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Sustainability of Community Water Supply Systems Managed by Water User Committee. - A Case Study of Rural Water Supply System in Nepal.

Raut, Kalyani

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Abstract

Many Nepalese rural communities are suffering from lack of safe drinking water. One of the reasons is that approximately one third to one half of all drinking water supply systems fail shortly after the construction. The main purpose of this thesis project was to analyze sustainability of rural water supply project managed by water user committee implemented by DWSS in Dhulikhel, Bhakundebesi, kavre and Panchdhara, Kathmandu. In addition, the thesis also reviewed water supply system and its sustainability in Nepal than in general.

This thesis focuses primarily on the assessments carried out in the field, observations notes, household survey and discussion with members of water user committee. Results shows that all the studied schemes are financially and technically sustainable and able to delivered good quality of water to the users. Though, the schemes are self reliant, DWSS regularly provide major technical assistance. Hence all of the water supply system seems to be smoothly operating without financial, technical or institution problems with in water supply system and the community. Thus, it can be concluded that three water supply systems are providing quality drinking water to the people.

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List of Abbreviations

ADB	Asian Development Bank
ANOVA	Analysis of Variance
APHA	American Public Health and Association
AWWA	American Water Works Association
BCHIME	Between Census household Information, Monitoring and Evaluation System
CRMO	Central Regional Monitoring and Supervision Office
DWSS	Department of Water Supply and Sewerage
ENPHO	Environment and public Health Organization
EC	Electrical Conductivity
FGD	Focus Group Discussion
FINNIDA	Finnish International Development Agency
GTZ	German Co-operation
GO	Government Organization
INGO	International Non-governmental organization
ISSD	International Institute for Sustainable Development
JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation
MDG	Millennium Development Goal
MLC	Maximum Concentration Levels
NDHS	Nepal Demographic and Health Survey
NDWQS	National Drinking Water Quality Standards

NFHS	Nepal Family and Health Survey
NGO	National Governmental Organization
NLSS	Nepal Living Standards Survey
NPC	National Planning Commission
NRs	Nepalese Rupees
O& M	Operation and Maintenance
RWSSP	Rural Water Supply and Sanitation Projects
UDLE	Urban Development through Local Efforts
WHO	World Health Organization
WTP	Willingness to Pay
WUC	Water Users' Committee

Chapter (I) Introduction

1.1 Introduction

Water is basic need and human right of people. People need water for various domestic purposes like drinking, cooking, sanitation, and irrigation. Besides domestic use, people also need water for other diversified livelihood including livestock, gardening, cropping, food processing, aquaculture and fisheries (Soussan 2003; Kopper et al. 2006). In rural and peri-urban areas of developing countries, where main occupation is agriculture depends upon water to sustain livelihood (Soussan 2003; Renwick et al. 2007).

Water is also an essential resource for survival and to secure good health. But people around the world are facing the problems of water scarcity. This scarcity of water forced the people to use unsafe water for the drinking and other domestic purposes (WHO, 2009). About 1.7 billion people in developing countries have no access to safe drinking water (Health UNICEF, 2013). As a result, about 50% of population in the developing countries suffered from water-borne diseases such as diarrhea, cholera, ascaris, hookworm (Murcoot, S., 2001). About 10 billion people die each year due to intervention of some 500 million new cases of waterborne diarrhea (Snyder, J. D., Merson. M. H., 1982). When people do not have access to safe water supply and sanitation, there will be higher risk in their health condition. Diarrheal infection alone is responsible for 1.8 million deaths a year worldwide, of which 90% are children under age of five (WSSCC, 2010). Like water, sanitation is also a basic way to ensure healthy life. Parallel to water, sanitation is a serious health risk and affront to human dignity. Sustainability of water supply system depends on social acceptability, social viability and technical and environmental sustainability.

Nepal is also suffering from water scarcity and lack of improved sanitation. Drinking water is the minimum need of all human beings and provisions of convenient, safe, clean and adequate drinking water is the declared commitment of government of Nepal (Human Development Report 2006). Population growth, rapid urbanization, industrialization increases demand of water supply and it pressurizes the government for development of more drinking water resources. The growing imbalance between demand and supply has brought various challenges. As a result of poor quality and quantity of water, high incidences of water related diseases are causing

significant damage to human well-being. Inadequate access to water supply along with poor sanitation and personal hygienic practices is likely the cause of water borne diseases.

To reduce the imbalance between water demand and supply, different NGOs, INGOs and private sector are fostering water supply projects in Nepal. In recent years, a number of water supply projects have been implemented in Nepal. These projects are mostly funded by international organizations like World Bank, Asian Development Bank, UNICEF, World Health Organization (WHO) and Water Aid. Sustainability appears to be primary issue of these water projects.

Various factors may contribute to the difficulty in developing sustainable water supply system. Post project evaluations are done in water supply and sanitation projects to identify strength and weakness of implemented projects. The major problems in water supply projects seem to be the lack of sustainability, as defined by "whether or not something continues to work over time" (Abrams, 1998). Many water projects seem to appear successful at the beginning but eventually crumble down after few years (Bourrigault, 2006). Experiences and feedback from the post projects evaluation of water supply projects have been identified the major issues related to the failure of water supply projects as: operation and maintenance, cost recovery, gender issues, financial support and hygiene education need to be addressed (Guerquin et al., 2003). Safe drinking water quality significantly improves the quality of life which leads to improved human well-being. Water borne diseases like Diarrhoea, Cholera, Giardiasis, Denque, Botilism etc in a poor or developing countries are related to poor water quality or unsafe water (Fabrizi, 2002). To control these diseases, a sufficient amount of safe drinking water is important.

