major capital maintenance, support to service authorities and service providers, monitoring and regulation.

2.3 Rural gravity flow systems

There are several technology options for rural water supply systems. Gravity systems are typical in hilly and mountainous areas, where water would otherwise need to be carried for long distances over steep terrain. In Terai areas, dug or drilled wells and hand pumps are common. (Brikké & Bredero 2003.) Other common water supply options include rooftop rainwater harvesting, rainwater catchment and storage dams, and subsurface harvesting systems. Conventional energy sources used for the systems include gravity, manual effort, animal traction and diesel engines, whereas solar power and windmills are new and emerging ones. (Brikké & Bredero 2003, 20)

In gravity systems, the water flows naturally from a higher elevation intake point to the lower point, where it is available for use. The water source must be located at a higher elevation than the village to be suitable. Possible water sources to be utilized include

springs, small streams, big streams and rivers. In a spring, water rises to the ground surface from an underground source. The flow in the spring usually varies seasonally and is affected by factors such as the size of catchment basin area, the seepage of the water through the ground and the width of the ground above the aquifer. (Jordan 1980.)

Springs are desirable sources of water as due to filtration through the ground, the water is usually quite free of pathogenic contamination. Small streams, even if they are spring-fed, are not as desirable as springs. Usually the water flow varies seasonally more in streams than in springs. If there is human habitation or animal grazing ground upstream, there is a danger of contamination. During heavy rainfall, the stream might flood, resulting in worse water quality. Big streams and rivers have even greater risk of being contaminated, which makes them least desirable sources. (Jordan 1980.)

An intake structure is built at the source to collect the water. An example of a spring intake is shown in Figure 2 and an example of an intake valve chamber can be seen in Figure 3. A good intake ensures that the water source is protected, there are no leakages and possibilities for contamination are minimized (RWSSP-WN 2009a, 40). If the water has a lot of suspended particles, a sedimentation tank can be constructed after the intake to let these particles settle down. For coarse particles, screening can be added at the intake (Baumann et al. 2010). Break-pressure tanks might be necessary, if the topographical differences would create excessive pressure in the pipe causing the risk of a pipeline burst. (Jordan 1980.)

Figure 2. *A spring intake in one of the visited villages, Kirtipur thulo gau. The spring (on the right) has been covered with stones to protect it. On the front, there are two valve chambers which are used to collect the water and pipe it forward to the reservoir tank.*

Figure 3. *View from inside of the valve chambers at the Kirtipur thulo gau intake. On the left: the water comes from the spring to the first valve chamber from where the two main lines go to the reservoir tank. There is screening in the pipes of the first chamber.*

The water is piped to the village through a pipeline. Shorter transmission mains are preferred when possible, because long distances might require pumping (Baumann et al. 2010). A reservoir tank is usually needed above the village level. From the tank, the water is distributed to tap stands in the village through the main line, branches and tap lines. Tap stands are placed around the village to reduce the distance of carrying water. (Jordan 1980.) Figure 4 shows the basic components of a gravity flow scheme.

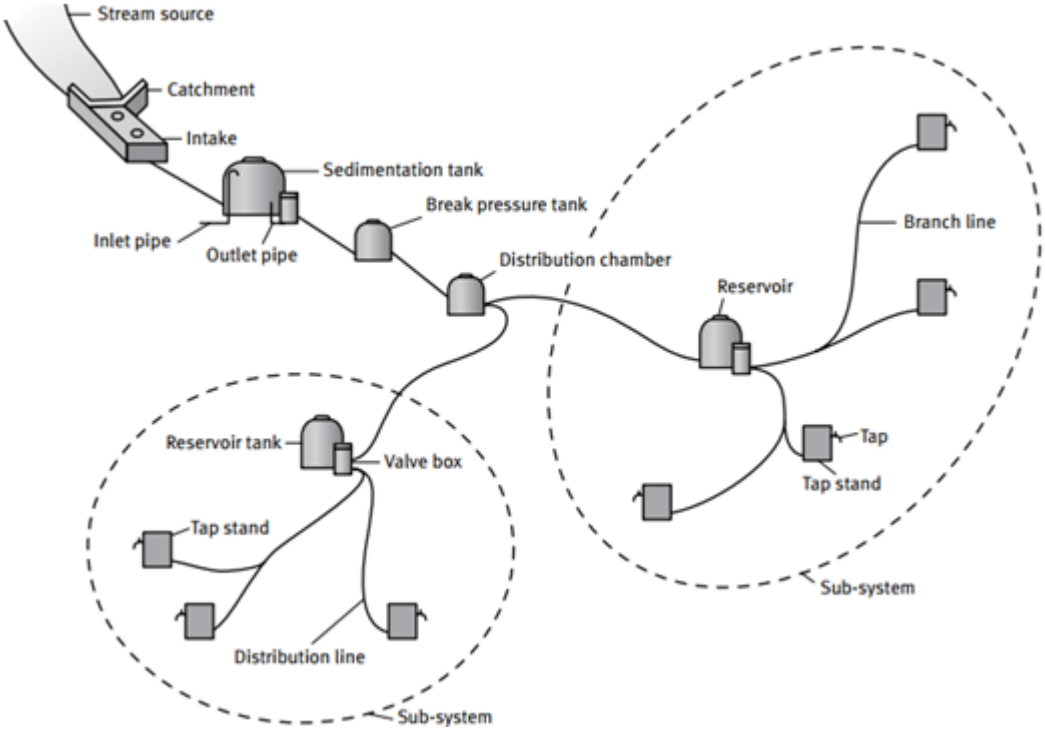

Figure 4. *Typical components of a gravity flow water system (WaterAid 2013a).*

The pipeline should be buried, if possible. The trench for the pipeline should be approximately one meter deep. There is no specific need for the width of the trench, usually it becomes wide enough automatically, because the worker who does the digging has to fit inside the trench to be able to dig. When buried at the depth of one meter, the pipe will be properly protected against heavy animals walking on top of it, insulated from freezing temperatures and it is below the depth of farming plows, too. (Jordan 1980.)

The water source chosen for the scheme should be reliable and adequate. An adequate water source is able to meet the present demand of providing drinking water in sufficient quality and quantity by community and official (such as national or WHO) standards. A reliable source, by definition, meets current and future water demand according to the design criteria both in quantity and quality. The source is reliable if it continues to provide service until the end of the design period. (Lee & Bastemeijer 1991.)

Water systems should be designed and constructed for a lifespan of 15 to 25 years. The design period must be decided at the beginning of the project and it is based on the observations of the village by the surveyor. If the village is very remote, the period can be

longer, but in the areas where development is faster, long-range demands of water are difficult to forecast. Growth rate of population must be estimated and taken into account in calculations. In Nepal, the population growth differs a lot between the geographical zones. The designer also has to consider whether there is the possibility to expand the system in the future. In gravity systems this can be implemented by ensuring that there are suitable places where additional reservoir tanks or public tap stands can be built. (Jordan 1980.)

2.4 Operation and maintenance

Every water supply system needs regular operation and maintenance (O&M) to perform efficiently and continuously (WHO 2012). Even though operation and maintenance are quite different activities, in the context of rural water supply it is common to refer to them in a single term, O&M. Both are necessary for the management of the water system. If there are major problems with maintenance, operation cannot continue, and if operation stops because users find a favorable source of supply, maintenance becomes insignificant. (Carter 2009.)

Operation includes activities that are linked with running the service itself such as general water treatment or mechanical procedures, starting and handling the pumps and control of water intake points. Operational activities can be performed by the user or the operator (Carter 2009). Maintenance includes technical activities planned in advance to keep the system in appropriate working condition when the level of work needed to make the system function is within the capacity of the community (WaterAid 2010b). (Brikké 2000.) According to Carter (2009), major rehabilitation or replacement of the system can be counted as a part of maintenance.

Maintenance can be divided into preventive and corrective. Preventive is conducted to prevent or minimize breakdowns, whereas corrective maintenance is performed after a breakdown has occurred. Preventive maintenance includes activities such as regular cleaning of intake and reservoirs and oiling of movable parts (Brikké 2000). As there will always be some breakdowns, corrective maintenance will be needed. However, with the right kind of preventive maintenance much less corrective maintenance will be necessary. Generally, in rural water programs, the need for maintenance is expected to be lot greater than for operation, unless treatment plants or motorized pumps are being used. (Cairncross et al 1985.) This applies for gravity systems, too (WHO 2012).

O&M of rural water supply systems is often challenging because of scarce resources: the operators are often undertrained or even untrained, as well as getting a low salary or even no salary at all. In the case of rural schemes, the community remoteness might make it difficult to get support from government or external agencies. Available financial resources to investments in repairs are often limited. (WHO 2012.)

2.5 O&M of a gravity flow system

What activities are necessary for operation and maintenance depends naturally on the type of the water supply system. Gravity flow schemes are relatively simple compared to other water supply technologies. For gravity systems, the parts that at least need to be maintained are intake structures, intake surroundings, reservoir tanks, break pressure tanks, pipelines, valve boxes, control valves and tap stands. Operation of the system includes taking care that the water can flow freely, possibly opening or closing valves and keeping the spring's surroundings clean. Some of the necessary activities are listed in Table 2. (Brikké 2000.)

Table 2. *O&M activities of a gravity flow system and their assignment (Brikké 2000, adapted from Fry 1993).*

O&M tasks	Operational responsibility	Financial responsibility
Ensure protection of spring	Community	Community
Check spring box for leaks and cracks, and repair if necessary	Community	Community
Check all pipelines and valves for leaks or breaks, and repair	Community and private contractor	Community
Monitor standpost use to encourage proper use	Community	Community
Check all standposts for leaks, wear and tear, and make repairs	Community and private contractor	Community
Flush all pipelines periodically	Community	Community
Clean standpost concrete apron(s) and drainage area(s)	Community	Community
Check standpost concrete and drainage area, and repair if needed	Community	Community
Conduct repairs on spring box, lines, and standpost if necessary	Community and private contractor	Community or government
Conduct water test for microbiological contamination	Government	Government
In case of contamination, locate and correct the problem and disinfect lines	Private contractor or government	Community and government
Measure water output periodically, at spring and standpost, and assess leakage	Community and private contractor/ government	Community and government
In case of high leakage, initiate leak detection and repair	Community and private contractor/ government	Community and government
Record all operations and maintenance activities in log book	Community	Community
Manage a stock of parts, tools, and supplies	Community, local mechanic, private sector and government	
Rehabilitate spring box/pipelines/standposts	Local mechanic, private sector, government	Community and government

Spare parts and tools are needed for O&M, and their availability is a considerable factor in O&M of the scheme. However, for gravity systems, a relatively simple set of parts and tools are needed: mechanical parts, tools (broom, bucket, machete, trowel and wrench), seals and washers, paint, possibly chemicals or other consumables. (Brikké 2000).

In the community management model, the overall responsibility of O&M is assigned to the communities (see Table 2). For this purpose, a Water User and Sanitation Committee (WUSC) is formed from the community members. The committees are responsible for operating the water system, managing maintenance activities and setting and collecting the water tariff. (Harvey & Reed 2006.) Typically, a specific Village Maintenance Worker (VMW) is hired and trained for each scheme for taking care of the technical O&M tasks. VMWs are nominated, supervised and supported by WUSCs. WUSCs are responsible for motivating the VMW, for example by paying a proper wage for their work. (RWSSP 2004.)

Village Maintenance Worker

The task of a Village Maintenance Worker is to keep the water supply scheme in a running condition. VMW has a major role in the operation and maintenance of the scheme, which affects the whole sustainability of the scheme. The basic requirements for VMW are that they should have adequate skills for the task, be permanent residents of the area and be among the beneficiaries. The responsibilities vary depending on the complexity and size of the scheme. (RWSSP 2004.) Typically, their tasks include solving minor problems such as joining the pipes, repairing the pipes, regulating water supply by opening and closing the shut valve and taking care of the storage for maintenance tools together with the community.

The VMWs should design and use an O&M plan to help the planning and tracking of the O&M activities of the scheme. The plans need to be tailored for each water supply system separately, and they should be updated yearly or when shortcomings are detected. I gained access into one RWSSP Water User Committee Management Manual. This manual mentions that the WUSC has to come up with a comprehensive plan of its own and that WUSCs have received several training sessions for different tasks during the construction of the scheme. (RWSSP 2004.)

The manual described some potential tasks to be included in the O&M plan:

- collect O&M funds and ensure their management
- operating bank accounts for construction and O&M
- ensure payment to Village Maintenance Worker (VMW)
- ensure water tariff collection
- manage preventive maintenance and small repairs
- ensure that outside resources are available for major repairs. (RWSSP 2004.)

As the VMW has a significant role in maintaining the scheme, they should be appropriately remunerated for their work and be employed with a formal contract. The formal contract increases their motivation and makes them take their responsibilities more seriously. Unfortunately, the salaries are often low, and as a result of this, the trained VMWs might leave the community to work somewhere else where they can get a better

salary (WaterAid 2010b; White 2016). In a study from 2013, 28 000 water schemes from Nepal's National Management Information Project database were analyzed and it was found that VMWs were getting paid in only 6000 of the schemes (FCG International & Total Management Services (TMS) 2013a). On average, they were paid 896 Nepalese rupees per month, which is only 25 % of an unskilled laborer's salary. On the other hand, the study showed hardly any correlation between VMW remuneration and the scheme functionality in general (3.6 vs. 3.4 for schemes not reporting remuneration, scale of 0 to 5).

3. COUNTRY CONTEXT - NEPAL

This chapter provides background information on Nepal essential for understanding the context of this study, including some geography, history, ethnical dimensions and administrational structures. At the end of the chapter, the water sector governance in Nepal and NAPA WASH project as well as the target area of this study are presented.

3.1 Country profile

Nepal, officially the Federal Democratic Republic of Nepal, is a landlocked country surrounded by China from the north and India in the west, east and south. Nepal ranges 880 km from east to west and 150-200 kilometers from north to south with a land area of 147,181 square kilometers. The population is approximately 29 million, of whom 83 % live in the rural areas. Nepal's population is demographically young with a median age of 21, while the average life expectancy remains 63 years. The country's capital, which also is its largest metropolis, is called Kathmandu. (WaterAid 2010a; Central Bureau of Statistics 2012.) Figure 5 shows Nepal in a satellite image with the target area of this study, Nawalparasi, circled on the map.

Figure 5. *Nepal in a satellite image (modified from Wikimedia Commons 2013). The study area, Nawalparasi, marked on the map.*

The diverse landscapes of Nepal have led to strongly localized cultures and patterns, and the population has always been ethnically and religiously diverse. The country has

more than 100 ethnic or caste groups and around 60 languages or dialects, and disparities between regions are significant. (Rautanen et al. 2014.) Before the 1950s, the law of Nepal was based extensively on Hindu principles, a legal base to treat people based on discriminative social division. The constitution of 1990 included for the first time a declaration of fundamental rights and equality for all of its citizens. However, the change takes time and discrimination based on caste, ethnicity and gender-based relations is widespread, and stronger in rural areas. (Sharma 2006; Pandey et al. 2006.)

During the past few decades, Nepal has seen improvement in the coverage of health and social services and in education. However, Nepal is one of the least developed countries (LCD) of the world. United Nations (UN) has defined LCDs based on three criteria: low gross national income per capita, weak human resources (indicators regarding health, nutrition, adult literacy and education) and economic vulnerability (indicators such as instability of agricultural production and export of goods and services). (UN-OHRLLS 2014.) Agriculture is the major source of employment and income, contributing approximately 50 % of the gross domestic product (GDP) (Sharma 2006).

Nepal's geography is characterized by difficult and rugged terrain. The area can be divided into three geographical zones: Mountains, Hills and the Terai (Figure 6). Differences in altitude and topography between these zones are pronounced. The Mountain zone is the northernmost part of Nepal with 33 % of Nepal's land area and 10 % of the population. On the Hill zone, the landscapes range between valleys and hills from 1500 to 3000 meters. The uneven surface makes it very challenging to build roads and travelling by foot remains the most common way to move around. The flat Terai plains, a narrow strip in the south along the border of India, consist mainly of fertile agricultural land. The plains are home to more than 50% of the population, with a high population density and the most of the economic activities. (Burbank 2002; Pariyar 2003; Sharma 2006.)