1.2 Problem Statement of the Research

Water supply system in Nepal has not been able to provide and sustain adequate drinking water services to all people. The main problem is lack of sustainable access to improved water supply service for the people in an efficient manner. The problems are noticed as lack of access to water supply and the poor and unsustainable services for people with access to water supply services. A large proportion of population does not have access to improved services and those with access are concerned with the quality of services such as water quality, adequacy, reliability, response to consumer complaints. Access to drinking water in Nepal has increase in the past two years. "Around 270, 000 households gained access to safe drinking water" (MDG, 2013). This

does not mean that they have access to the best quality water. Despite these gain, still 700,000 household are without safe drinking water (MDG, 2013).Those without access of improved source relay on natural sources such as river, groundwater, and surface water.

There are number of factors which impact upon the effectiveness of the water supply system. These factors are socio-economic situation, financial, technical, institution, user participation, water quality. These factors have been key components of sustainability of water supply system. The influence of these factors is important for understanding the performances and behaviors of the water supply system.

The aim of this study is to examine the water supply projects in Nepal in terms of technical, institutional, and financial sustainability.

1.3 Research Objectives and Questions

The study will evaluate the status of Dhulikhel, Bhakundebesi and Panchdhara water supply systems managed by water user committee. The main objectives of the study are as follows:

- To review water supply system and its sustainability in Nepal than in general.
- To analyze the quality of water supplied to the community through project intervention.
- To study technical and financial viability of water supply system.
- To study institutional arrangements of the water supply system.

Chapter (II) Literature Review

2.1 Water and Sanitation in Global Context

Millennium Development Goals (MDGs) are set of targets established by the United Nations to address worldwide poverty. Among these, the provision of clean drinking water to "halve by 2015, the proportion of population without sustainable access to safe drinking water basic sanitation" (UN 2009). This target has been a key factor in many governments and organizations undertaking efforts to improve drinking water access to urban and rural populations in developing countries. In between 1990 and 2010, more than two billion people gained access to improve drinking water sources (UN 2009). The proportion of people using an improved water source rise from 76% in 1990 to 89% in 2010 (UN 2009).

Globally, the proportion of populations with access to improved drinking water sources increased from 77% to 87% and sanitation coverage from 54% to 77% in between 1990 and 2008 (JMP, 2008). Despite this progress, it is estimated that in 2008, there were still 884 million people lack of improved drinking water sources and more than hundreds of millions will still lack of sustainable access of safe drinking water (JMP, 2008). Definitions of the different development stages of water supply and sanitations coverage are given in below table (1 and 2).

Table 1: Definition of stages in drinking water development JMP (2008).

Piped water on premises	Piped household connection located inside the user's plot or yard.
Improved drinking water sources	Public taps/standpipes, boreholes/ tubewells, protected dug wells.
Unimproved drinking water sources	Unprotected dug wells, tanker truck, unprotected springs, and bottled water, surface water (river, dam, lakes and pond, canal, stream, and irrigation channels).

Table 2: Definition of stages in sanitation development JMP (2008)

Improved	Flush or pour-flush toilets/latrines combined with piped sewer systems or a septic tank, ventilated improved pit (VIP) latrines with a slab and composting toilets.
Shared	Sanitation facilities that are shared between two or more households including public toilets.
Unimproved	Sanitation facilities without hygienic separation of excreta, such as pit latrines without a slab.
Open defecation	Direct defecation in the surrounding environment.

In south Asia, it is estimated that 705 million people still practice open defecation in rural areas compared to 74 million people who do in urban areas (UN 2009). Therefore improving sanitation coverage with access to safe drinking water is of very importance for the development and ensures to achieve the Millennium Development Goal (target 7C). The quality and status of water supply in the ground reality as indicated in table 2 will influence the sustainability in the water supply system.

2.2 Sustainability in Water Supply System

Sustainability is a term widely used and has a different meaning depending on the context where it is used. One of the most well known definitions of sustainability is: the Brundtland report in 1987 defines "Sustainability development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (issd 2013). Although Brundtland definition is very broad and applicable to many disciplines, later it's definition is applied more thoroughly to water and sanitation sector. The Agenda 21 (UN 2009/a) states that " by achieving sustainable development all people, regardless of their stages of development and social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs".

Besides the definition of Brundtland Report Mihelcic et al. (2007) define sustainability in term of infrastructure as "the design of human and industrial systems to ensure that humankinds use of

natural resources and cycle do not lead to diminished quality of life due either losses in future economic opportunities or to adverse impacts on social conditions, human health, and the environment". Moreover, there are other aspects of sustainability besides these. These aspects include institutions, public participation, social awareness, capacity building, operation and maintenance, technical and financial. Smith (2011) outlined that: "community water supply systems are engineered solutions that operated through social cooperation. And also mentioned that the technical adequacy is the first and most critical for long- term sustainability of water system."

Brikkr (2002), In: Cardona and Fonseca, (2003) stated that a water and sanitation system is sustainable when:

- It continues to function over a prolonged period of time and able to give appropriate level of benefits like quality, quantity, continuity and health to all.
- Its management is institutionalized.
- Its operation, maintenance, administrative cost are recovered at local level and can be operated and maintained at local level with limited but need feasible external support.
- It does not affect the environment negatively."

But this definition does not cover the financial management required to recover cost. Since, finance is a problem in community managed system and it is important to address. Brikke and Rojas (2001) reported that financial management is effective if committee is able to budget the income and expenditure over a define period of time, collect service fees, keep financial information and record, and control and monitor the financial performances of the system. Another conclusion drawn on the sustainability of water supply projects in Northeast Brazil, have identified how environmental and community assessment, community engagement in planning as well as training capacity building and monitoring can help to meet the sustainability criteria(Silva et al., 2013). Similarly, Katz and Sara, (1998); Carter et al., (1999); Gleitsmann, Kroma and Steenhuis, (2007); Barnes and Ashbolt, (2010) concluded in their paper that, when local communities participate directly in planning their own water supply systems, these systems are more likely to be sustainable than systems that are imposed by the government or donor

organizations. When community are engaged in the planning process and are more likely to select supply options that they are willing and able to operate and maintain (Montgomery, et al. 2009).

Furthermore, social capital (set of shared community norms, expectations and pattern of interaction) within a rural community is also one of the factors that affect the sustainable rural water supply systems. Social capital can help a community to develop and deploy their own administrative and financial capital to manage a system. A research carried on irrigation in rural areas by Lam (1998); Ostrom, (2000), concludes that when infrastructure development does not consider the availability of social capital in a community, the systems are less likely to be sustainable.

Montgomery et al., (2009) presents that the support of social capital building, there must be an active communication by local leaders with community members regarding the planning and operation of water system. In addition to social factors, administrative, financial and technical capacities are essential criteria for sustainable rural water supply systems to ensure a system operates effectively over time and at reasonable cost (Harvey and Reed, 2004). Additionally, the sustainable systems are likely to be found where the communities and project operators have adequate financial and administrative capacity for system operations and maintenance (Montgomery et al., 2009).

Many scholars claim that water supply system will be sustainable when consumers are willing to pay user charges that are sufficient to cover all the costs. Willingness to pay (WTP) can be constructed as an indication of the demand for improved services and their potential sustainability (Kaliba et al., 2003). In contrast, Bohm et al., (1993); concluded that rural water supply systems are not sustainable unless grants are available to finance most or all initial construction costs.

2.3 Sustainability Studies of Water Supply System in Nepal:

Bhandari and Grant(2007) discussed in their article that technology, people and institution are the main three factors of water supply system, which determines whether the scheme is sustainable or not. The study was carried out in the rural village and rural market through the questionnaire survey to find the differences in maintaining and operating water supply system.

They concludes their survey as, in the rural village weak institutional capacity is the main obstacle for the provision of drinking water while in rural market centers technicalities are the major problems of the project sustainability.

Chauhan, (2013) carried out study on environmental sustainability of rural water supply systems implemented by Rural Water Supply and sanitation project in Western Nepal from the institutional and financial point of view. The study was focused on organization and management capacity of Water Users and Sanitation Committees to ensure the proper functionality and Sustainability. The main findings of this study is most of the studied schemes have been affected by several water contaminants like E. coli which decreased the life of projects sustainability.

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According to government policy of Nepal, operation and maintenance costs of the projects should be financed by community itself while the investment cost is covered by the donor agencies or the government (NPC, 1998). Community may also contribute to project investment by providing labor, land and local materials. A sustainable drinking water future depends on appropriate prices and the necessary resources need to come from project consumers (World Bank water Demand Research Team, 1993; Whittington, 1998). However, in Nigeria rural consumers do not want to pay for water in advance or commit themselves to a fixed monthly payment due to their mistrust of public providers (Whittington et al. 1990). Water User Committee plays a vital role in the sustainability of rural water supply schemes (Lopez-Gunn and Cortina, 2006).

2.4 Water Quality Monitoring

Water supply: water is a fundamental to life on the earth and one of the most valuable resources. With the increasing population, global water consumption has grown twice as fast as population due to urbanization, industrialization, tourism development and irrigation (WELL, 1998). Water is not only use as resources but also as a sink for pollutants. Wastes/ pollutants of various kinds

released to aquatic environment to be released and dispersed. The tolerance level of any environment is limited and it may be degraded.

Water quality: Drinking water quality is subject to extensive quality standards, regulating the maximum allowed level of contaminants (MLCs) or maximum concentration level (MCL). Due to local differences in the quality of water, public attitude and impact of different parameters are different for different countries. WHO (2004) has define drinking water as "if and only if no any significant health risks during its lifespan of the scheme and when it is consumed". In term of drinking water quality, user perception is one of the most important things (Sheat 1992, Doria 2010). There are various factors that influence the perception of drinking water quality such as human sensor perceptions of taste, odor and color of water are related to mental factor. These are most important because it may detect contamination related to chemicals. And people may perceive risks if they experiences health problem caused by water. The presence of E. coli provides strong evidence of fecal contamination, (WHO, 2004, Stevens et al., 2003). The risk of E. coli presence, slightly greater than WHO guideline's zero count per 100ml may be of only low or intermediate risk. Risk classification of E. coli for rural water supplies is given below table 3 and 4 (IRC, 2002; as cited by Michael H., 2006).

Table 3: Water Quality per 100mL and Associated Risk

Count per 100mL	Risk category
0	In conformity with WHO guidelines
1-10	Low risk
11-100	Intermediate risk
101-1000	High risk
>1000	Very high risk

This study is based on the WHO guidelines for drinking water supply and national drinking water quality standards of Nepal (2062 BS).

Table 4: Drinking Water MCL for Nepal and WHO guidelines (National Water Quality Standards and Directives, 2005)

Parameters	Units	NDWQS	WHO guidelines
Temperature	^{o}C	-	-
PH	-	6.5-8.5	6.5-8.5
Electrical conductivity	µs/cm	1500	1500
Turbidity	NTU	5	10
Total hardness as $CaCO_3$	mg/L	500	500
Fluoride	mg/L	0.5-1.5	0.5-1.5
Ammonia	mg/L	1.5	1.5
Nitrate	mg/L	50	50
Iron (Fe)	mg/L	0.3	3
Manganese (Mn)	mg/L	0.2	0.2
Total coliform	CFU/100mL	0	0
E. coli	CFU/100mL	0	0

Note: NDWQS= National Drinking Water Quality Standards

Physical and chemical assessment: Heavy metals like fluoride, nitrate and arsenic are crucial to human health. These substances can be traced in the bedrock. But anthropogenic activities such as mining may increase their concentration in the water bodies. Excessive amount of nitrate on the water bodies are due to the activities of human like discharge from wastewater treatment plants, runoff from agricultural land, leakage from latrines.