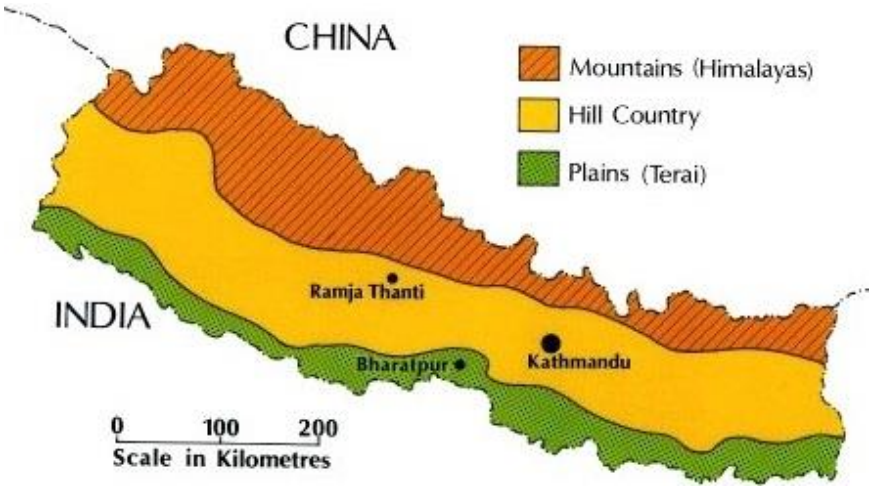

Figure 6. *The geographical zones of Nepal (modified from Tyman, n.d.).*

The climate of Nepal varies from tropical to arctic within the range of 200 km from south to north. The average rainfall is 1500 mm per annum. Monsoon, or rainy season lasts four to five months, from June to September, during which Nepal gets about 80 % of its annual rainfall (see Figure 7). The rain falls often in sudden, heavy cloudbursts. They are usually concentrated and many of them last for several days. This leads annually to many cases of flooding, which cause deaths and damage to property and infrastructure, including water supply systems. Nepal is very vulnerable to floods, as it is to other natural disasters and the effects of climate change (UNDP 2013). (Ahmad 2004; Burbank 2002.)

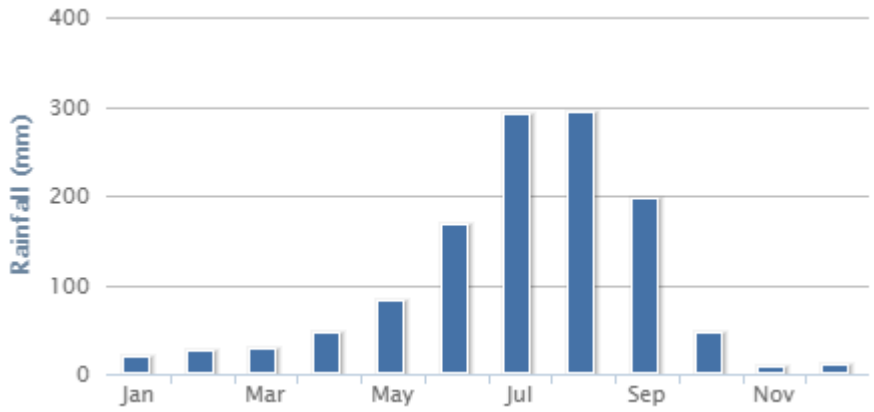

Figure 7. *Average monthly rainfall for Nepal 1990-2012 (World Bank 2016).*

The Himalayan region has been inhabited for thousands of years, but Nepal was unified for the first time by Gurkha king Shah in 1768. After 1846, when a military leader Rana seized the power, made himself prime minister of Nepal and reduced the king's role to ceremonial, Nepal spent more than a hundred years under a reactionary and despotic rule. Nepal's borders were almost completely closed to foreigners. At the time, developing industrial production was perceived as creating conditions for revolutionary potential, and education was forbidden for some time for the same reason. (Brown 1996; Burbank 2002; Sharma 2006.)

In the latter half of the 20th century, Nepal experienced a struggle for democracy. The Rana dynasty was overthrown in 1950 and the king was back in power. The first democratic elections followed in 1959. However, the cooperation between the new king and the cabinet was not smooth and soon the king banned all the political parties and usurped power. Governmental corruption rampaged, but in 1979 the citizens voted for continuing with the same constitution. In 1990, after severe riots, the king handed over most of his power to a democratically elected multiparty parliament. The Maoists did not succeed in the elections, and they decided become an underground party instead. They started to recruit frustrated, unemployed young people particularly from remote rural areas. In 1996, they were able to start armed guerrilla attacks which drove the country into a civil war. (Brown 1996; Burbank 2002; Sharma 2006.)

The internal armed conflict took the lives of over 13,000 people and destroyed a plenty of infrastructure such as roads, hospitals and bridges before ending in 2006, when the government and the Maoists signed a Comprehensive Peace Accord. The monarchy was abolished and the country turned into a republic. Now the country is progressing towards a functioning democracy, although the sociopolitical situation still remains unstable. (Ministry for Foreign Affairs of Finland 2013.) The new constitution was promulgated finally in 2015.

3.2 The water and sanitation sector in Nepal

The WASH sector in Nepal is fragmented, and many institutions and agencies are involved. They have different ways of planning and implementing the projects. The sector coordination is under two key ministries in Nepal: Ministry of Urban Development (MoUD) (former Ministry of Physical Planning and Works) and Ministry of Federal Affairs and Local Development (MoFALD). The responsible departments are Department of Water Supply and Sewerage (DWSS), under MoUD, and Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR), under MoFALD. In Government of Nepal's Rural Water Supply and Sanitation policy from 2004, DWSS was named responsible for the WASH projects with over 1000 beneficiaries, while DoLIDAR is responsible for the smaller ones. There is one other separate body, Rural Water Supply and Sanitation Fund Development Board (RWSSFDB) for the implementation of projects funded by the World Bank, founded in 1996 (FCG International & TMS 2013b). (WaterAid 2010b.)

DWSS, established in 1972, is the leading WASH sector agency. It is officially responsible for water supply policy formation. Its responsibilities include sector coordination and planning, technical standard development, implementation of water and sanitation projects including construction as well as health and hygiene education coordination. It started with focus on larger projects on urban and district central areas but has later expanded to semi-urban and rural areas. DoLIDAR is not focused on WASH projects only but rural infrastructure development in general. Income and livelihood generating activities can be included in the projects. Originally DoLIDAR started with small community schemes. (FCG International & TMS 2013b; Hänninen 2014.) On the district level, the ministries coordinate together to avoid duplication in the operations as the limit of 1000 is not strict, but left to interpretation (WaterAid 2010b).

Administratively, Nepal is divided into five development regions (Eastern, Central, Western, Mid-Western and Far-Western), 14 zones and 75 districts. Districts are divided into villages and municipalities, which are divided into wards, the lowest administrative level. The local governance structure is two-tiered with district level bodies as the higher tier and the village/municipal bodies as the lower. The district bodies are called District Development Committees (DDC) and the village bodies Village Development Committees (VDC). Municipalities have Municipal Councils. Each VDC has 9 wards

while municipalities can have any number of wards from nine upwards. (Hänninen 2014.) The current decentralized governance structure was formed in 1990 after the democracy restauration. The power, duties and functions of the local bodies were set in The Local Self-Governance Act 1999 (2055 BS) and the Local Self Governance Regulation 1999 (2056 BS). (RWSSP-WN, 2009b.)

The implementing body of DWSS at district level is District Water Supply and Sanitation Division or Sub-Division Office (DWSSDO). The implementing body of DoLIDAR is District Technical Office (DTO) but it implements its activities through DDCs and VDCs, too. (FCG International & TMS 2013b.) Specific WASH Units, operating as a part of the DTO, assist user committees in implementing and O&M of WASH facilities, however, they have been facing a lack of adequate technical manpower to provide enough support. (WaterFinns 2014.) In addition, the threat of violence due to civil war dispersed most of the VDC staff for many years, leaving only mainly the secretaries to provide services inside the VDC. This created a leadership vacuum leaving limited chances for communication between the local bodies and communities and a low accountability towards citizens and communities. (RWSSP-WN, 2009b.)

At the district level, District WASH Coordination Committees (DWASHCC) are responsible for planning and coordinating hygiene and sanitation activities overall in the district. The role of DWASHCC is crucial, as there is a large number of actors operating within the district. All the institutions working in the area should be linked to DWASHCC. (FCG International & TMS 2013b). Village WASH Coordination Committees (VWASHCC) operate VDC-wide. Their establishment and role was defined in the Nepal National Sanitation and Hygiene Master Plan in 2010, making them relatively new institutions. They are not only responsible for drinking water and sanitation issues but other issues concerning water resources, namely livelihoods and microfinance. (Haapala et al., n.d.)

Water User and Sanitation Committee (WUSC) is the water users' representative body and the main executive agency responsible for the operation and maintenance of the water supply facilities. WUSC should include members from all caste and ethnic groups so that it represents the beneficiaries adequately. At least 30 % of the WUSC members should be women. WUSCs consist of Chairperson, Vice-Chairperson, Treasurer, Secretary and members. WUSCs should register at their districts' Water Resource Committee in order to legally exist. (RWSSP 2004.) Federation of Drinking Water and Sanitation Users Nepal (FEDWASUN), an umbrella organization for WUSCs in Nepal, supports WUSCs by offering them training and advocacy as well as links them together enabling cross-learning. (FCG International & TMS 2013a.)

Figure 8 shows a simplified organizational structure of the main governmental organizations involved in implementation of rural water supply projects in Nepal.

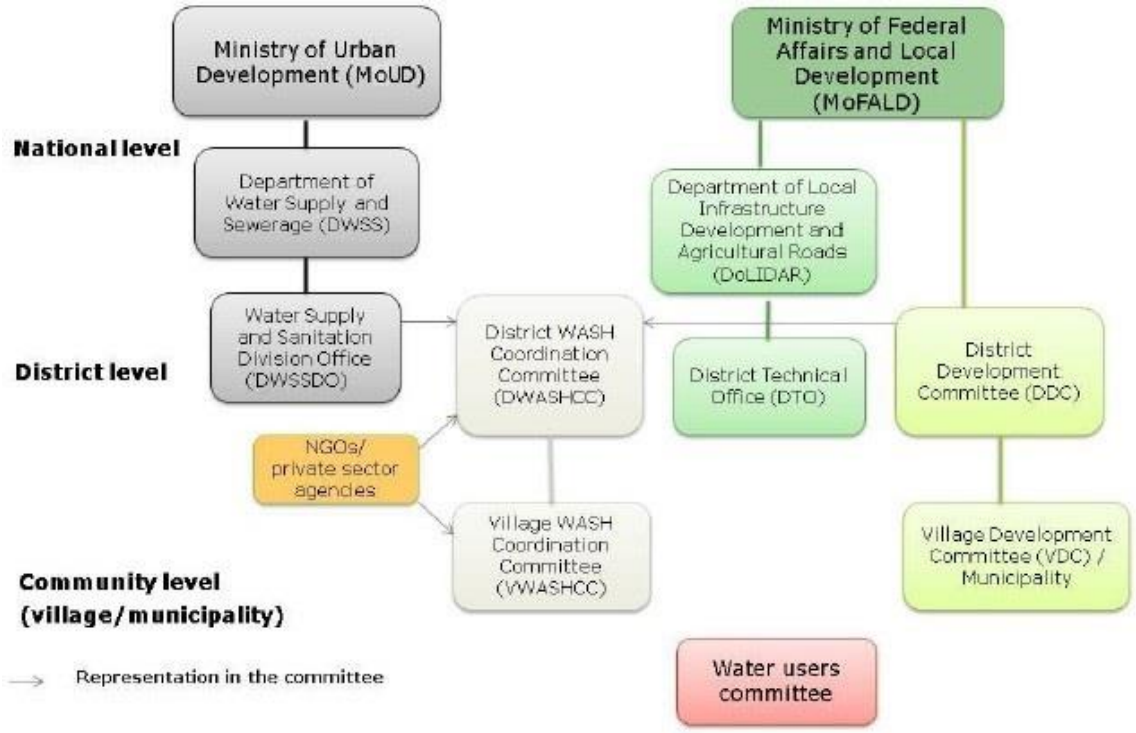

Figure 8. *A simplified organizational structure of the main governmental organizations involved in implementation of rural water supply projects in Nepal (modified from Pesonen 2016).*

Regarding O&M, there is no coordination between WUSC, VDC and DDC to maintain and support the completed water projects. As there is no established monitoring mechanism at national and district levels, a lack of accountability follows. The districts have no budget to support WUSCs in O&M activities beyond their technical or financial capacity. (WaterAid 2010b.) According to Hänninen (2014), the capacity of the local bodies is weak. Based on the Local Self-Governance Act 1999 (His Majesty's Government of Nepal/Ministry for Law and Justice, 10), the VDC is responsible for preparation of drinking water projects for the supply of drinking water required within the village development area - - and to maintain and repair - - wells, deep water, ponds, taps etc. within the village development area. However, the VDCs do not have the capacity to do this. The capacity of DDC is also weak, but it needs less strengthening to be able to fully take over its responsibilities.

3.3 WASH sector cooperation between Finland and Nepal

Collaboration between Finland and Nepal in the WASH sector began in 1988 when the planning of the Rural Water Supply and Sanitation Project (RWSSP), so-called Lumbini project, was started. The actual project began in 1990 and was implemented in six districts of the Lumbini zone in Western Nepal. The first phase (Phase I) of the project

lasted until 1996, during which 110 drinking water and sanitation schemes were constructed and implemented. These schemes served approximately 237 000 people in 54 VDCs.

The Phase II (1996) started in the same area right after, continuing the Phase I efforts. The aims of the Phase II were the capacity development at the district and VDC levels and enhancing the coordination between sector agencies, private sector as well as water user groups. During Phase II, water supply schemes were constructed to serve more than 100 000 people. Phase III (1999-2005) continued from where Phase II left. During the Phase III, water supply coverage expanded for 216 000 more people. (Ministry for Foreign Affairs of Finland 1997; Caldecott et al. 2012.)

RWSSP was recognized as successful by several stakeholders and external evaluations recommended continuing it and replicating the project. The project was thanked for its grounding in community participation, which was demonstrated clearly in the promotion of communities' financial self-sufficiency, holistic view of connecting health and education issues with water and sanitation, acting in the framework of decentralized government, strong gender and social inclusion strategy and adapting into local conditions. (Caldecott et al. 2012.) Therefore, a new project for Western Nepal called RWSSP-WN was started in 2008. Phase I of RWSSP-WN was finished in 2013 and Phase II started right after, scheduled to last until 2018.

Another large bilateral water supply project between Finland and Nepal was the Rural Village Water Resources Management Project (RVWRMP) in the Mid- and Far-Western development regions of Nepal. Phase I of RVWRMP lasted from 2006 to 2010 and Phase II from 2010 to 2015. The project targeted some of the poorest parts of Nepal, ten districts in a mountainous area. The region is remote and difficult to access, driving from Kathmandu takes two days, and to reach the furthest regions one additionally needs to walk for several additional days. In these areas, schools have hardly any teachers, malnutrition is common, and the overall development is minimal; these areas have the lowest Human Development Index values in the whole Nepal. The project's aims were to provide sustainable and equitable water services which increase livelihoods opportunities and improve health, environmental and housing conditions. During the project, comprehensive water-use master plans were developed which emphasized taking environmental issues in consideration. (Caldecott et al. 2012.)

The current Finnish country strategy for Nepal states that Finland will continue to support sectors of water supply and sanitation, education and forestry. The strategy is focused on empowering the most marginalized and vulnerable people of the country, the main target areas being the remote rural areas with the poorest people of the society. The aim is to improve the poorest people's access to basic services and enhance their livelihoods. (Ministry for Foreign Affairs of Finland 2013). NAPA WASH project is in alignment with these strategy lines.

3.4 Background to the NAPA WASH project

Nawalparasi and Palpa Districts Sustainable Water Supply and Sanitation Project (NAPA WASH) is a development cooperation project implemented by WaterFinns with a local Nepalese partner Center for Appropriate Technology Nepal as well as local Village Development Committees (VDC) and Water User and Sanitation Committees (WUSC). WaterFinns, a non-governmental organization based in Helsinki, Finland, implements water-related development projects in different countries with local partner organizations. The aim is to promote water sector professional know-how in developing countries and transition economies while transferring professional knowledge and expertise of Finnish senior experts to WaterFinns' younger members. (WaterFinns 2014.)

The NAPA WASH project has a 3-year life span from 2014 until the end of 2016. Project area consists of 6 VCDs in Nawalparasi and Palpa districts which have approximately 20,000 inhabitants.

The overall objectives of the project are:

- to increase the self-reliance of rural communities
- to change the focus of organizing water supply from short-term construction activities to long-term sustainability
- to increase understanding of the sustainability of WASH services
- to reduce poverty and increase general well-being in the project area.

Four Finnish and three Nepalese students conducted theses as a part of this project. The dissertations are qualitative studies focused on different topics related to sustainability in rural water supply schemes. Other parts of this project focus on capacity building at village and district levels. VDCs and WUSCs will be facilitated to plan, allocate funds and implement O&M plans in their area. (WaterFinns 2014.)