Physical parameters like electric conductivity (EC), hardness, PH, color, odor and turbidity is not concern with human health but it should be ensure to user acceptability. However, these parameters are function as indicators of other contaminants.

Turbidity measures how much light is observed by suspended materials in the water such soil particles and organic matter. Higher level of suspended materials from erosion, discharge, storm water and biological growth in the water is the indicator of water contamination. Turbidity level

tends to vary with stream flow and velocity. Turbidity can protect microorganism from disinfection effects, can stimulate the bacterial growth and create problem in treatment processes (WHO 2004). For effective disinfection, turbidity should be below 0.1 NTU, turbidity less than 5 NTU is usually accepted to consumers (WHO, 2004).

Alkalinity of water measured in PH is crucial for several chemical and biological processes. If PH of water is known, then it is possible to tell in which ironic form a substance is present and which chemical reactions that will occur. PH has no direct impact on consumers. According to WHO, 2004, low PH level can enhance corrosive characteristics resulting in contamination of drinking water and adverse effects on its taste and appearance.

Electrical conductivity (EC) measures the electric current that can be passed through the water, a function of number of ions in solution. High conductivity indicates the presence of inorganic substances, such as an aluminum, calcium, chloride, iron, nitrate, phosphate, sodium and sulfate.

Microbial assessment: A health risks associated with drinking water are infectious diseases, caused by water contamination by bacteria from human or animal feces (WHO, 2004a). Bacteria, viruses, protozoa and helminthes can be found in human and animal feces but bacteria are likely to present together with any other which make them suitable as indicator species. Feces are not only the causes of microbial contamination of water bodies, naturally large number of microorganisms exist in water and the environment (Scholz, 2000). Presence of pathogen in water bodies depends on several factors. Besides from the human and animal activities in the water, physical and chemical characteristics of the catchment are also responsible (WHO, 2004a). Both point source like discharge of wastewater, storm water, runoff from agriculture and leakage from latrines and non point source of pollution are crucial to water pollution (WHO, 2004a).

Microbiological testing of water is commonly done by using total coli form or E. coli as indicator species. Both are found in the intestine and feces of warm blooded animals. Total coli form also naturally exists in plant and soil so their presence in water bodies does not provide conclusive evidence of fecal contamination. According to Government of Nepal the “Water Supplier” themselves are responsible for water quality monitoring. Different private agency like NESS (Nepal Environmental and Scientific Services) also involved for monitoring of water quality of number of projects in Nepal. In rural projects, NESS studied water supply schemes

with surface and groundwater sources at different development phases: source identification, construction and performance evaluation of completed schemes (NESS, 2012).

The parameter and frequency of monitoring for rural and urban water supply systems is given below table 5. For rural water supply system, microbiological parameters should be monitored at least three times in a year (pre-monsoon, during monsoon and post-monsoon) (National Drinking Water Quality Standards and Directives, 2005).

Table 5: Frequency of Monitoring for Urban and Rural Water Supply System

S.N	Category	Parameters	Monitoring frequency
1	Physical	Turbidity	Daily
2		pH\Color	Daily
3		Taste and Order	Daily
4		EC	Monthly
5		TDS	Quarterly
6	Chemical	Residual Chlorine	Daily
7		Ammonia	Monthly
8		Chloride	Monthly
9		Nitrate	Monthly
10		Total Hardness	Monthly
11		Calcium	Monthly
12		Iron	Yearly
13		Manganese	Yearly
14		Sulphate	Yearly
15		Arsenic	Yearly
16		Cadmium	Yearly
17		Copper	Yearly
18		Fluoride	Yearly
19		Cyanide	Yearly
20		Lead	Yearly
21		Chromium	Yearly
22		Zinc	Yearly
23		Mercury	Yearly
24		Aluminum	Yearly
25	Microbiological	E.coli	Monthly
26		Total coliform	Monthly

Source: National Drinking Water Quality Standards and Directives (2005).

Chapter (III) Methodology

3.1 Study Area

3.1.1 Selection of Case Studies

Three case studies Dhulikhel water supply system, Bhakundebesi water supply system and Panchdhara water supply system were selected with the help of DWSS(Drinking Water Supply and Sewerage System) and the District drinking water offices (figure 1 Map of Nepal).

Figure 1: Map of Nepal showing Study Area

The published and unpublished reports were reviewed from district water offices to gain the detailed relevance overview and for other case studies. The three case studies were selected on the basis of following criteria.

- The project is completed and it is easier to measure sustainability of completed project.
- These 3 schemes have different water source i.e. surface water flow, groundwater flow and spring water.

- Projects sites are easier to access and feasible for investigation in limited time period.

3.1.2 Dhulikhel Drinking Water Supply System

Dhulikhel Municipality is located at about 30 km east of Kathmandu, the capital city of Nepal. Dhulikhel is one of the three municipalities of Kavrepalanchok district. Dhulikhel is popular for its natural beauty and ancient traditions. It is typical Newari town with nearby Tamang villages.

People of this municipality are also equally laborious, hardworking and have a sense of unity for the betterment. Several developmental activities initiated by the local people and supported by different agencies have been made successful in the region. Dhulikhel drinking water project is managed and controlled by the consumers group on its own resources.

The dhulikhel municipality has two water systems, one is old and other is new water supply system. In 1982, the old system was built at the initiation of community with the financial support of Indian embassy. The system has 27 public taps located in ward no. 2, 3, 4 and 5 of the municipality. The system collects water from the springs near to the forest. With the growing population, the system could not cope up the water demand. Moreover, drinking water supplied from the system was contaminated due to unscientifically constructed intake and reservoir. However, the public are still functional and are managed by the water user committee formed by new water supply system.

Due to increase in water demand, people of this area were looking for a better source of water from which sufficient water can be obtained. But due to lack of enough resource, it was not possible to launch a project on their own. They had to look for either the government or the other donor agencies in order to carry out the project.

In 1983 people requested the concerned authority to manage drinking water in the area. The government then inspected some of the sources of water and a brief feasibility survey was carried out. The study concluded that it would be very expensive to bring water from those sources. Then people of this area requested German Co-operation (GTZ) for its help in this respect.

Dhulikhel community approached German Development Agency (GTZ) in 1987, which was working in nearby area Bhaktapur then GTZ put two conditions to the community: first to bring a request letter from the government, and the second to convert Dhulikhel Village Development Committee (VDC) into municipality. Then the delegation of Dhulikhel people approached concerned ministries and demanded for the two requirements as asked by the GTZ. Later, the Government converted Dhulikhel VDC into municipality in 1986, and also sent a request letter to GTZ for the provision of drinking water in the municipality. Besides, the community fulfilled some other conditions including formation of a water user committee and collection of NRs.300, 000 as operation and maintenance fund.

With the fulfillment of the above conditions, GTZ became ready to provide technical and financial assistance to establish Dhulikhel Drinking Water Supply system. After getting assurance from GTZ, some energetic youths visited different possible places to find out reliable water source. Ultimately they identified Khar Khola (Khar Stream) located at 13.5 km in Bhumidanda Village Development Committee (VDC), southeast of Phulchoki Mountain. They made an agreement with the VDC and submitted a request for support from GTZ to bring water to Dhulikhel. The implemented water supply system is given below.

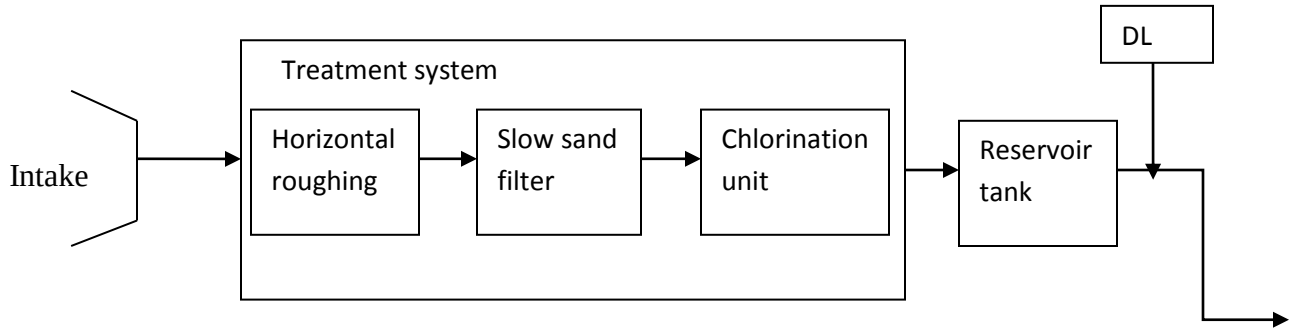

Figure 2: Schematic Diagram of Dhulikhel Water Supply System

Note: DL= Distribution line

3.1.3 Bhakundebesi Water Supply System

Bhakundebesi is situated at a distance of 22 km south east of Dhulikhel and 52 km south east of Kathmandu in kavrepalanchok District of Bagmati Zone. It is a small valley stretched south east in North West and forms the low lying areas of surrounding nine VDCs. The Banepa Bardibas Highway (B.P Highway) passes from the mid area of this valley and is the main thrust to the development of this Bazar. The Bazar area is situated on a gentle slope along this highway. Main Bazar lies in the ward no. 3 and 7 of khanalthok VDC. Bhakundebesi Water Supply Project was constructed to supply drinking water for 3 VDC; Methikot, Khanalthok and phulbari.

The Bhakundebesi is seen as the upper extension of the Panchkhal valley and lies at an altitude of about 1400m above the mean sea level. The valley is sloping towards south east. Mostly People depend on subsistence agriculture. Basic need such as water supply is one of the high demands in the area; especially the safe drinking water is a major problem. There was not pipeline supply of drinking water. People use to fetch water from natural source (Kuwa, river,). In addition, women and girl spent much of their time in fetching water, which limits them from other opportunities such as education and income generation.

There are very few water sources around the vicinity and surface water sources were not sufficient for fulfilling the demand. The surfaces sources too are contaminated by high calcium content and existing project faced calcium deposition problems.

Due to lack of sufficient drinking water in the Bhakundebesi, government started the project to provide drinking water. Bhakundebesi drinking water supply and sanitation project was started in 2003/04 by the joint approach of local people and division Chief Manoj Ghimire. The project was completed in 2008/09 and starts to distribute to ward no. 2, 3, and 4 of methikot, ward no. 6 of phulbari and ward no. 7 of khanathok. The type of water source is ground water. The water supply system is given below.