The project contributes to the formulation of a coherent National WASH program by bringing thorough understanding about the different factors affecting the long-term sustainability of WASH programs. Successful community practices and strategies along with faced difficulties were studied. The project also adds Monitoring and Evaluation data to the national database and brings light into the community management problems (e.g. shortage of funds or technical skills, natural calamities, discriminatory practices) throughout the life cycle of WASH facilities. (WaterFinns 2014.)

4. RESEARCH METHODS

In this chapter, the methodologies of the quantitative and qualitative studies are presented. The quantitative study was implemented to get a "big picture" of the sustainability of the gravity flow schemes in the Nawalparasi district, and the qualitative case study deepened and clarified the conclusions of the quantitative study.

4.1 Quantitative study design

The quantitative data collection was made with a structured questionnaire for VDC officials, WUSC members, VMWs and water user households (HH). The data was collected by Nepalese enumerators in Nawalparasi between January 16 and February 5, 2015. The main responsibility for the design and implementation of the quantitative data collection in NAPA WASH project was under the Nepalese partner organization CATN. The study design included preparing the representative sampling framework, sampling, preparing the questionnaire, conducting the survey and analyzing the results. For the first three steps, the WASH experts and statisticians of CATN did most of the work, but WaterFinns' senior experts and the student researchers were included in all the steps, giving their comments. The Nepalese enumerators hired by CATN conducted the survey, after which the results were sent to the NAPA WASH student researchers to analyze.

4.1.1 The sampling framework

The sampling framework was based on the objectives of NAPA WASH project, one of them being the assessment of the long-term sustainability of the gravity flow water supply services supported by Finland in RWSSP projects. To make the sample representative, some additional criteria were needed. The schemes were selected according to the following criteria:

1. The scheme must be a gravity flow scheme constructed in RWSSP project and older than 10 years
2. The scheme must have been implemented with 50:50 funding modality
3. Schemes from all phases (I, II, III) of RWSSP must be included
4. Schemes from different geographical locations (Hills, Inner Terai, Terai) must be included
5. Both large (>=150 households) and small (<150 households) schemes must be included

All in all, 76 schemes located in 24 different VDCs or municipalities in Nawalparasi district fulfilled the first two requirements. A sample size of 40 schemes was considered representative for Nawalparasi. At least one scheme needed to be selected from each VDC or municipality, and the rest of the schemes were selected based on the criteria 3 to 5. The final sample included 15 schemes from RWSSP Phase I, 17 schemes from Phase II and 8 from Phase II. 12 of the schemes were large and 18 small; 25 schemes were located on the Hills, 12 in Inner Terai and 2 in Terai. The number of Terai schemes is small as this study only includes gravity schemes which require such topographical differences as usually do not exist in Terai area. From every scheme, the WUSC and one VMW were interviewed. For every VDC or municipality, an interview for one or a group of VDC level officials was conducted.

The proper sample size for household level survey was considered 17 households (HHs) from each scheme, making the total sample size 680 HHs. For each scheme, HHs were selected from three different ethnic groups (Brahmin/Chhettri/Thakuri, Janajati, Dalit) so that they would represent the ethnic composition of the all households which use water from the scheme. The final selection of the households was done with a systematic random method. Figure 9 illustrates the sample of the quantitative study.

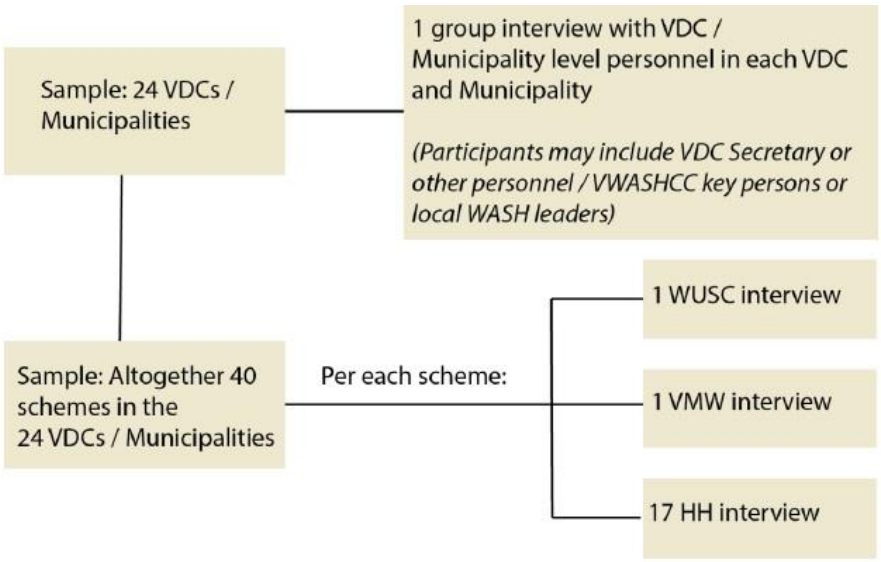

Figure 9. *The sample selection for the quantitative study (Liski 2016).*

4.1.2 The data collection

The quantitative data was collected through questionnaire-based interviews. Most of the questions were close-ended for all the four different interviewed groups. The whole quantitative questionnaire is being shown in the Appendix of Liski (2016).

The VDC level interviews included questions of the remoteness of the VDC/Municipality, general questions of the WASH situation and strategy in the area

and questions regarding natural hazards and preparedness for them. The WUSC level interviews included questions of the remoteness of the scheme, general technical questions (construction, rehabilitation, water yield, number of taps etc.), questions of number and ethnic composition of HHs in the area, social accountability of WUSC, environmental sustainability and climate change mitigation, and institutional, financial and technical management sustainability of the scheme. The VMW level questionnaire included questions regarding training, tools, nature of the work, and payment and contract. The HH level questionnaire included questions regarding household characteristics, water services at HH level, users' assessment of social accountability of WUSC, water safety practices and willingness to pay.

For this thesis, the most relevant questions in the VDC level interview were the questions regarding remoteness and VDC's technical/financial support to the scheme in the case of a scheme breakdown. In WUSC level interview, the most important questions were about the scheme remoteness, availability and quality of tools, O&M training of WUSC members, O&M fund, availability and skill of VMW. The whole VMW level questionnaire was of interest to this thesis. In HH level questionnaire, the most interesting questions were about the HH's opinions of scheme O&M, quality of rehab works and VMW services in the scheme.

4.2 Qualitative study design

Qualitative research aims to find out about the world by interpreting the actions and perceptions of its actors and interacting with them. Qualitative methods are used to explore the character and reasons for individual behavior, what makes our world meaningful for people. It is typical for qualitative research to collect data in natural settings, where people live their everyday lives. Qualitative methods build theory from observations, inductively, rather than testing a theory. There is a variety of methods available for qualitative research, such as interviewing, conversation and discourse analysis, fieldwork diaries, ethnography, participant observation and inspecting documents such as photographs, letters and films. Qualitative methods can be effectively combined with quantitative ones, too. (Brockington & Sullivan 2003.)

As opposed to quantitative methods, qualitative methods have been called anecdotal, or that they are used in situations where it is not possible to form precise data with hard facts. However, they are a powerful tools in situations where one needs to address the "why" questions, the actual reasons behind the numbers. With quantitative methods, data can be produced which for example tells about the numbers of drug abusers, levels of street crime and HIV infection rates or other problems among the urban poor. But these numbers do not answer questions such as why people use drugs or what do people gain from using drugs. This is where qualitative methods step in. (Brockington & Sullivan 2003.)

The methods need to be selected according to the focus and objectives of the research. There is no "good method", but some might better suitable than others, depending on the purpose of the research. As this study looked into the variety of problems experienced by the communities with the O&M of gravity flow schemes and the solutions they have developed to tackle them, it was best to ask primarily from the water committees and maintenance workers themselves about them. The methods selected for this study were literature review, interviews with key informants, focus group discussions and direct observation of the target communities and walkthroughs in the area.

Literature review is necessary for most research projects. It is useful when the research is a part of a larger study, reliable enough data about the target population exists or some of the research questions might be already answered by existing data. (Laws et al. 2003.) The purpose of a literature review is to draw together from the important books, articles and other sources that have previously been written about the area of interest, and evaluate and analyze this material (University of Illinois at Urbana-Champaign 2015).

Interviews are useful when there is a need to know about people's views or experiences on some level and one is able to rely on the information given by a rather small number of informants. (Laws et al. 2003.) Interviews are usually divided into structured, semi-structured and unstructured, although the differences between them are sometimes not easy to tell. Structured interviews are conducted with a pre-set list of questions, semi-structured interviews have a list of suggested themes and unstructured interviews provide the interviewee the chance to take the interview in any desired direction. Semi-structured interviews are usually the most popular, as the researcher can confirm that the important issues are discussed, but the interviewee can bring forth their own ideas. (Willis 2006.)

Focus group discussions are interviews where around 6 to 8 people are brought together to discuss. Often they share some experiences, but sometimes this is not the case. During the discussion, the interaction between the members should be encouraged. (Laws et al. 2003.) Focus group discussion is an excellent tool for examining collective views on social issues and observing group behaviors and interactions, for example what kind of contradictions precede a collective decision. The discussion might also drive the individuals for the first time to reflect why they maintain their daily routine or act in a certain way. (Lloyd-Evans 2006.)

Observation is important in all research. By observing the researcher can cross-check whether what people say is reflected in their actual actions. Observation can produce a lot of data in a rather short time, can generate a basis for a discussion with the observed and directly tells what people do. Observation is a good tool for correcting the researcher's preconceived perceptions (Donge 2006). On the other hand, it doesn't tell of the

people's motivations, can lead to oversimplifying and the presence of the observer can change the behaviors of the people. (Laws et al. 2003.)

4.2.1 The sample selection

The schemes for the qualitative study were selected from Nawalparasi district in Western Nepal. Schemes from Palpa district, which is the other district included in NAPA WASH project, were not considered due to the quantitative study having not yet been implemented in the area at the time of selecting the schemes. It would have been challenging to choose the schemes without enough background information. According to the project staff, the water supply situation in Palpa is worse than in Nawalparasi, one of major reasons for this being that the terrain is hillier and the district more remote.

The final scheme selection for this study ended up being "all the schemes from the area of the former Devchuli VDC". The location of the former Devchuli VDC in Nawalparasi district can be seen in Figure 10. Devchuli VDC was merged together in 2014 with Dibyapuri and Pragatinagar VDCs, establishing Devchuli Municipality, but only the former Devchuli VDC was chosen as a target area for this study. The number of the schemes was unknown that this time but the staff of NAPA WASH project estimated it would probably be approximately 20. After my arrival in the area, the actual number of schemes was revealed as 11, but it was approved by the project staff as a sufficient number of schemes for this kind of study.

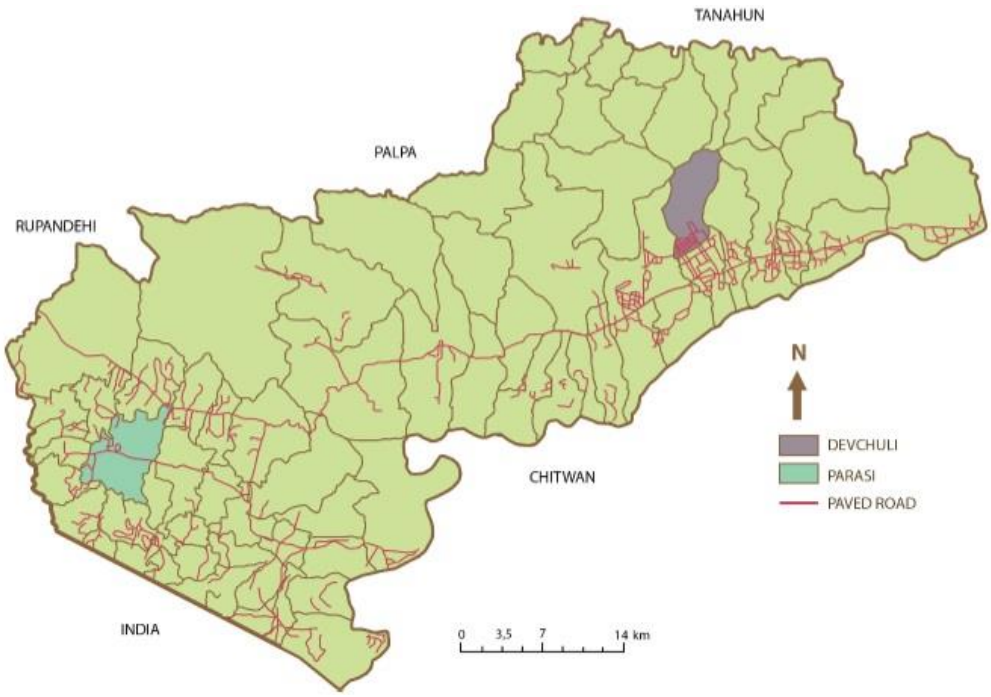

Figure 10. *The location of the former Devchuli VDC in Nawalparasi. The district capital Parasi is also marked in the picture. (Modified from Liski 2016.)*

Other Nawalparasi VDCs, Mainaghat, Benimanipur, Dedgaun and Ruchang were considered as target areas, too. Mainaghat was considered because I gained access to a social assessment report of Mainaghat VDC from 2003 which would have worked as interesting background material for a new study. Finland-supported schemes needed to be included in this study, and based on the quantitative survey, Benimanipur, Dedgaun and Ruchang were the only VDCs in Nawalparasi among Devchuli that for certain had at least 3-4 Finland-supported schemes in each VDC.

In the end, Devchuli was selected because based on the quantitative study, the VDC seemed to be more developed, WUSCs seemed to be more active and the situation regarding water supply seemed to be better there than in the other areas, while there was also some variation between the schemes. The results from the quantitative study are further elaborated in chapter 5 where one can compare the results of Devchuli with the results of the whole sample of Nawalparasi. In Devchuli there was supposed to be one scheme constructed in the 1960s, which I wanted to know more about.

The idea behind the selection was to study the change in development within the VDC, as it is known that the change tends to be faster and people's demand for better services tends to be higher in the schemes closer to big roads and it could have been one of the specific reasons for some schemes/WUCs operating better than others or being more successful than others, which were being looked for in this study.

Devchuli belongs geographically to the Inner Terai area, which means that some parts of Devchuli are situated on flat Terai plains, whereas some parts are located on the hillier area (Figure 11). The southern border of the former VDC area is only 4 kilometers from a highway through Nawalparasi district which leads to Kathmandu. Right at south of Devchuli, there is a busy market center called Daldale.

Figure 11. *The main road through the Devchuli VDC, plain Terai area in the front and hills in the background.*

4.2.2 The data collection

The research methods used in this study consisted of literature review, interviews with key informants, focus group discussions, direct observation of the target communities and walkthroughs in the area. Documents used in this research included guides for designing gravity systems and their operation and maintenance, WASH guidelines, reviews, plans and reports of the previous water projects in the target area, statistics of the population of Nepal and research papers, theses and dissertations about rural water supply in Nepal and other countries. Documents were obtained from NAPA WASH staff, informants in Devchuli, Finnish libraries and online.

I started familiarizing myself with the topic by carrying out literature research. The fieldwork in Nepal took place between April 1 and May 15 in 2015. Most of the field trip time was spent in the target villages. Part of the time was spent in Kathmandu preparing for the fieldwork period with the staff of Center for Appropriate Technology Nepal who are working for the NAPA WASH project. Analyzing the results and writing the thesis was done between June 2015 and November 2016.

Interviews

Interviews were conducted on VDC or Municipality level, community level and household level. The plan was to include a few district level official interviews (DDC, DWS-SDO), too. Due to the Gorkha earthquake that occurred during the fieldwork time, the

officials were occupied with other more urgent work and the interviews were not possible. Focus group discussions were conducted with the Water User and Sanitation Committees. They were an easy choice for focus groups, as they would know best what is going on in their water scheme. The views of all the members and the dynamics between the members were of interest.

The interviewed officials on VDC or Municipality level were:

- The chairperson of the Devchuli Municipality
- Ward chairperson for wards 6-9 in the Devchuli Municipality
- VWASHCC staff could not be interviewed due to inactivity of VWASHCC in Devchuli, but VWASHCC meeting minutes were available and studied.

Interviewed on community level:

- 10 WUSCs, from all schemes operating in the former Devchuli VDC area
- one woman's group from one scheme with WUSC members and water users
- VMWs from all the schemes, some of them had more than one VMW
- office secretaries and meter readers from a couple of schemes
- the staff of Amarapuri WUSC, who work for the NAPA WASH project
- the managing director of the Pragatinagar WUSC, a large scheme in former neighboring VDC of Devchuli, nowadays part of the Devchuli Municipality.