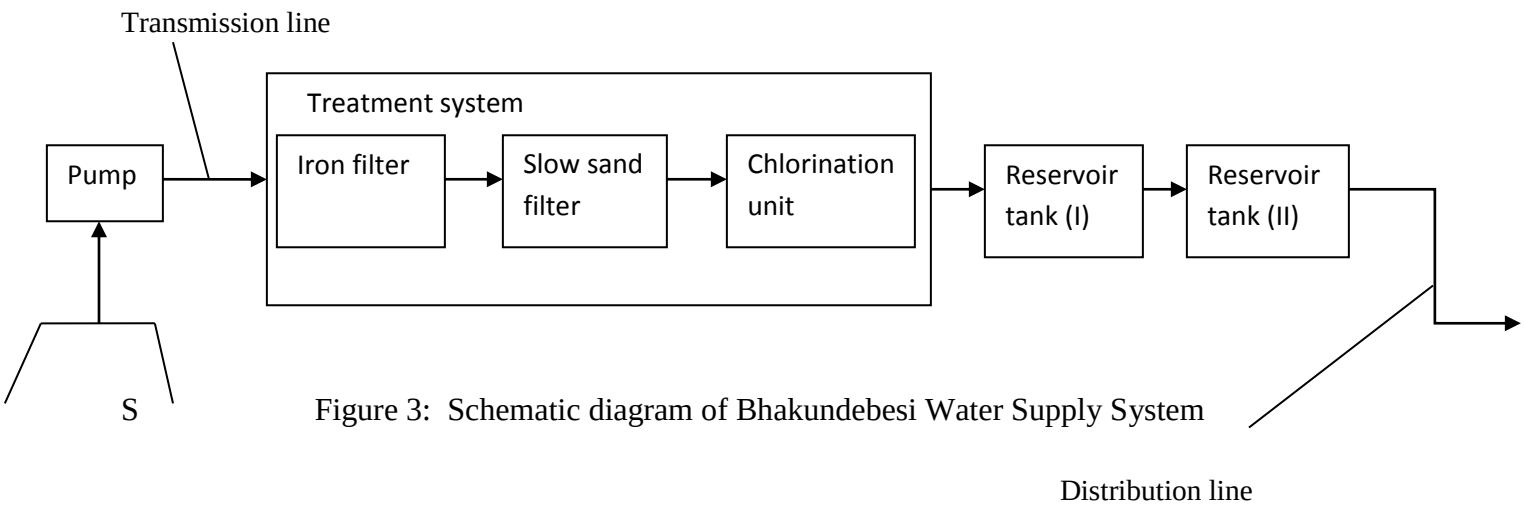

Figure 3: Schematic diagram of Bhakundebesi Water Supply System

Note: S= water source

3.1.4 Panchdhara Drinking Water Supply and Sanitation System

Ichangu Narayan Village Development committee (VDC) lies in the western part of Kathmandu Valley. Panchdhara Drinking Water Supply System is surrounded by Goledhunga VDC in the North, ward no. 15 of Kathmandu metropolitan City in the East, Ramkot VDC in the South and Nagarjun Forest in the West.

The project area is terrace and sloping towards east. The source of the project lies on the panchdhara spring located in ward no. 4 of Ichangu narayan VDC. The area is dominated by chhetri and Brahmin and others are Newar, Tamang and Lama.

The source of panchadhara is the spring water. Local people of that area used to collect water in a bucket to fulfill their water need. The villagers feel that they have to maintain this source in order to use water in long run. In that course, villagers made a committee panchdhara amendment service. After the formation of committee, artistic 5 stone spouts was constructed in 2001 with a total cost NRs 76,000 and the cost was raised from the local people at the rate of NRs 1000. After that the committee decided to made storage tank in front of panchdhara of 65,000 liters of capacity. For this, VDC provide NRs 150,000 and also some contribution from local people in cash and kind for the construction of storage tank. After one year the committee changed their name to panchedhara origin conservation and drinking water user committee. The

committee was registered in Kathmandu water resources association in 2002. They proposed government for the enhancement of the water supply system. The agreement was made between panchdhara drinking water users committee and government. Department of Water Supply and Sewerage (DWSS), and Central Regional Monitoring and Supervision Office (CRMSO) are responsible as a lead agency to provide proper water supply and sanitation. The survey was carried out following the standard guideline and detailed survey format adopted by DWSS. The survey team organized meeting with local beneficiaries and discussed about the proposed water supply system and sanitation facilities and to conform the commitments to be constructed by them on their contribution and participation.

Before the implementation of the project, local people or beneficiaries formed water user committee with 11 members, agreed to participate in the implementation of the project and to share the project cost providing voluntary labors and ready to operate and maintain the system after completion.

Panchdhara water supply system was completed and started to distribute water to the ward no. 4, 5, and 6 of Ichangu VDC and ward no. 8 and 9 of Sitapaila VDC from 2008. The implemented water scheme is given below.

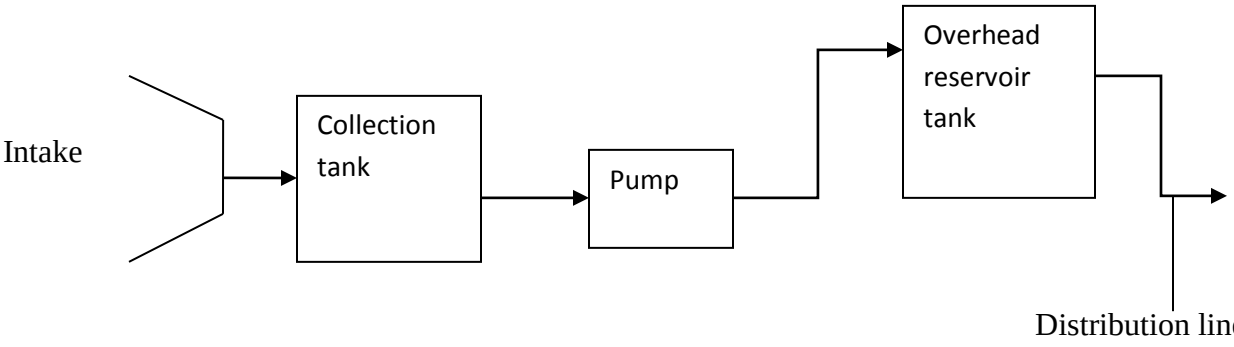

Figure 4: Schematic diagram of Panchdhara Water Supply System

3.2 Data Collection

The study focuses on the status of community water supply system to measure the sustainability of the system. In order to do that, the indicators covering technical, financial, institution and social and environmental information were chosen. The research questions were formulated to find the answers of indicators, which are as follows.

- How much people pay for water supply and sanitation either directly or by coping costs?
- How tariff are fixed?
- How system can be managed with sustainable manner with focus on service and delivery?
- What is life cycle cost of the project?
- What is the financial contribution from different stakeholders for water supply and sanitation system and how is it maintained afterwards?
- Have the community initiated the projects and what is the participation level of the community member during the project implementation?
- How are different stakeholders involved during the project and after the project?
- How user committees take decisions?
- What is the environmental condition of the study area, at water source, the state of toilets and how waste is managed?

Thus, both quantitative and qualitative method for the data collection was concluded as appropriate for this study. To gather the information, qualitative interviews were selected as the main tool for collecting data. Qualitative interviews are a structured to understand the purpose and later describe the outcomes of the conversation (Kvale & Brinkmann 2009). In a structured interview, the researcher has decided both topics and questions before and uses a given answer that is ticked off as the respondents are answering (Johannessen et al. 2011). In this study, structured interview form was used as appropriate method to collect the data.

Furthermore, a focus group discussion (FGD) was also selected as a data-collecting tool for this research. And it is explained as a way of collecting data that involves the engagement of a small group of people to perform an informal group discussion focused on a particular topic or set of issues (Wilkinson 1997). This method has multiple benefits as it is cost effective and an efficient way of obtaining data from many participants during a relatively short period of time (Berg & Lune 2012). FGD was also selected to obtain data and data can be interoperated as community feelings and give an overall answer to the research questions (Annex2).

3.3 Household Sampling

The number of surveyed households was based on the project report prepared by the water user committee. A sample size of 327 households was selected from a total of 2200 benefited households of Dhulikhel drinking water supply project. Similarly, a sample size of 156 from 263 households of Bhakundebesi drinking water supply project and 186 from 360 households of Panchadhara drinking water supply project. The sampling methodology assumed at 95% confidence level. The sample size was computed from the following formula (Arkin and Colton 1963).

$n=NZ^2*p*(1-p)/Nd^2+Z^2*p\ (1-p)$

Where,

n= sample size

N= total number of households

Z=Confidence level (at 95% level, Z=1.96)

P= estimated population proportion (0.5)

d= error limit of 5% (0.05)

3.4 Determining Households for the Interview

Systematic Random Sampling was used for household survey (McClave and Sincich 2003). It is the process of selecting every n^{th} number of the households arranged in a list using sampling interval. In this method, 1^{st} sample is selected randomly and the remaining samples are taken in a calculated sampling interval.

A sample interval is calculated by using following formula (McClave and Sincich 2003).

Sampling interval= total number of household in a given project/ sample size need to be taken for that project.

For Dhulikhel, sampling interval= 2200/327= 6.7≈7

Similarly, sampling interval was calculated for each schemes and household was selected accordingly.

3.5 Field Work

Field survey was conducted to gather information required for this research. The primary information gathering method was the household survey. It was conducted in 156 sample households out of 263 households in Bhakundebesi, 327 sample households out of 2200 households in Dhulikhel and 186 sample households out of 360 households in Ichangu panchdhara. Other field work methods include key informant interviews; focus group discussion and observation walk to the source which was carried out to gather technical information.

Apart from information collected on the field, secondary information was also collected using related relevant documents, literatures, internet, and project support unit at DWSS.

A structured questionnaire was prepared and uses it as a main tool for gathering information (Annex 1). The question were about the economic status of the respondent, present water use and fetching, waste management, perception of the respondent about water supply, willingness to contribute. The aim was to find out the present water management, opinion, knowledge and understanding of the project.

The survey was conducted during October- November 2013 to 156 households out of 263 beneficiary households in Bhakundebesi, 327 households out 0f 2200 beneficiary households in Dhulikhel and 186 households out of 360 beneficiary households in Ichangu panchadhara. A questionnaire used for household's survey is attached in Annex1.

3.7 Focus Group Discussion

My field work was at the time of constitutional election in Nepal due to which it was a little bit difficult to gather members of water user committee (WUC) in each benefited ward. So only one focus group discussion was held with 10 members of WUC on each site. As women were mainly involved in fetching water supply, we included more women for the discussion. The chairperson was responsible for organizing of the FGD. During the FGD, the information was recorded and later interpreted. Main topics raised and questions asked for the FGD was made. Questions selected for the FGD are to be found in annex 2.

3.8 Observation

An observation walk to the source was carried with the project manager of Dhulikhel Drinking water supply project, office staff of bhakundebesi water supply system and with chairman of Panchadhara water supply system to observe and gather technical information.

The information from household survey, focus group discussion, an informal interview with key informant and observation were utilized to evaluate the status of water supply system managed by water user committee, technical and financial viability and institutional arrangements of the water supply system.