Interviews on household level:

- a few randomly selected households from different schemes in former Devchuli VDC area.

Other interviewed persons

- staff of WaterFinns' Nepalese partner organization Center for Appropriate Technology Nepal (CATN)
- interpreters and support staff in the villages.

Interviews included a combination of structured, semi-structured and open questions. The questionnaires (one for WUSCs and one for VMWs, available in the Appendix) were conducted during the fieldwork period, after having spent approximately two weeks in Nepal, when the circumstances were a bit more familiar. The questionnaire included questions about the basic characteristics of the scheme along with questions based on the research questions of this thesis. The questionnaires were not tested per se, but they were modified somewhat after the first interview. As the interviews were semi-structured, the interviewees were allowed and encouraged to talk freely and answer the questions in a longer fashion if they wanted to. Some of the interviews ended up being very long, for example the visit to Mirtung khola scheme and the WUSC interview took

altogether 9 hours, although this included a transect walk with the villagers to the source, reservoir tank and around the village.

The fieldwork process

The fieldwork started in the beginning of April 2015 as I arrived in Nepal. The first four days were spent in Kathmandu meeting with the staff of Centre for Appropriate Technology Nepal, discussing about the research topics and the practical arrangements regarding the fieldwork period. Another Master's Thesis student from the NAPA WASH project was with me for the first two weeks of the fieldwork time. On April 5 we and our interpreters departed Kathmandu and arrived in Devchuli.

Learning about the water schemes and the village life started right after the arrival in Devchuli, given a place to stay in one of the community's key persons' house. He had been strongly involved with the water projects earlier, even being the one who originally applied support from RWSSP to get water supply in the village. This family, together with the NAPA WASH staff working in Devchuli, gave information about the schemes in the area and their locations, provided the contact details of the WUSCs as well as showed us around and told about life in the village. Staying at the homes of local people provided an opportunity for exchanging information in a more informal way and gaining better mutual understanding on both sides.

Visiting the schemes and interviewing the WUSC members and other informants started the next day with a visit to the reservoir tanks of two water schemes and the shared spring/river source of these two schemes. Some WUSC members of these schemes were with us during the visits so interviewing was easy. The work continued in a similar manner, interviewing WUSCs, VMWs and other informants for the rest of the time spent in Devchuli which altogether lasted for one month.

5. RESULTS AND DISCUSSION

In this chapter, the results from the quantitative and qualitative studies are presented. Altogether, there were 11 schemes in Devchuli VDC area. All the schemes were visited during the qualitative study, and 3 of these were included in the quantitative study.

In the quantitative study, officials from 24 VDCs, 40 WUSCs, 39 VMWs and 680 HHs (17 HHs from each scheme) were interviewed. The results for Devchuli from the quantitative study are highlighted for most of the questions. The purpose of this is to give perspective for all the results in general, as these schemes were also visited during the qualitative study and they are presented in more detail later in this chapter.

As one can see, the Devchuli schemes included in the quantitative study were from the larger end of all the schemes included in this study (n=40 schemes) and more developed than the others. During the qualitative study it was revealed that these three schemes from Devchuli included in the quantitative study were the most successful of all 11 schemes in Devchuli. This means that one has to think the quantitative Devchuli results in the light of the qualitative study and vice versa.

5.1 The quantitative study

In this chapter, the results of the quantitative study are presented. They are classified in four different sections, according to the interviewed groups: VDC representatives, WUSC members, VMWs and households.

5.1.1 VDC level questions

Remoteness of the VDCs, which is a very important factor regarding sustainability, was analyzed with a few questions. Availability of a road connection makes reaching the village a lot easier. There was a year-round road connection to the VDC center for 38 % of the VDCs, and for 62 % there was not. For those VDCs without a year-round road connection to the VDC center, the average distance to this kind of a road was 6.1 km, and for 93 % of these VDCs there was a seasonal road to the VDC center. Devchuli is located on Inner Terai and there is an all-year round road connection.

Availability of tools and spare parts is connected to remoteness of the VDC. The VDCs were asked if there was a hardware shop within the VDC selling small water supply fittings and tools such as small wrench, spanner, faucet tap or socket. The shop did not have to have complete fittings and tools for new construction. Altogether 38 % of the

VDCs had a hardware shop in their area, and for those who did not have, the average distance to the nearest shop from the VDC center was 30.2 km. Devchuli was one of the VDCs with a hardware shop in the area.

The VDCs were asked if the WUSCs get financial or technical support in case of a breakdown of the scheme beyond the capacity of the WUSC. Of the VDCs, 46 % replied the WUSCs get both technical and financial help, 17 % only financial help and 37 % that no help was available. None of VDCs reported WUSCs getting only technical help. The help would mainly come from (multiple answers were allowed) the VDC (46 % mentioned) or from DDC (38 % mentioned). NGOs were mentioned as the source of the help by 25 %, DWSSDO by 25 %, other government offices by 8 % and DWASHCC by 4 %. Devchuli reported both technical and financial help being available to the WUSCs, from DDC, DWSSDO, VDC and NGOs.

5.1.2 WUSC level questions

The sample included 40 WUSCs. In the sample, there were three schemes from former Devchuli VDC area. On average, the schemes in the sample were constructed in 1996. Rehabilitation works had been done in 20 % of the schemes. The schemes of Devchuli had been constructed in 1995, 1997 and 1999, and all of them had been rehabilitated.

Remoteness

There was a year-round road connection to the main village of the scheme for 38 % of the schemes, and for 62 % there was not. For those schemes without a year-round road connection to the main village of the scheme, the average distance to this kind of road head was 5.8 km. For the schemes without a year-round road connection, there was a seasonal road connection to 76 % of schemes. Another way to analyze remoteness was to ask from the WUSCs if there was a hardware shop in the scheme area selling tools for small repairs such as small wrench, spanner, faucet tap or socket. Tools for complete new scheme construction did not need to be available. There was a shop available in 30 % of the scheme areas and in 70 % there was not.

General scheme information

The WUSCs were asked about the scheme construction implementation modality, and three answer options were given: scheme was constructed either by the WUSC, a construction company or the funding agency. This question reflects perception of the ownership of the scheme. It is better if the WUSCs perceive they were in significant role in the scheme construction. Some 70 % of the WUSCs answered the scheme was constructed by the WUSC and 30 % by the funding agency. All the Devchuli WUSCs replied WUSC being the one who constructed the scheme.

The average number of households using water from the schemes was 288 HHs. There were less than 100 HHs in 42 % of the schemes, 100 to 500 HHs in 48 %, and more than 1000 HHs in 10 % of the schemes. The Devchuli scheme sizes were 320, 450 and 500 HHs, which means that they were on the larger side of the sample. The average WUSC size was 10.3 members, whereas all the Devchuli WUSCs had 11 members. The average number of current WUSC members who had received training on O&M of water supply system was 1.2 per WUSC. For Devchuli, the numbers were 0, 2 and 11 members per WUSC.

The number of community taps built at the time of scheme construction on average was 19.2 taps. There were less than 25 taps per scheme in 83 % of the schemes, 25 to 45 taps per scheme in 12 % of the schemes and approximately 100 taps per scheme in 5 % of the schemes. At the original construction year, some private connections alongside public taps had been constructed in 8 % of the schemes. Currently, in 40 % of the schemes there were private connections. In 35 % on the schemes, there were only private connections. The Devchuli schemes had only private connections.

Associations of WUSC

The WUSCs were asked if they were associated with organizations which would help them in finding funding and technical support, and in capacity building for improving functionality of the scheme (multiple answers were allowed). The most common answer was that the WUSC was not associated with any organization (35 %). For the WUSCs that had connections, the most common one was VWASHCC (28 % of the schemes). All the connections can be seen in Table 3. Devchuli WUSCs told they had 2 to 4 connections per scheme, to VWASHCC, WASH Unit of DDC, Repair and Maintenance Unit of DWSSDO, NGOs and District Land Conservation Office.

Table 3. *WUSCs connections to institutions which can give help in improving the functionality of the scheme.*

Connections of WUSC (multiple answers)	% of WUSCs (n=40)
None	35 %
VWASHCC	28 %
WASH Unit of DDC	25 %
Repair and Maintenance Unit of DWSSDO	20 %
NGOs	15 %
VDC	10 %
District Land Conservation Office	8 %
FEDWASUN	3 %

O&M cost recovery and water tariff

The WUSCs were asked of the main pricing model of the scheme. The answer options and the number of WUSCs can be seen in Table 4. The enumerators clarified the meanings of these terms in the interviews the following way: O&M is regular expenses of the office such as meetings, travel, chlorination or water quality test. Repair is works carried out to repair structures, pipelines and replacing valve and fittings in the scheme. Rehabilitation is carried out in the scheme when pipelines and structures need to change due to high population growth or some other reason, and it needs technical design with support of engineers or overseers.

Table 4. *The main principle of pricing model in the schemes.*

Principle of tariff	% of WUSCs
to pay VMW only	43 %
to cover VMW and O&M	10 %
to cover VMW, O&M and repairs	18 %
to cover VMW, O&M, repairs and rehabilitation	5 %
to cover repairs only	18 %
other (specify)	8 %
Total	100 %

The three WUSCs which replied "other" did not have water tariff. Two of the Devchuli VDCs answered that the tariff covers VMW, O&M and repairs and one answered it covers VMW, O&M, repairs and rehabilitation.

An O&M fund existed in 75 % of the schemes, while 25 % had no fund. The total amount of funds currently available for the O&M of the schemes was on average 442 000 Nepalese rupees (NPR). In 57 % of the schemes with the fund, the balance was less than 100 000 NPR, 30 % had 100 000 to one million NPR and 10 % had more than one million NPR. There was a typing error in the results for one scheme. O&M fund was mainly kept in a bank account (77 % of the WUSCs) or as a loan to needy with interest (33 % of the WUSCs). All of the Devchuli schemes had an O&M fund which was between 400 000 and 500 000 NPR. All the Devchuli WUSCs were keeping some or all of the money on a bank account. Two WUSCs had also given a loan with interest.

A fixed monthly salary was being paid to the VMW in 75 % of the schemes, in 17 % schemes no salary was being paid at all and in 8 % schemes single payments were being paid when maintenance work was being done. VMWs were usually paid with cash (73 % of WUSCs who paid salary) and in few cases with grains (18 %), labor exchange (6 %) or both cash and grains (3 %). The annual VMW salaries are presented in Table 5. If there were many VMWs in the scheme, only the salary of main VMW was included. On average, the VMWs were paid 45 500 NPR annually. The Devchuli VMWs were paid

more than the average VMW, two even more than double the average VMW salary, the salaries being 63 000 NPR, 102 000 NPR and 126 000 NPR.

Table 5. *Annual salaries of VMWs.*

Annual VMW salary (NPR)	% of VMWs (n=33)
< 10 000	30 %
10 000 - 50 000	42 %
50 001 - 100 000	9 %
> 100 000	18 %
Total	100 %

The WUSCs were asked how much money was collected from households for O&M and repairs during the past 12 months and how much was used. This included expenses used in structure and pipeline repairs, changing of valves and fittings works. Salaries and office expenses were not included. 75 % of the WUSCs had not collected or used any money at all, 25 % had either collected or used money.

For 20 % of the WUSCs, the water tariff was adequate to cover all the necessary O&M expenses and for 80 % not. The WUSCs were asked to state the main reasons why the tariff was inadequate to cover the expenses (multiple answers were allowed). The too high O&M cost of scheme was stated as the reason by 30 % of the WUSCs, 30 % said the service level of water supply is poor and they are not justified to charge higher tariff, 15 % said users would pay higher tariff only for a private tap, 10 % said the water quality should be better and 8 % that all the money goes to the VMW as salary.

Next, the WUSCs were asked if the present tariff was not adequate, what kind of plans they have to increase the amount of funds for O&M when there is a need for repair (multiple answers were allowed). The most common answer was that there is no plan (35 % of the WUSCs). Increasing the tariff or asking funds from the VDC was mentioned by 20 %, asking funds from an NGO or donor was mentioned by 18 %, and 3 % were planning a transition to private taps and metering which would justify a higher tariff.

VMW, tools and materials availability

There were trained VMWs in 75 % of the schemes. General VMW availability in the area was screened by asking how many trained VMWs there were in the scheme area to carry out the maintenance of the scheme but not necessarily employed at present. There was no VMW in 25 % of the schemes, one VMW was available in 25 %, two VMWs in 33 % of the schemes and more than two VMWs in 17 % of the schemes.

The next question was about if the WUSC knew any skilled technical people in the area who could work as a lead person to construct and repair water supply structures, pipelines and fittings. The most common answer was that the WUSC do not know personally but know where to ask for when needed, such as VDC, DWSSDO, DDC, FEDWASUN or NGO (40 % of the WUSCs). One fourth (25 %) replied the current VMW is able to carry out all the needed works, 25 % replied they do not know anyone and 10 % told they know someone else than VMW and have used his/her services. All the Devchuli WUSCs told VMW can carry out the works.

The availability of a highly technical person to carry out survey and design of major repair/rehab works (overseer or engineer) was asked next. Almost half of the WUSCs (45 %) did not know such a person personally but knew where to ask for when needed, 30 % did not know anyone, 22 % knew someone else than VMW and had used their services and 3 % told the current VMW is able to carry out all the needed works. All the Devchuli WUSCs said they know someone else than VMW and have used their services.

The WUSCs were asked to assess their own knowledge about where to purchase materials and fittings for the repairs. Most (53 %) knew where to purchase minor tools and fittings, 33 % knew where to purchase larger tools, fitting and materials for rehabilitation and 14 % did not know where to purchase any tools and fittings. All the Devchuli WUSCs told they know where to purchase larger tools and materials.

Most WUSCs (60 %) told they had purchased materials and spare parts since the construction of the scheme and they were satisfied with their quality, 8 % told they had been not satisfied with the quality and 32 % told they had not purchased tools or materials. To the question of the current stock of tools, 17 % told they have sufficient tools and equipment for repairs of the scheme, 75 % told their tools are insufficient and 8 % said they have no tools at all. All the Devchuli WUSCs had purchased tools and their quality was good. Two of Devchuli WUSCs said they have insufficient tools and one WUSC said tools are sufficient.

Quality of scheme design and construction

The WUSCs were asked to score the WUSC's participation in the design of the scheme (WUSC involvement in selection of the design itself, level of services, cost, post-construction operation of the scheme) on the scale of 1 to 5, 1 being very poor and 5 very good. If none of the original WUSC members were present, the question would be skipped. The average grade for all the schemes was 4.4 and for Devchuli schemes 4.7. Similarly, the WUSCs were asked to score the quality of design of their scheme (whether it matches the desire of community for level of services, is it the best possible alternative to operate and maintain by the community and so on). The average grade for all the schemes was 4.1 and for Devchuli schemes 4.3.

The quality of construction work of the scheme and the used materials was similarly assessed by the WUSCs. The average grade for all the schemes was 4.2 and for Devchuli schemes 4.7. The quality of repair works and materials was also assessed by the WUSCs. The average grade for all the schemes was 3.6 and for Devchuli schemes 4.7. The present functionality condition of the scheme was assessed by the WUSCs with a similar definition as in National Management Information Programme (NMIP), a national scheme functionality database. The scale can be seen in Table 6. The average grade for all the schemes was 3.3 and for Devchuli schemes 4.

Table 6. *The assessment scale of the scheme functionality.*

Grade	Definition	
5	Fully functional	no need for repairs
4	Minor repair	can be repaired by WUSC without external support
3	Major repair	needs repair with external technical (technician) and/or financial support
2	Rehabilitation	needs repair with both technical (engineer)and financial external support
1	Not functional at all	no taps functioning in the scheme (closed down)

Only one fifth of the 40 schemes were fully functional. The WUSCs from "not fully functional" schemes were asked to state due to which problems the schemes were not fully functional (multiple answers were allowed). The increased number of households in the area was mentioned by 40 % of those WUSCs, insufficient yield from the water by 27 %, users' demand of a private connection by 27 %, problems with water quality either at the source or at the taps by 27 % and some other reason by 27 %. For Devchuli, the reasons for the two schemes not being fully functional were increase in the amount of households and water quality not being good at the source.

5.1.3 VMW level questions

Altogether, 39 VMWs from 40 schemes were interviewed, one VMW could not be reached.

Acquirement of VMW skills

The VMWs were asked how they learned their skills and profession. The majority (74 %) of the VMWs told they either learned their skills on the job during the construction of the scheme or through other work experience. Approximately one fifth (18 %) had been previously trained, 5 % had learned both through training and work experience and 3 % told they are not skilled to do repair works. Next, the VMWs were asked of the types of trainings they had received (multiple answers were allowed). The most common trainings were VMW and plumbing trainings. About one fourth (26 %) of the VMWs had had both VMW and plumbing trainings (26 %). One or two VMWs had had more specified trainings such as water tank and dam construction training, biogas plant construction training and pipeline calcium mitigation training.

Table 7. *Types of trainings received by the VMWs.*

Type of training received (multiple answers)	% of VMWs (n=39)
VMW	49 %
Plumbing	49 %
Masonry	15 %
Social mobilization	13 %
Other (specify)	8 %
Latrine builder	5 %
Water Safety Plan	5 %
Rainwater Jar construction training	0 %

The VMWs were asked if they had confidence in their ability to do O&M works. The majority (85 %) told they were confident of very confident, 12 % "to some extent" and 3 % could not say. All Devchuli VMWs were confident or very confident.

Availability of tools

The VMWs were asked about the availability of tools. The most (79 %) said they have limited tools, 13 % said they have sufficient tools and 7 % had no tools. Two thirds of the VMWs (67 %) were in the possession of the tools themselves, 21 % told tools are being kept in the WUSC store, 5 % VMWs had no access to tools and 7 % did not answer. Two Devchuli VMW had limited and one had sufficient tools, all were in the possession of the tools.

About a half (54 %) were aware of a shop where they could purchase small tools and fittings, 21 % knew a shop for larger tools and fittings for rehabilitation and 25 % were unaware of any shop selling tools. In 72 % of the schemes, WUSC was responsible for purchasing the tools, in 13 % of schemes the VMW and 15 % did not either know or give an answer. About a half (54 %) rated the quality of tools and fittings good, 21 % not good and 25 % had not yet purchased tools. Two Devchuli VMWs knew a shop for small tools and one for larger tools. In two Devchuli schemes, WUSC purchased the tools and in one scheme the VMW. The quality of the tools was good in all Devchuli schemes.

Nature of VMW work

The VMWs were asked questions about the content of their tasks and their workload. Pipeline was the component which needed the most frequent maintaining from the VMWs. The components are listed in Table 8. All the Devchuli VMWs mentioned taps or private connections and two VMWs mentioned the pipeline.

Table 8. *VMWs' opinions on which scheme components need most frequent maintaining.*

Major components to maintain frequently (multiple answers)	**% of VMWs (n=39)**
Pipeline	77 %
Source and intake	62 %
Tap, faucet or private connection	38 %
Reservoir tank	31 %
Washout valve	15 %
Break-pressure tank	8 %

The VMWs were asked how often they need to do a thorough scheme visit. More than a half (59 %) answered they will only do it as required, 33 % said the interval varies between weekly and monthly, 3 % did the visit daily, 3 % yearly, and 3 % could not say. The median duration of doing a thorough scheme visit was 6 hours, and the average duration was 10.4 hours. Similarly, the median number of hours spent on O&M work by the VMW every week was 6 hours, and the average duration 14.8 hours. For Devchuli, the average number of a thorough scheme visit was 19.3 hours and average duration of hours spent on O&M work was 38.3 hours. The differences in these numbers between all the schemes and Devchuli schemes are large, but it is understandable as the schemes from Devchuli were from the larger side of schemes included in the sample.

Payment to VMW

The most of the VMWs (69 %) told they get regular payment (cash, kind, labor etc.), 26 % got no payments and 5 % got single payments when they do some kind of work in the scheme. The form of payment was asked next, and multiple answers were allowed. The majority (76 %) got the payment in cash, 17 % got grains and for 7 % the form of payment was labor exchange. The most of the VMWs were getting paid yearly (45 %) or monthly (38 %). All Devchuli VMWs were getting paid monthly in cash.

The average annual VMW salary (n=29) was 34 600 NPR and median salary 13 000 NPR. The average VMW salary in Devchuli was 100 500 NPR. The VMWs who were getting paid were asked if they were satisfied with their salary and 59 % told yes, 41 % no. Nine of the unsatisfied ones wanted an increase in the payment, one wanted the payment in cash and one wanted increase and monthly payment. The response of one VMW was unclear. Two of the Devchuli VMWs were satisfied with the salary, one was not and instead they wanted the payment in cash.

Of the 29 VMWs who were getting paid, 24 % had a job contract in a written form with the WUSC. The majority (72 %) had only a verbal understanding with the WUSCs and 3 % did not have any kind of contract. Of the 22 VMWs without a contract in written form, 77 % said they think they need a written contract and for 23 % verbal understand-

ing was ok. Two of the Devchuli VMWs had a written contract and one was satisfied with the verbal understanding.

5.1.4 HH level questions

Type of taps

The most of the households (72 %) were using water from a community tap, 28 % had a private connection. The majority of the households with a private connection (94 %) had their tap outside the house: on the yard, plot or compound. Only 6 % had a tap inside the house. In Devchuli, all the households (n=51) had a private connection with a tap on their yard.

For the ones using water from the community tap (n=490), the average distance from their dwelling to the tap was 70 meters and the median distance was 40 meters. The average fetching time for 20 liters of water from community tap (walk from home to the tap, fill the pot and return) was 15 minutes and the median time was 10 minutes. The average number of households sharing the same community tap was 9 and the median number 7.

Water availability and quality

The average number of months in a year with water available in the taps was 10.3 months and the median number 12 months. The average number of hours in a day with water available in the taps was 15.5 hours and the median number 24 hours. At the time of the interview, there was water available in the taps in 73 % of the households and in 27 % there was not.

The households were asked to score the quality of water in the taps during wet and dry seasons on the scale of 1 to 5, 1 being "never of good quality" and 5 "always of good quality. "Good quality of water" was defined as acceptable by the household according to their perception of taste, smell and appearance of the water. The average grade for all the schemes (n=680) during wet season was 2.9 and during dry season 4.0. For Devchuli schemes (n=51) the average grade during wet season was 2.1 and during dry season 4.6.

Users' assessment of WUSC

The households were asked to score the level of water supply services provided by the WUSC, on scale of 1 to 5, 1 being very poor and 5 very good. The average grade for all the schemes was 3.5, and for Devchuli schemes 4.4. Similarly, the HHs' scoring of the services of VMW was on average 3.5 and for Devchuli schemes 3.8. The average grade for participatory decision making of WUSC for all the schemes was 3.4 and for

Devchuli schemes 3.9. The average grade for financial transparency of WUSC for all the schemes was 3.5 and for Devchuli schemes 3.9.

The quality of original scheme construction work and materials was scored by the HHs, and the average grade was for all the schemes 4.0 and for Devchuli schemes 4.3. The quality of the rehabilitation work done in the scheme and the materials used in it was scored with the average grade of 3.4 and 3.9 for Devchuli schemes. The most of the households (81 %) reported being satisfied with the current O&M of the scheme, whereas 18 % were not satisfied. In Devchuli, 67 % of the households were satisfied and 33 % were not.

Willingness to pay

The HHs were asked if there was a tariff for the water supply. The most of the respondents (81 %) replied yes and 19 % no. In Devchuli, 100 % replied yes. Next, the HHs were asked if they knew what the tariff was supposed to be used for. The options were not read aloud, all that were mentioned without prompting were circled. The top three purposes were salaries of WUSC and VMW and tools and materials for O&M and larger repairs (see Table 9).

Table 9. *The households' perception of water tariff usage by the WUSC.*

Households' perception of water tariff usage (multiple answers)	% of all the respondents (n=680)	% of Devchuli respondents (n=51)
Salaries of WUSC and VMW	56 %	57 %
Tools and materials for larger repairs	31 %	71 %
Tools and materials for O&M	18 %	25 %
Other	6 %	6 %
Saved for emergency works in the future	5 %	0 %
Office rent of WUSC	3 %	6 %
Transportation and food expenses for WUSC	1 %	6 %

For the 550 of 680 households with water tariff in the scheme, the most common form of paying the tariff was cash (76 % of the respondents), followed by kind (17 % of the respondents). The other forms were labor, cash and kind, cash and labor or some other option. The average monthly water tariff was 30 NPR and the median tariff 20 NPR. Next, the households were asked if their household paid the tariff and 99 % said yes. Almost everyone (97 %) said their household pays the tariff on time, the payment is not delayed. Nearly all (96 %) of the respondents told that the same water tariff rate applies for all the users, and for Devchuli the number was similar (94 %). In Devchuli, 100 % of the households paid the tariff, on time, by cash. The average tariff in Devchuli was 42 NPR.

The HHs were asked their opinion on whether a price could be charged for a water service, and 89 % replied yes and 11 % no. In Devchuli, 100 % of the respondents said yes. The HHs were asked to state the main benefits of having a tap water service (the options were not read aloud and multiple answers were allowed). The benefits are listed in Table 10. The main benefit was being able to keep livestock, mentioned by 66 % of the respondents.

Table 10. *The households' opinion of the main benefits of having a water tap service.*

Main benefits of having a water tap service (multiple answers)	% of HHs (n=680)
Livestock	66 %
Personal cleanliness	56 %
Toilet use	51 %
Health	46 %
Vegetable farming	44 %
Dignity	17 %
Hygienic living conditions	17 %
Other reason	10 %
Restaurant/other business	7 %

Of the 550 of 680 households with water tariff in the scheme, 42 % said they would be willing to pay a higher tariff, 57 % would not and 1 % could not say. Next, the households willing to pay a higher tariff were asked to choose the most desirable improvement in the water supply service worth paying the higher price. The top three options were private connection or household tap (40 % of respondents), water available 24 hours a day (18 %) and regular and reliable service in general (17 %). Next, the households were asked to imagine that this improvement would happen and the tariff would rise, and name the highest tariff they would be willing to pay per month. The average named tariff in this case was 82 NPR/month and the median tariff 50 NPR/month, which are more than double the current average monthly water tariff (30 NPR) and the median tariff (20 NPR).

Of the Devchuli households (n=51), only 16 % said they would be willing to pay a higher tariff. 75 % of these households would pay more for more reliable service and 25 % if water was available 24 hours a day. For Devchuli, the average of named highest possible tariff with the improved service was 188 NPR/month. Since all of the Devchuli households included in this sample already had private connections, it is logical that they are not as eager to improve their services as the all households included in the sample. The water tariff in Devchuli was already higher than the average tariff in the sample, too.

Perception of the water supply ownership

The HHs were asked about their perception of who built the water supply service in the community. The most common response was donor (43 %), followed by government and donor (20 %) and do not know (19 %). 7 % told "government", 6 % "government, donor and the community" and 5 % "the community itself". Of Devchuli HHs, 74 % replied "donor", 24 % "do not know" and 2 % "government and donor". The HHs were also asked to choose a statement related to the ownership of the scheme that they agreed the most with. The results are listed in Table 11. Among all the respondents, the most popular response was "the whole community owns this water supply". Surprisingly, among Devchuli respondents the most popular response was "the donor owns this water supply".

Table 11. *Perception of the ownership of the water supply scheme among households.*

Statement regarding ownership of the water supply scheme	% of all the respondents who agreed (n=680)	% of Devchuli respondents who agreed (n=51)
I am the owner of this water supply	2 %	0 %
My family is one of the owners of this water supply	2 %	0 %
The whole community owns this water supply	53 %	18 %
The user committee owns this water supply	8 %	14 %
The government owns this water supply	8 %	8 %
The donor owns this water supply	24 %	61 %
Other	1 %	0 %
Total	**100 %**	**100 %**

5.2 The qualitative study: Devchuli schemes

Some basic information of the schemes has been collected in Table 12. Of the eleven schemes, seven were constructed or reconstructed as a part of RWSSP program. The rest of the schemes were supported by United Mission to Nepal, Gurkha Welfare, DWSSDO, VDC, DDC or several of these. The scheme areas and locations are being shown in the Figure 12. Devchuli belongs geographically to the Inner Terai, but in practice in the area there were two different types of terrain, plains and valley (see Figures 11 and 12), and the schemes are divided accordingly.

Table 12. *Basic information on the water schemes in Devchuli.*

Scheme name	Type of terrain	Year of construction	Construction support organization	Year of major rehab or reconstruction	Rehab/ reconstruction supporter	Number of taps	Number of households
Bisaltar	plain	1995	RWSSP	2010, 2015	VDC, DWSSDO	450 private	450
Aaptari	plain	1997	RWSSP	2013	VDC	320 private	320
Ram Bas Sita Bas	plain	1999	RWSSP	2013	unknown	500 private	500
Ranibel	plain	1984	United Mission to Nepal	-	-	20 public	30
Munde	plain	1995	Gurkha Welfare	2000	RWSSP	19 public	205
Mirtung khola	plain	1991	VDC	-	-	5 public	18
Kirtipur thulo gau	hilly	1985	Gurkha Welfare	2004	RWSSP	14 public	115
Nayachhap	hilly	1986	Gurkha Welfare	2004	RWSSP	2 public	14
Sangupari	hilly	1987	Gurkha Welfare	2003	VDC	5 public	29
Chuhar	hilly	1999	VDC	2012	VDC	10 public	13
Kumsot	hilly	1994	RWSSP	2013	United Mission to Nepal	11 public	52

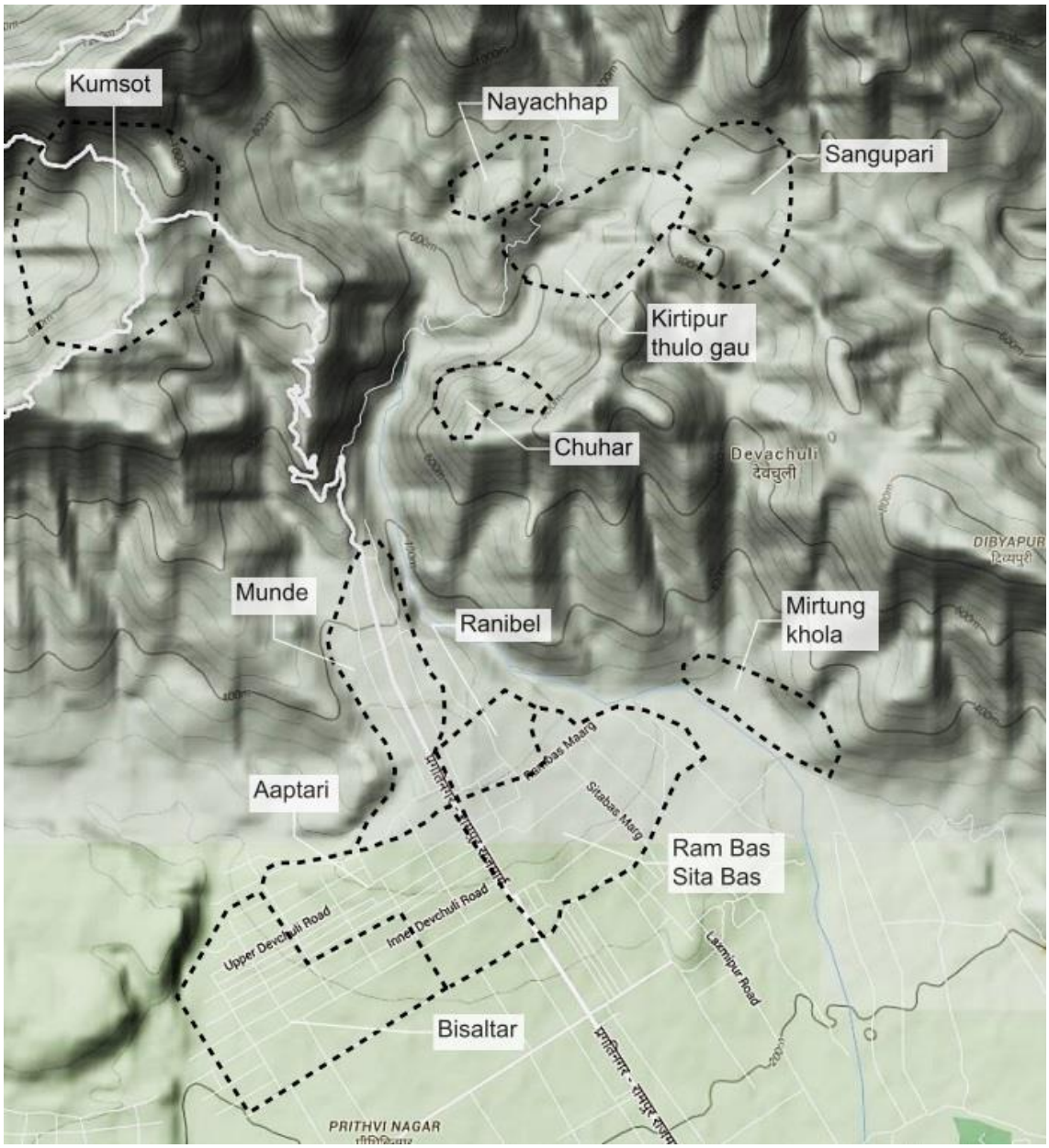

Figure 12. *The approximate areas and locations of the water schemes in Devchuli.*

The ethnic compositions of the populations of the schemes are presented in Table 13. The Hindu caste system is complex and will not be presented here except very briefly for the groups mentioned in the table: Brahmins and Chhetris are the highest caste, Janajatis include many different groups of the indigenous people of Nepal and Dalits are the lowest caste. Of the indigenous groups of Nepal, there were only Magars living in the study area. The information of the ethnic composition of the village is not interesting only as a background information, but it also provides understanding why some villages were cooperating more with each other and some were not. It could also be a factor when trying to understand why some schemes were more successful than the others.

Three of the schemes (Ram Bas Sita Bas, Aaptari, Bisaltar) were more developed than the others and exactly these ones had the most heterogenic composition of population by ethnicity. These were the same schemes which had the largest percentage of Brahmins and Chhetris. It could be possible that Brahmins and Chhetris have wider social networks and better contacts with people who have a lot of prestige and can provide them help more easily. They might have better education and experience which might help running the scheme, and it is possible that these people have better self-esteem which provokes them to maintain and develop the scheme, too.

Table 13. *Ethnic composition of the population in different schemes of Devchuli. (*K.C., R., Prasain, J.N. 2014.)*

Scheme Name	Number of households	Janajati	Brahmin/ Chhetri & Others	Dalits
Ram Bas Sita Bas*	500	38 %	46 %	16 %
Bisaltar*	450	53 %	34 %	12 %
Aaptari*	320	67 %	19 %	14 %
Munde*	205	84 %	5 %	10 %
Ranibel	30	Most Magar	0 %	a few
Mirtung khola	18	100 % (Magar)	0 %	0 %
Kirtipur thulo gau	115	100 % (Magar)	0 %	0 %
Sangupari	29	100 % (Magar)	0 %	0 %
Chuhar	13	100 % (Magar)	0 %	0 %
Nayachhap	14	100 % (Magar)	0 %	0 %
Kumsot	52	100 % (Magar)	0 %	0 %

The schemes could be divided into categories based on many different ways, for example by their location (situated either on the flat plains or the higher valleys), or whether they were part of the RWSSP program. Here I have chosen to divide the schemes in two categories by their level of performance: three schemes could be called progressive, whereas the rest of the schemes, eight schemes, were coping with mediocre success. The progressive schemes are presented first, then the rest.

5.2.1 The progressive schemes

The three schemes which were more successful than the others were Bisaltar, Aaptari and Ram Bas Sita Bas. Each of these schemes were situated in the plain area, next to each other. Each of these schemes were large with a few hundred households (320-500). Reason for calling these schemes successful is mainly that they had done the transition to private taps from public taps on their own, they were keeping regular WUSC meetings and General Assemblies, they had active WUSC members who were interested in

developing the scheme and they were collecting a regular large enough water tariff to enable them to make investments in the scheme (e.g. new main line, new reservoir tank). In addition to the WUSCs, these schemes had advisory committees which consisted of some former WUSC members or other people skilled in water issues. All of these schemes were employing an office secretary who was responsible for administrative tasks such as revenue collection, helping people writing applications to become members in the scheme and water meter reading.

Aaptari was founded in 1997 and 320 households were currently using its water. There had been many minor rehabilitations in this scheme, too. During the time of my visit, they were constructing an additional pipeline from the source to the reservoir tank to cope with an increased population and therefore increased water usage. One year before that, they had constructed another collection chamber at the source as well.

Private taps were constructed for this scheme in 2013. People making illegal connections was one of the reasons that lead to the decision of private tap construction. Aaptari and Ram Bas Sita Bas share the same source, and they had formed a separate joint source committee consisting of WUSC members from both schemes. During the recent years, they had been rehabilitating some parts of the scheme. At the time of my visit, the villagers were doing reconstruction work for a distribution line of 350 meters (Figure 13), from the reservoir tank to a primary school. The main VMW of this scheme had recently arranged a basic short VMW training for whole WUSC.

Figure 13. *Villagers reconstructing a distribution line in Aaptari.*

The **Bisaltar** scheme was established in 1993. Currently 450 households were using water from the scheme. The scheme had gone through many minor rehabilitations during the years, including adding two additional sources due to population growth (although one of them is in use only during dry season), replacing sources due to drying out, and constructing a new large reservoir tank where the water from all the sources was directed to (instead of putting pipelines straight from the sources to the village). These rehabilitations were funded by collecting a water tariff from the villagers but also with support from outside, from VDC, DDC and DWSSDO. The construction work was mainly done by the villagers, WUSC and VMW.

Private taps were constructed for this scheme in 2010. After the construction of private taps, they have been compelled to regulate the water so that is it available only for some hours a day, due to water scarcity. It came as a surprise to the WUSC and the villagers. During my visit, the scheme was going through a 5-year rehabilitation plan supported by DWSSDO. DWSSDO had hired a contractor to do a major part of the construction work but people's participation was being used for the construction as well.

Ram Bas Sita Bas was founded in 1999 and nowadays it supplies water for 500 households. Private taps and two new reservoir tanks were constructed in 2013 for this scheme. At the time of my visit, there was a new house being constructed for the purpose of being used as WUSC office. A water user had donated the land for the WUSC. This scheme had suffered from a pressure problem with 32 households, who were located in the area of this scheme but situated too high to get water. They had resolved the issue by fetching water from another scheme (Ranibel) but as Ranibel had trouble in supplying water, sometimes they were forced to fetch water from river.

5.2.2 The other schemes

The eight schemes of mediocre performance were Munde, Ranibel, Mirtung khola, Kirtipur thulo gau, Sangupari, Chuhar, Nayachhap and Kumsot. The schemes' performance was called moderate because although people were getting water, there was no established long-term planning for the future of the scheme and schemes were facing some problems they had trouble solving. It was clear though that there were some people who were active in trying to find outside support for developing the scheme.

The Kirtipur thulo gau, Sangupari, Chuhar, Nayachhap and Kumsot schemes were located on the valleys. In the valley area of Devchuli, there were two main areas: Kirtipur and Kumsot areas. Four schemes were located in the Kirtipur area: Kirtipur thulo gau, Sangupari, Chuhar and Nayachhap, whereas only the Kumsot scheme was in the Kumsot area. Kirtipur thulo gau (thulo gau means a large village in Nepali language) was the main village of Kirtipur with more than a hundred households, and the other villages in the Kirtipur area were a lot smaller with 13-29 households. The Kirtipur villages were

cooperating together a lot in many things, for example purchasing spare parts. Of these eight schemes, Munde, Kirtipur thulo gau, Nayachhap and Kumsot were constructed or rehabilitated during RWSSP project. The scheme supported by RWSSP was the first one constructed in Kumsot, but in the other schemes there was already an existing scheme at the time, supported by Gurkha Welfare. Ranibel, Mirtung khola, Sangupari and Chuhar were never in RWSSP project.

The **Munde** scheme was constructed originally in 1995 with the support of Gurkha Welfare, but this scheme suffered from severe problems with lime encrustation (Figure 14), and in 2000, a new scheme using a different water source was constructed in RWSSP project. This scheme supplies water to 205 households and there are 19 public taps. According to VMW, yearly landslides are the main problem in this scheme. Recently, the community had constructed a gabion box wall to protect the pipelines from the landslides. Because of population growth, a new reservoir tank and a new bigger main pipeline are needed and the workload of the VMW has grown. The Munde WUSC has suffered from motivation problems among the current and previous WUSC members, yet they still had a vision for the future that there would be private taps within five years.

Figure 14. *Lime in the water. It accumulates in the bottom of the pot after boiling the water.*

The **Ranibel** scheme was founded in 1984 and it was supported by United Mission to Nepal. There are 20 public taps. There are 30 households which are using water primarily from this scheme, but in addition to this, circa 50 households from Mudabas area, who are primarily Munde scheme water users, sometimes use water from Ranibel. According to the members of one Ranibel household, people go to the taps where there is a shorter queue. This scheme was the oldest in the area and it was in a clear need of rehabilitation (see for example the old reservoir tank in Figure 15). Water is being regulated in the scheme so that it is available only in the morning between 6 and 8 a.m. and in the evening between 5 to 6.30 p.m. 4 to 5 years ago the villagers were forced to start regulating the water seasonally, too. Nowadays the water will be cut from the taps in July

and connected back in November or December. During this time, people must go to the reservoir tank to get water or use some other sources.

Figure 15. *The already old reservoir tank of the Ranibel scheme.*

Mirtung khola (khola means river in Nepali language) was constructed in 1991 with the support of DWSSDO. This scheme had currently 18 households and 5 public taps of which only one was still fully functional and properly in the tap stand. The scheme has suffered for a long time from serious problems with lime encrustation, the lime in the water clogs pipes and taps. Due to the problem they have taken the pipeline out of the tap stand and take water directly from the pipe (Figure 16). From time to time, they must dig up the pipes and clean them up. Twelve years ago there was a severe flood where two people died and 300 meters of distribution line was destroyed, after which two households have been fetching water from river. This scheme had no VMW or any tools, but recently they had appointed a caretaker (most likely basically a VMW) to clean the source and the reservoir tank.

Figure 16. *From Mirtung khola scheme, on the left: a broken or abandoned tap stand. On the right: a public tap without a proper tap stand.*

The **Kirtipur thulo gau** scheme was constructed for the first time in 1985 with the support of Gurkha Welfare. The scheme was reconstructed in 2004 with the support of RWSSP. This village has 115 households and 14 public taps. This scheme has a joint WUSC with another scheme, Nayachhap. The reason for this is that at the time of reconstruction of this scheme, Nayachhap had only 5 households so they were not eligible to apply for support from RWSSP, so they decided to apply together with the main village.

This area does not suffer from floods and landslides are very rare as well, there was only one landslide within 35 years. Due to population growth, this scheme suffers from water scarcity, which they have been relieving by adding another pipeline to the river during the dry season. They are interested in getting private taps in the village because according to the WUSC, people waste water from public taps and the water consumption would probably be less with water meters. They are looking for financial support but are ready to do the construction work themselves.

Nayachhap was constructed for the first time in 1986 with support of Gurkha Welfare and reconstructed at the same time with support of RWSSP as Kirtipur thulo gau, in 2004. They have 14 households and 2 public taps. This scheme, too, suffers from pipes clogging with lime. The pipes sometimes break down when cleaning them up, for example the pipeline from source to sedimentation tank has broken down many times. The people built a gabion wall (Figure 17) at the source 2 years ago and after that, it has been a lot easier to keep the source clean. They funded this work themselves.

Figure 17. *A typical gabion wall built at the source to cover it from flooding and landslides.*

The **Chuhar** scheme was founded in 1999. Construction was supported by VDC and the community. There are 13 households in this village and 10 public taps. This scheme was reconstructed 2.5 years ago, after a landslide completely destroyed their previous spring source. The new water source was located on the other side of the nearby river and therefore the villagers had been compelled to make the main pipeline cross the river above it (Figure 18), however this had not caused any problems. Overall, there had not been any problems in the new scheme and the villagers were otherwise satisfied with it, but they were hoping to get a larger main pipeline.

Figure 18. *In the Chuhar scheme, the water source is located on the other side of the river, and the main pipeline has been installed in the air, crossing the river.*

The **Sangupari** scheme was constructed in 1987 with the support of Gurkha Welfare. 42 households are located in the area of this scheme but only 29 households used water from this scheme, the rest of the households were fetching water from river. The reason for this is that houses have been built in new areas where there is no distribution line yet. At the time the WUSC was planning to build a new line but so far they did not have sufficient funds for it. Due to population growth, the scheme is also suffering from water scarcity which has forced the people to use river water for bathing during the past five years. The yield from the source has been the same the whole time. This scheme suffers from yearly landslides which might destroy the main and distribution lines. After the landslides the villagers clean the area and put the pieces of pipe back. This scheme has not been rehabilitated, but recently they constructed a gabion wall at the source to control the river floods during rainy season. Figure 19 shows the reservoir tank of Sangupari scheme which is old already.

Figure 19. *The reservoir tank of the Sangupari scheme.*

The **Kumsot** scheme was constructed in 1994 with the support of RWSSP, and reconstructed later in 2013 with the support of Isaj Samaj Nawalparasi, a Christian non-profit organization operating in Nawalparasi, and United Mission to Nepal. There are 62 households in the area but only 52 are getting their water from the scheme, 10 households are located further from the other houses and they did not want to join in the new scheme (it would have required financial investments and doing the construction work) but instead rather they fetch their water from a river. These houses had been built after the construction of the first scheme.

Isaj Samaj Nawalparasi began working in the village after its chairperson, who used to live close to Devchuli, noticed that literacy rate was very low among women in Kumsot. Therefore, they decided to implement a 2-year literacy program in the village. At the time of the literacy program the organization built 20 toilets in the village. Later, the villagers asked if the organization could help them with the water supply issues as well. The old scheme had fallen into bad condition and pipes had broken down in many places and children had dropped out of school to be able to fetch water. The WUSC was existing but inactive. United Mission to Nepal decided to donate funds and give technical support and Isaj Samaj Nawalparasi was responsible for the social mobilization. The villagers' contribution as work was 33 % of the scheme's cost. (United Mission to Nepal 2013; Collins family in Nepal 2014; Tearfund 2014.)

After the construction of the new scheme, the villagers are satisfied with the new source and reservoir tank, but they would like more public taps because currently they feel they

must walk too far to the taps. The new reservoir tank is shown in Figure 20. In this area, there have been landslides that have destroyed parts of the scheme approximately every 5 years. After the landslides, the villagers have collected the pieces of pipe and put them back or changed the damaged pipes to new ones.

Figure 20. *A new reservoir tank in Kumsot village, constructed in 2013.*

5.3 Observations from the field

There was a clear interest towards developing better water supply services in all the villages visited. Three of the schemes had been exceptionally proactive but also in the rest of the schemes, there were active WUSC members or villagers who had for example applied for funds during the recent years from the local government for improving the schemes.

Many of the interviewed WUSC members and villagers highlighted how the improved water supply in the village had brought a significant change in their lives. Before the majority of the schemes were constructed, everyone in the Terai areas was either fetching water from the Ranibel scheme (constructed in 1984) or from a nearby water body such as river or a pond. Fetching water from only one scheme was laborious: the villagers walked to the tap and queued. If the water ran out, they had to walk to the river. Fetching water from the river and walking back one time took 2.5 hours altogether. When the schemes had been constructed and the villagers had water, it saved a lot of

their time. They had more time for agriculture, which meant more food for the family and the cattle.

Population growth in the area and water scarcity

Issues that frequently came up in the interviews were population growth in the area and the water scarcity that has resulted from it. I did not get the exact rates of change of the number of households from all the schemes, but three schemes reported significant changes in population numbers since the scheme construction: Kumsot (population growth of 73 %) Nayachhap (150 %) and Sangupari (180 %). These schemes were not the largest in the sample, however the change is considerable. All of these schemes were situated on the hillier, less populated area too.

When visiting the Kumsot scheme, I was able to take a look at the survey and design plan for the rehabilitation/reconstruction of the scheme. The new scheme had been designed for a period of 20 years and population growth rate of 2.29 %. This growth rate per year equals population growth of 57 % in 20 years. Nepal's yearly population growth rate was 1.35 % in 2011 (Central Bureau of Statistics 2012) but Nepal is urbanizing rapidly - Nepal has one of the highest urban population growth rates in South Asia (FCG International & TMS 2013b), and the Kathmandu Valley is one of the fastest-growing metropolitan regions. Small towns are mushrooming in proximity to highways and on the border with India, too. The average urban population growth rate has been about 6 % per year since the 1970s. (Muzzini & Aparicio 2013.) Devchuli is of course not yet urban but the direction of change is clear.

Several WUSCs mentioned suffering from seasonal or constant water scarcity. Water scarcity does not necessary mean a decreased yield from the source, but that due to population growth, the yield is not sufficient anymore. The WUSCs had eased the problem by adding an additional water source to the scheme seasonally or permanently. For example, in one scheme a new pipeline was built from a nearby river, without any constructed intake, mixing the spring water with river water. The villagers seemed to think this solution was not good, as they had been telling the VMW that the scheme should be redesigned. In another scheme, the villagers wanted to add a temporary pipeline from a nearby river during the dry months, but they did not have the pipe material for this purpose. They had earlier taken water from this river but that pipeline had been destroyed in a flood.

In another typical example from another scheme, the scheme had only one source in use which had been constructed 30 years ago, when the scheme was originally constructed. This source used to be sufficient but due to population growth, the villagers were using river water for bathing. The WUSC has looked for another suitable source and they have found one, but taking it into use would require constructing a new main line. The

villagers do not have sufficient funding for the needed materials which included 1600 meters of 50 mm pipeline for the main line, intake and collection chamber materials and a new distribution line from the reservoir tank to the newer households in the village. Figure 21 shows what might happen as a result of shortage of water: people, including children, have to go fetch it from a small stream outside the village.

Figure 21. *Little boys fetching water with a canister from a small stream near Sangupari village.*

Size of the main pipeline (pipe from the source to the reservoir tank) was limiting the availability of water in the villages in four schemes, and the WUSCs had recognized a need for a larger main line. In one scheme the main line length was altogether 1 km, of which the pipeline diameter was 2 inches for 150 meters and 1.5 inches for the rest. According to the chairperson of WUSC, 3-inch pipeline would satisfy better the community's need for water. If they got the larger pipeline, they would need another reservoir tank, which would be constructed next to the current reservoir tank. In two other smaller schemes, the pipeline diameter was 1-1.25 inches, which the WUSCs reported being too small and they were hoping to get a 2-inch line. In one larger scheme, the 2.5-kilometer long main line was currently 1.5-2 inch but they would need a 4-inch line.

Interest towards private taps

Of the schemes which still did not have private taps, two schemes explicitly mentioned interest in getting them. I found it likely that the other schemes would like to have their private taps, too, but currently the other issues in the schemes were more urgent. People seemed to think that private taps are modern and therefore desirable, as for example one household expressed their dissatisfaction in the fact that they do not have a water meter, instead of not being satisfied for example with having to walk to the community tap and back. A typical private tap and a water meter is shown in Figure 22.

In one scheme, according to one household and WUSC interviews, all the households in the area would like to have private taps. The WUSC predicted they would be able to get private taps for the scheme within 5 years. Another WUSC which expressed their interest towards private taps told that villagers would be willing to do the construction work themselves but they need to find other funding as well. There was one WUSC which expressed their interest in getting more public taps because of the too long distance of carrying water, too. They were satisfied with the scheme otherwise.

It has been suggested that one of the main reasons why people desire better services, including private taps, is that their income has increased, also because a growing number of Nepalese are working abroad and sending remittances back home (K.C. 2015). According to the Nepal Living Standard Survey 2010/11, the average household income grew by more than 363 percent between 1995 and 2010. Similarly, the average amount of received remittance among households who received remittances increased to more than 5-fold between 1995 and 2010, whereas the percentage of households receiving remittances increased from 23.4 % to 55.8 % (Central Bureau of Statistics 2011, 75).

Figure 22. *A private tap and a water meter (circled in the picture) in a yard in Aaptari.*

Local solutions to problems

Villagers had been resolving some of their problems with creative local solutions: repairing pipes with bamboo and using a wooden stick as a "tap". Using the wooden stick as a tap was connected to the problems of taps and pipes becoming clogged by lime. The villagers had resolved the issue by removing the tap from the standpipe and taking water directly from the pipe. One other scheme was without taps, too, but it was unclear whether this situation was new or if they ever had had any taps. Instead of taps, they stopped the flow of water by sticking a piece of wood inside the pipeline.

One scheme had suffered from bad pipeline quality, and WUSC had decided to try to repair the broken parts with pieces of bamboo instead (Figure 23), because they thought pipeline was too expensive. They had tried this method for the first time 1.5 years ago and they were satisfied with it although they have to change the bamboo parts every once in a while.

Figure 23. *Some pipelines that have been fixed with bamboo.*

Purchasing practices of tools and spare parts

The practices of purchasing tools and spare parts seemed to vary and were relatively flexible. In some schemes, WUSC was responsible for all the purchases, in other schemes people would give the VMW some money and ask him to go, or people would do the purchasing themselves and ask VMW to do the fixing. For example, in one scheme, WUSC was responsible for buying spare parts for the main line, whereas the users would purchase spare parts for the taps. Approximately 12 households shared one public tap, and they would collect money from everyone and someone would go buy.

The road connections to the nearby market centers or bigger cities were relatively easy from the whole Devchuli area, so the geographical distances or the topographical differences would not be a major problem. The same places for purchasing the spare parts were mentioned by five WUSCs: Daldale and Dharapani (smaller market centers within a distance of 4 to 8 kilometers), Narayangarh and Kawasoti (larger towns within a distance of 13 to 30 kilometers) or Butwal, the 12th largest city of Nepal, located 95 kilometers away. The other schemes located in Kirtipur area told they would get spare parts from the largest village in Kirtipur.

One problem which came up was that the villagers were not necessarily able to assess the quality of the spare parts, which could lead them to purchase low quality parts. The solution to this could be that the WUSC would purchase a large amount of good parts and sell them to villagers. There would probably be a discount for a large amount of parts, too.

Economic and political disputes related to water schemes

Some kind of economic or political disputes related to the use of the water systems are often bound to arise, as the users are humans. Also some other "human problems" that might unexpectedly arise are curious adults or children abusing or playing with the system. Disputes had occurred at least in three schemes in Devchuli VDC.

One scheme mentioned two cases of conflicts. Before the private taps were installed, people did not think they had enough water in use. Because of this, several people, including WUSC members, had made illegal connections to the public tap. Other people followed their example, which caused a conflict. As a solution to this, it was decided in a General Assembly that a private connection will be built for everyone. Another conflict was about five households in the neighboring scheme's area. These households suffered from low water pressure in their own scheme, and the WUSC chairperson of another scheme had decided to build them private connections against a fee from another scheme, without consulting the other WUSC members or villagers. These households were not originally there to help in construction work of the scheme and therefore people felt they should not be allowed to benefit from the water supply. Some villagers got angry and they went to cut down their connections. The WUSC chairperson was forced to resign as a result of this conflict.

In one scheme there was still an ongoing dispute over the rights to the water source, a river. There were two large villages with more than 1000 households situated upstream of the river. These villages take such a large quantity of water that the downstream scheme suffers from water scarcity. Villagers of the downstream village had resorted to disconnecting the other village's main pipeline for some time during the nighttime and releasing water to the river, without the other WUSC knowing.

In one scheme, the conflict was a dispute between the VMW and the villagers four years ago. There was an air blockage in the water system at the time and VMW did not fix the problem. Villagers were forced to ask help from outside. Due to this, villagers decided they do not need the services of the VMW anymore, quit paying salary to him and decided they would take care of the necessary fixing of taps and pipes themselves.

Water source protection practices

As a part of NAPA WASH project, Water Safety Plan trainings and water quality tests had been arranged in Devchuli. It was not clear though, which WUSCs had sent a representative to the trainings. Someone from at least Ram Bas Sita Bas, Aaptari, Sangupari and Mirtung khola had participated. After this training, these WUSCs had formed a

WSP committee for their own schemes. As a result of this training, at least the WUSC of Ram Bas Sita Bas had cleaned the water source area, painted the reservoir tank white and fenced it (Figure 24), and the main VMW of Aaptari had drawn a map of the pipelines in the scheme area. However, it remained unclear what was the exact state of the WSP actions before NAPA WASH project started in the area.

Figure 24. *The source area of Ram Bas Sita Bas and Aaptari which had a proper fence. One of the springs (in the front) has been covered with stones.*

The WUSCs told that it is the task of the VMW to clean source area. However, when I visited the source areas, there was often some vegetation which can affect the water quality. For example, there was algae growing in the river, very close to the Mirtung khola intake (Figure 25). Also, several WUSCs mentioned that during the wet season the water becomes "dusty". This statement is in harmony with the quantitative survey results, which showed that the water quality during wet season assessed by the households in Devchuli got only a grade of 2.1 (on the scale of 1 to 5, 1 being "water never of good quality" and 5 "water always of good quality"). However, villagers did not bring up problems with water quality in the interviews as a major concern. Also, villagers or WUSC members of three schemes mentioned that the villagers have no health problems and their health is good. The villagers said that at the time when the schemes had not been constructed and the people were drinking water from the river, they suffered from stomach disease a lot more often.

Figure 25. *The intake of the Mirtung khola scheme with the intake pipe circled in the picture. A lot of algae was growing in the river close to the intake.*

Four WUSCs had constructed a gabion wall (Figure 17) at the water source to protect it during the past 1 to 2 years. Three WUSCs had taken recently taking a source protection measurement of covering the source with stones. One WUSC had covered the source with stones already at the time of scheme construction. Members of one WUSC told that during RWSSP project they learned that it is important to have trees in the surroundings of the source, and before the project they used to cut them. Also during the rehabilitation of the Kumsot scheme in 2013, the project had included bamboo and broom planting on landslide prone areas, planting of grass at the source area and gabion box building.

Two main patterns in self-organization of WUSCs

WUSCs could be divided in two groups according to their level of self-organization. Some others were more organized in their operations whereas others had a more reactive approach. The organized ones kept regular meetings and had more clearly defined official patterns in selecting new WUSC members and collecting funds for the WUSC. The reactive ones kept meetings only when something needed to be done or decided, and funds were mainly collected only if a problem occurred and something needed to be purchased. However, the reactive WUSCs seemed to be operating with a moderate success. The reason for this might be that the communities had more unity than I expected. For example, if something broke down, everyone would gather together and go help. It

must be noted though that with growing population and with urbanization, the cohesion of the communities might diminish, resulting in the need of stronger self-organization of WUSCs. Some cases of WUSCs with reactive actions are presented next.

Kirtipur thulo gau

A new WUSC had been elected for Kirtipur thulo gau scheme just recently, after having had the same WUSC for 10 years. They have a joint WUSC with the Nayachhap scheme located nearby. The committee had consisted of the same members for 10 years because the members liked being in the committee and the general opinion among villagers was that it is better that the committee members are experienced. The new WUSC was elected now because some WUSC members wanted to retire from the committee due to their age, and villagers wanted to give a change to newer members. The new WUSC was selected by discussing together with everyone in a General Assembly, and the villagers nominated people to the committee based on their skills.

Before the election of new WUSC for Kirtipur thulo gau, it had been decided that members from Nayachhap village would be included in the new WUSC. Eventually two people from Nayachhap were selected. Earlier the villagers of Nayachhap felt that they do not need to have a WUSC or representatives in the Kirtipur thulo gau WUSC, but now their opinion had changed. They cooperate a lot with Kirtipur thulo gau in other issues as well. Regular WUSC meetings were not held, water supply issues were discussed in other meetings. After making decisions, one person would go around the village and inform everyone.

Ranibel

The Ranibel scheme had been without an active WUSC for a long time. After the scheme was constructed in 1984, there was no WUSC. There seemed to be some confusion of the existence of the WUSC, as the current VMW was not aware of it. According to the villagers, a WUSC was formed 5-6 months ago. The villagers were required to form a WUSC because they wanted to apply funds from the VDC for maintaining tap stands and fixing pipes, and the requirement for applying was an existing WUSC in the scheme. The term of this WUSC lasted until 1.5 months ago, until the current WUSC was elected. The current WUSC was formed with the support of NAPA WASH staff and two chairpersons of WUSCs in Devchuli. Before the formation of these WUSCs, VMW used to be the one who alerted the people if there was a problem in the scheme. For example, if a pipeline broke down, the VMW would call all the people there to repair the pipe. The VMW was not working due to not being compensated but she would alert the people anyway.

Chuhar

The WUSC had consisted of the same five members for a long time, altogether for 16 years. 16 years ago there were only five households, now the amount had increased to

eleven. WUSC meetings were being held four times a year. General Assemblies were held when needed but they were for all kinds of issues, not only for water-related issues. The WUSC had started to collect a water tariff only 7 to 8 months ago, and they were planning to use it if a landslide would damage the scheme. The scheme had been entirely destroyed by a landslide 2.5 years ago, and they wanted to be better prepared if it were to happen again.

Sangupari
The WUSC had been formed 6 to 7 months ago either for the first time or after a long period of being inactive. The WUSC reformation had been put forth after a Sangupari community key person participated in a training which was implemented as a part of NAPA WASH project. During the 6 to 7 months, they had only had two meetings, where they planned their future WUSC operations. There was no water tariff: if a problem occurred, money would be collected from all the villagers.

5.4 Village Maintenance Workers

There was a Village Maintenance Worker in all the schemes visited but the actual type of work of the VMWs varied extensively between the schemes. Partly, this was because the schemes were of different sizes and types – some would naturally require more work from VMW, such as the schemes with private taps. In five schemes, three of these with private taps, there was a full-time working VMW. In six schemes, the VMW was either working only a few hours a month (depending on the need for their services), newly appointed or retired but still living in the village. Many of the schemes who were using only a part-time VMW were doing so because of the nature of the work needed to be done in the scheme. This included for example cleaning the source area after a landslide. All the villagers were needed for the cleaning, as it would have taken a very long time for one person only.

The routine activities of VMW included tap fixing, pipeline fitting and fixing and cleaning the reservoir tank. The reservoir tanks were being cleaned from the inside approximately once a month. In two schemes it was the duty of VMW to regulate the availability of water by opening and closing the valves during the daytime. In one scheme, it was the only duty of the VMW. In one scheme there was a task division between the two VMWs: the other one was responsible for maintaining of the source and the surrounding area in good condition, while the other was responsible for everything in the village area. The basic information of VMWs of the Devchuli schemes has been collected in Table 14.

Table 14. *Basic information on the Village Maintenance Workers of the water schemes in Devchuli.*

Scheme name	Number of VMW's	Years as VMW in the scheme	Age of VMW (years)	Gender of VMW	Ethnicity of VMW	Training	Salary a month (NPR)	Work-load a day (h)
Bisaltar	1 full-time	12	46	M	Magar	1 month *	9500	5
	1 part-time	3	21	M	Magar	learned by doing	4500	unknown
Aaptari	1 full-time	3	42	M	Magar	trained by prev. VMW	8500	7
	1 part-time	16	64	M	Brahmin	1 month *	2000	
Ram Bas Sita Bas	1 full-time	19	64	M	Brahmin	1 month *	7000	12
Ranibel	1 part-time	15	60	F	Magar	learned by doing	0.5 kg wheat	<1
Munde	1 full-time	14	50	M	Magar	1 month *	3000	2
Mirtung khola	1 newly elected part-time	0,3	unknown	M	Magar	unknown	1100	<1
Kirtipur thulo gau	1 newly elected	0	unknown	un-known	unknown	unknown	unknown	unknown
	1 retired, still living in the vil-lage	8	53	M	Magar	1 month *	1500 (when he was working)	3
Naya-chhap	1 part-time	11	50	M	Magar	1 month *	none, voluntary work	<1
Sangupari	1 part-time	some	45	M	Magar	learned by doing	2 kg maize	unknown
Chuhar	1 retired, not working since 2 years	some	65	M	Magar	learned by doing	550 (when he was working)	<1
Kumsot	1 full-time	16	55	M	Magar	learned by doing	3000	1

** The training was provided by RWSSP.*

Future availability of VMW

Four of the eleven WUSCs or VMWs mentioned there might be trouble in the future to find someone working as VMW in the scheme. One VMW told that if he were to quit, he would not know anyone who would like to take the job. Another VMW told he is already 64 years old and will retire at some point. He had told the WUSC he would be willing to train the new VMW but the WUSC should find the suitable candidate. So far,

the WUSC had ignored his warnings. In two other schemes, people were not interested in working as VMW, but the current VMW would be willing to train the new person if a candidate was found. One VMW told that the reason people do not want to the job is that the salary is too low.

VMWs' employment abroad

In Nepal, it has been causing problems that VMWs who have been trained to take care of the scheme later leave abroad to work, as they now have better qualifications to get a job, which earns them more money (White 2016). This is unfortunate, as then the community will be left without a VMW but it is entirely understandable as often the VMW job is only part-time and the salary is not good (see the end of chapter 2.5). However, the phenomenon was not visible in Devchuli. Of the seven schemes which were included in the RWSSP program and where the VMW had been trained during the project, six schemes still had the same VMW in the village. In one scheme the VMW had passed away.

Also, of the eleven interviewed VMWs, only two mentioned having been working abroad (the question about working abroad was explicitly asked from seven VMWs). One of them had been working in Malaysia for 2 years, but he had returned 12 years ago and was not interested in leaving again. Another one had been in India for 1.5 years doing labor work but had returned. During his absence there had been another person working as VMW.

The phenomenon of people leaving to work abroad was visible in the villages. Most frequently mentioned countries where the people had gone to were Malaysia, United Arab Emirates and Qatar. Approximately 250 people had moved abroad from Kirtipur thulo gau which had 115 households. In Ranibel, there was someone working abroad from 15 of the 30 households in the village. From smaller villages such as Chuhar, Sangupari and Nayachhap, there were 5 to 8 people working abroad from each.

5.5 Assessment: Lessons learned

This chapter shortly reviews some parts of the work of doing this study. In general, I could call the fieldwork period relatively successful as I managed to collect enough material for the study and no major setbacks occurred. There was an exceptionally large earthquake (Gorkha earthquarke, epicenter 73 km from Devchuli) during my time in Nepal but fortunately it did not affect my work in a significant way. Sadly, several households in Devchuli area lost their homes, but nobody died. The water supply systems were not affected by the earthquake, either.

The original research questions had to be modified a little bit as the reality in the field turned out to be different from what I had imagined. Almost everyone whom I planned to interview were there and agreed to give their time. Especially all the villagers were very kind and tried their best so that I could get my hands on all the information and documents I was looking for. One thing that has to be taken into account is that only few of the interviewed people spoke English. Therefore, I was working with an interpreter during the whole fieldwork period. This naturally brought its own challenge to the work, but it was the only way to work during this kind of a short mission.

Regarding the selection of the study area, before leaving for Nepal, I studied the map of Nawalparasi and decided which area to choose for this case study. Having not visited Nepal before, Devchuli looked more remote to me on the map and larger. After arriving in Devchuli, I realized geographical distances will not explain any significant differences in the schemes within this VDC. Devchuli is not very large and the terrain is not too difficult, as it was possible to reach the furthest schemes (Kumsot/Sangupari) after approximately 3 hours of walking from the market center of this VDC.

In Finland I thought that the availability of tools and water supply system spare parts could be one thing explaining the differences between the successes of the schemes but when I arrived at the area I realized this factor is the same for all the schemes selected for this study. The distance was only a bit longer from the northern part of the VDC, where the terrain is hillier. Yet, only later I realized that I could have tried to ask about this kind of issues from the NAPA WASH project staff who had been working in these areas.

Regarding the selection of the research question, topic and methods, as an engineering student, I was naturally oriented towards approaches used in natural or engineering sciences. Therefore, I was wondering if there was a way to measure the construction quality with some kind of relatively exact method, as construction quality is one of the factors related to the sustainability of the scheme. Some methods suitable for this purpose would be taking samples of the concrete structures to determine the concrete composition or to look for the documents from the construction period and see what they told about for example the origin or composition of the materials. In the end, the ideas were abandoned because they were too difficult or impossible to implement. Taking and analyzing the concrete samples would probably not have given significant information and the documents have most likely been lost. I was also considering if I could have performed water quality measurements as a part of the study, but this idea also was abandoned in an early phase of the study.

After I arrived in Devchuli and visited a couple of schemes, I was positively surprised of how well the schemes seemed to be operating. Sure there was a lot of room for improvement, but hearing from the villagers how much better the situation was now compared to the time before the schemes were constructed and seeing the situation myself, it

seemed adequate. The objective of this study was to discover water supply “Cinderella” stories, which means learning how the communities had overcome bigger problems and learned from them. Actually currently it seems to me that these schemes had never really encountered exceptionally huge troubles and tragedies related to water supply but they were constantly and steadily doing operating moderately. On the other hand, I think what counts as a huge trouble is a matter of perception. For example, many WUSCs mentioned the scheme suffering from yearly landslides which destroy parts of the scheme. However, usually they were able to fix the problems in a reasonable time such as a few days or a week.

When I was doing the literature survey in Finland before leaving for the field, it seemed puzzling to me how is it possible that the systems fall so quickly into the condition that demands repairs. Based on the fieldwork observations, it seems that the one of the major reasons is the population growth which has been faster than what was expected at the time of designing the scheme. The reasons for the population growth are the natural growth and the migration movement from the more remote areas to the more developed and urban areas. Also, the introduction of the private taps seems to make it easier to consume more water.

6. CONCLUSIONS AND RECOMMENDATIONS

The main objective of this thesis was to study the impact of operation and maintenance practices on the long-term sustainability of the Finnish-funded water supply projects (RWSSP projects) implemented in the Lumbini zone, Western Nepal. This thesis was a part of NAPA WASH project, a project implemented by the Finnish non-governmental organization WaterFinns in partnership with a local Nepalese organization Center for Appropriate Technology Nepal and local Village Development Committees (VDC) and Water and Sanitation User Committees (WUSC).

The worldwide drinking water coverage has increased significantly over the past few decades, but achieving sustainable solutions has not been easy. Too often, the water systems fail prematurely or operate below the expected level of performance. A national review from a few years back revealed that of the 38 000 gravity flow schemes in Nepal included in the study, only 18 % were performing well, the rest were in need of repair. This study aimed to gather information of the practical problems the communities are dealing with and which might drive the water systems into need of repair.

This thesis included a quantitative and a qualitative study. The quantitative study was implemented as a survey which targeted 40 WUSCs, their Village Maintenance Workers (VMW) and altogether 680 water user households in the Committees' area, as well as 24 VDCs in Nawalparasi District. The survey included a broad set of questions including general information of the water schemes, institutional, financial and technical management sustainability of the scheme, population composition in the area, social accountability of WUSC and environmental sustainability and climate change mitigation.

The qualitative study was a case study of the former Devchuli VDC in Nawalparasi. The qualitative study included a literature review and a four-week fieldwork period in Devchuli, during which the eleven water supply schemes of Devchuli were visited. Seven of these had been constructed during Finnish-funded RWSSP projects, the rest were included for comparison. Interviews were conducted with WUSCs, VMWs, local officials and some other stakeholders.

The condition of the schemes in the Devchuli area could be called moderate, sometimes even good. All the schemes were still delivering water to the villagers and three of the WUSCs had been proactive to improve the state of their scheme. Technical problems encountered by the communities in Devchuli included water sources running out, water systems becoming clogged with lime and decreased water quality during rainy season.

The construction quality of the schemes had not been causing problems to the WUSCs, instead it had been experienced as very good. Availability of spare parts and tools was not a problem in Devchuli, as there were good road connections to rural market centers within a distance of a few kilometers and other larger towns not much farther.

Availability of technical personnel in the villages seemed to be moderate. Of the 40 schemes from Nawalparasi in the quantitative study, 75 % had a trained VMW in the scheme. In Devchuli, there was a Village Maintenance Worker in all of the schemes or a retired one residing in the scheme area (and willing to work when necessary) but their skill and nature of tasks varied a lot. The VMWs of the three largest Devchuli schemes were skilled. In some schemes, the villagers had decided that due to the nature of the work needed in the scheme such as cleaning after a landslide which requires a lot of workforce, a VMW is not needed. The presence of a skilled VMW would still be beneficial as otherwise nobody will do any proactive maintenance.

Technical or financial support from the local government to WUSCs was not available easily. The 40 WUSCs were asked if they were associated with some organizations that could help them in finding funding and provide technical support to improve the functionality of the scheme. The most common answer (35 %) was that the WUSC do not have such connections, followed by a connection to Village WASH Coordination Committee (28 %) or to WASH Unit of District Development Committee (25 %). Of the 24 VDCs, 63 % told that in the case of a breakdown of the scheme beyond the capacity there is technical and financial, or only financial help available, while 37 % told there is no help available. As a result of this, some WUSCs had resorted to temporary, cheaper repair solutions such as repairing the pipes with parts of bamboo.

In Devchuli, the three proactive WUSCs had a relatively large operation and maintenance fund on their bank account, but the other WUSCs were mainly collecting money for repairs on a reactive manner. On the other hand, probably because the communities appeared to be tight, this seemed to work decently. If there were a problem such as a landslide destroying parts of the scheme, everyone would go help. Some schemes suffered from yearly landslides but usually the villagers were able to return the scheme to a functioning condition in a week.

Population growth in the area and the water scarcity caused by it appeared to be one of the major reasons why the schemes were in need of rehabilitation. Forty percent of the 40 WUSCs who in the quantitative study scored their scheme less than “fully functional”, mentioned the increase in the number of households in the area as one factor causing problems to the functionality. The field visit in Devchuli supported this conclusion. In many villages, the amount of households had doubled. The WUSCs had eased the water scarcity by adding additional sources to the schemes but often these solutions were more of ad hoc type and not properly constructed.

Another issue of rising interest among the villagers were private taps, or household connections. Private taps had been constructed in the three biggest schemes in the Devchuli area over the last few years, they were relatively new in the area. Private taps were rather rare at the time of RWSSP project, some private connections had been constructed in only 8 % of the Nawalparasi schemes at the time. At present, there were some private taps in 40 % of the schemes and 35 % of the schemes had only private connections. The initiative of constructing private taps in the scheme had come from the villagers and WUSC members.

It seems that among the people there is some willingness to pay for better services. Of the households with a water tariff already in the scheme, 42 % said they would be willing to pay a higher tariff. The most commonly mentioned desirable improvement in the service was private connection, mentioned by 40 % of those willing to pay a higher tariff. It is difficult to estimate the effect of private taps on the consumption of water. With the private taps, the water is "within easier reach" and doesn't have to be carried from away, which could increase the consumption. On the other hand, people might waste water from public taps as the water tariff is fixed. With a water meter of their own, they might act thriftier.

Operating the scheme with private taps will require a more professional way of managing the scheme than what many of the WUSCs were currently doing. A part-time or full-time Office Secretary will need to be hired for processing scheme membership applications and billing. Maintenance of the private taps will increase the workload of the Village Maintenance Worker, which can be assumed to raise their salary. Currently, the profession is not very popular due to its low level of remuneration. Earlier it has been noted that many trained VMWs have left the country for a better job. Six of the seven VMWs trained by RWSSP were still living in Devchuli.

In the future, the population growth and urbanization should be better taken into account when designing a scheme, although it is difficult to forecast. I recommend considering the construction of private taps in the schemes, but it should be not an automatic choice as it requires more maintenance work and good availability of spare parts for the taps. The income level of the villagers and their willingness to pay must be figured out before the decision to construct private taps as the water tariff will most likely be higher. The WUSCs are now moderately coping on their own, but they would benefit a lot from better post-construction support provided through the local government bodies, or even private operators and NGOs. The support should be provided on proactive basis, which currently was not the case.

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APPENDIX I

Interviews and personal communications from fieldwork period, April-May 2015

3/4/2015. Interview with CATN staff, Ram K.C. and J.N. Prasain. (2 males).

5/4/2015. Interview with CATN staff, Ram K.C. and J.N. Prasain. (2 males).

6/4/2015. Travel from Kathmandu to Devchuli. Interview with advisor for all water supply schemes (male).

7/4/2015. Focus group discussion with Ram Bas Sita Bas and Aaptari WUSC members and a transect walk to the water source and reservoir tanks (5 males). Focus group discussion with Aaptari, Ram Bas Sita Bas and Ranibel WUSC members and advisory committee members (11 males).

8/4/2015. Household interview with an Aaptari water user (female). Household interview with Aaptari water users (1 male, 3 female). Transect walk with Aaptari office secretary (female).

9/4/2015. Focus group discussion with some women members of Aaptari WUSC as well as water users from Aaptari (7 female). Interview with Aaptari office secretary (female).

10/4/2015. Discussion with former Ranibel WUSC member (male). Interview with ward chairperson for wards 6, 7, 8, and 9 in Devchuli municipality (male). Discussion with former Ram Bas Sita Bas WUSC member (male).

11/4/2015. Participation in the General Assembly meeting of Ram Bas Sita Bas. Focus group discussion with Ram Bas Sita Bas WUSC members and Devchuli social mobilizer (1 female, 3 males). Interview with a restaurant owner and water user of Munde scheme (female). Focus group discussion with Munde WUSC members (4 males). Interview with Ranibel VMW (female).

12/4/2015. Interview with the manager of Pragatinagar Water Supply and Sanitation Consumer Association (male). Interview with the Chief Executive Officer of Devchuli Municipality (male).

15/4/2015. Interview with former Ram Bas Sita Bas WUSC member (male).

18/4/2015. Interview with Aaptari VMW (male). Interview with Munde VMW (male).

19/4/2015. Interview with the former chairperson of Kirtipur thulo gau WUSC (male).

20/4/2015. Transect walk to the source of Kirtipur thulo gau scheme. Focus group discussion with Kirtipur thulo gau WUSC members (2 males, 1 female). Interview with Kirtipur thulo gau VMW (male). Transect walk to the source of Sangupari scheme. Focus group discussion with Sangupari WUSC members (4 males). Interview with Sangupari VMW (male).

21/4/2015. Focus group discussion Chuhar WUSC (4 males) and their former VMW, transect walk to the source of the Chuhar scheme. Transect walk to the source of Nayachhap scheme. Interview with the VMW of Nayachhap (male). Focus group discussion with newly elected Nayachhap WUSC members (2 males) as well as some villagers.

22/4/2015. Focus group discussion with Kumsot WUSC, also one Aaptari WUSC member was present (2 females, 2 males). Interview with Kumsot VMW (male). Interview with Bisaltar VMW (male). Focus group discussion with Bisaltar WUSC, meter reader and office secretary (5 males).

23/4/2015. Interview with Ram Bas Sita Bas VMW (male). Transect walk to the reservoir tanks of Munde. Interview with the chairperson of Munde WUSC (male). Household interview in Ranibel (1 female, 3 males).

24/4/2015. Transect walk to the source of Mirtung khola, focus group with Mirtung khola WUSC members (1 female, 2 males).

25/4/2015. Transect walk to the sources of Bisaltar. Interview with Bisaltar office secretary (male).

27/4/2015. Transect walk to one of the reservoir tanks of the Aaptari scheme. Interview with Aaptari secretary (male). Interview with Aaptari VMW (male).

28/4/2015. Visit to Amarapuri scheme which is one of the most advanced rural water schemes in Nepal. Interview with the Amarapuri Field Coordinator and Manager (2 males)

29/4/2015. Focus group discussion with Ranibel WUSC members (2 males), former citizen forum coordinator (male), ward committee coordinator (male) and water users (almost 30 people, males and females).

30/4/2015. Interview with engineer of Devchuli Municipality (male), interview with Municipality accountant (male), interview with the board members of Isaj Samaj Nawalparasi (2 males, 2 females).

2/5/2015. Focus group discussion with Kirtipur thulo gau WUSC members (2 males), focus group discussion with Sangupari WUSC members (2 males).

3/5/2015. Focus group discussion with Kirtipur thulo gau WUSC members (3 males, 1 female

4/5/2015. Phone calls with remaining questions to the WUSCs, interview with former Ram Bas Sita Bas treasurer (male).

5/5/2015. Reviewing the meeting minutes of Devchuli VWASHCC.

APPENDIX II

Questionnaires for qualitative study interviews

The interviewees were first told that the questionnaire is not strict and they were encouraged to talk freely about the topic. These questionnaires provided mainly themes for the interview.

Questionnaire for WUSCs

1) [To everyone who was present in the interview:] Please introduce yourself: what is your name, age, caste, gender, ethnicity and religion? Do you have positions in other organizations than this WUSC?

2) Please tell about your water scheme in general.

3) Please tell about the structure of the scheme: name, location and type of source? What is the type of intake? Are there collection chambers break-pressure tanks or reservoir tanks? How is the source the protected? Do you have technical layouts or drawings of the scheme?

4) What was the amount of households and population at the time of scheme construction and at present?

5) When was the WUSC formed, and what was the process of formation like? How often WUSC meetings and General Assemblies are being held?

7) Do you collect the water tariff and how? How much is it? Is it enough to cover the expenses? Do you have an O&M fund? If yes, tell more about it? Do you have other income sources?

8) Has the water quality ever been measured? If yes, please tell more about it.

9) What kind of problems do you face with the scheme? Has there been any big breakdown in the past?

10) Who buys the spare parts and tools?

11) What is the biggest ethnic group in the area? What is the education level of people in the area?

12) Are you satisfied with the scheme in general?

Questionnaire for VMWs

1) Please introduce yourself: what is your name, age, gender, ethnicity and religion? Do you have positions in other organizations than this WUSC? For how long have you lived here? What is your education background?

2) How long have you been in this job? What jobs did you have before?

3) Who recruited you in this job and why? Where there many people interested in this job?

4) What are your routine activities in this job?

5) [Question only for the schemes with private taps.] How did this job change when the private taps were constructed?

6) How many hours a week do you work in this job? Do you have any other job?

7) What kind of training did you have for this job?

8) What are the main difficulties you face in this job?

9) What spare parts and tools do you need? What is their cost and availability? Who pays for them? Where do you buy pipeline?

10) Who buys the spare parts and tools? Who stores them?

11) How is your salary? Has it changed? Do you have a job contract on paper?

12) Have you ever been working abroad? Would you like to go (again)?

13) Are you satisfied working in this job? Would you like to change jobs?

14) What is the villagers' perception about this job? Do you feel appreciated?

15) How often do you go this scheme's WUSC meeting? Do you go to other scheme's meetings? Do you meet other VMW's on a regular basis?

16) How has this job changed during the years, from the construction of the scheme until today?