3.9 Data Analysis

The qualitative data obtained from the household interviews was coded in excel sheet for the analyzing and interpretation. The qualitative data from personal opinion, literatures, results of key informant's information, conclusion drawn from focus group discussion were used as a basis for its analysis and interpretation.

3.10 Water Quality Sampling

For Dhulikhel and Bhakundebesi water supply system, water samples were collected from four sampling points namely from at the source, after the treatment, in the distribution system and at the consumer point. In case of Panchdhara, water samples were collected from at the source, at the distribution and at the consumer point. Samples were also collected on the sterilized bottles provided by the laboratory. Two samples were taken from each point for the replication of samples. The samples were taken in the morning hours for analysis. Samples were analyzed for bacterial contamination (total coliform and E. coli) and physiochemical parameter (temperature, PH, turbidity, electrical conductivity, total hardness, fluoride, ammonia, nitrate, iron and manganese) in the Environment and public health organization (ENPHO) laboratory in Kathmandu. The analysis was carried out using Standard Method of Analysis (APHA, 2012).

The microbiological analysis was carried through the membrane filtration method (APHA, 2012). The detail methods of analysis for other parameters are given below.

Table 6: Methods for Water Quality Analysis (APHA, 2012).

Parameters	Test methods
Temperature	Thermometer
PH	Electrometric Method
Electrical Conductivity	Conductivity Meter
Turbidity	Nephelometric Method
Total hardness as $CaCO_3$	EDTA Titrimetric Method
Fluoride	SPADNS Method
Ammonia	Phenate Method
Nitrate	UV Spectrophotometric Screening Method
Iron (Fe)	Direct Air- Acetylene Flame Method (AAS)
Manganese (Mn)	Direct Air- Acetylene Flame Method (AAS)

Data were analyzed by using statistical method using analysis of variance (ANOVA). This analysis was done to complete the differences between different points with each water quality parameter. ANOVA analyses were done utilizing the Microsoft excel data analysis tool pack. The ANOVA analysis was based upon a 95% confidence level or P- value of 0.05

Chapter (IV) Result and Discussion

4.1 Rural Water Supply System and Sanitation in Nepal

In Nepal, people traditionally considered flowing water to be pure and safe. However, modern systematic and planned development of public water supply and sanitation only started with the first five year plan 1956- 1961. Since then, it has always been a state's one of the most priority. In recent years, different NGOs, INGOs and private sector also supported drinking water and sanitation programmes in Nepal.

The Department of Water Supply and Sewerage (DWSS) was established in 1972 and has become a main agency for the water supply and sanitation sector. The aim of DWSS is to provide to access to safe water supply and sanitation to all by 2017.

Along with DWSS different organizations/ institutions are involved in providing drinking water and sanitation services and facilities to the rural people. like United Nations Children's Funds (UNICEF), United Mission to Nepal (UMN), Red Cross Society, Finnish International Development Agency (FINNIDA), Rural Water Supply and Sanitation Projects (RWSSP), Water Aid, World Bank, Asian Development Bank (RWSS,FUND).

Various agencies have surveyed on water supply and sanitation over the year 1991 (Table7). The latest figure documented by NPC/ UNCT, 2010, Nepal has already achieved its MDG target for water supply, with current national coverage of 80% against a target of 73% by 2015. In sanitation sector, the MDG target is not achieved yet, the coverage of sanitation is of 43% against a target of 53% by 2015.

Table7: Water Supply and Sanitation Coverage

Survey and year	Water Supply (percent)						Sanitation(percent)	
	Urban			Rural			Urban	Rural
	piped	Other	Total	Piped	Other	Total	Total	Total
NFHS 1991	51.3	43.6	94.9	16.3	50.4	66.7	65.8	12.0
NDHS 1996	57.4	32.6	90.0	29.1	47.0	76.1	71.3	13.4
BCHIMES 2000	61.9	36.7	98.6	46.3	47.1	93.4	66.5	22.6
Census 2001	66.1	31.0	97.1	51.1	37.6	88.7	72.3	33.6
NDHS 2001	55.2	40.4	95.6	33.0	49.0	82.0	76.6	19.4
NLSS 2004	67.6	25.4	93.0	39.2	39.8	79.0	79.5	25.3
NDHS 2006	50.5	39.5	90.0	38.9	41.1	80.0	77.0	29.4

Source: NMIP/DWSS 2010

Notes: NFHS = Nepal Family Health Survey; NDHS = Nepal Demographic and Health Survey; BCHIMES = Between Census Household Information, Monitoring and Evaluation System;

NLSS = Nepal Living Standards Survey.

In Nepal, rural water supply systems are partially or fully funded from governmental and non-governmental organizations. Many governmental organizations (GOs), non- governmental organizations (NGOs) and international non- governmental organizations (INGOs) are working to coverage and to provide safe water supplies and sanitation to poor populations in remote areas. The consumption of water in rural communities is quite different in Nepal than other countries. Normally people do not have to pay for water from public taps that are located among 5-15 houses within a 500 meter distances (Asthana, 1997). However, other countries and agencies such as the World Bank recommend that users should pay for services (Asthana, 1997). To escape problems created by this approach, Singh et al., 1993, stated on their report that the donor and governmental organization in developing countries should focused on financial issues, especially the generation of revenue through domestic connection.

In Nepal, most drinking water supply schemes appears unsuccessful due to lack of involvement of women during planning stages, supporting mechanism for the handover of DWSS,

governmental supervision and coordination between local water user committee, local government and district water supply authorities (Sharma, 1998; Bhandari et al, 2005).

According to the government policy of Nepal, operation and maintenance costs of drinking water supply projects should be financed by the community itself while the investment cost is covered by the donor agencies or the government (NPC, 1998). Community may also contribute to project investment by providing labor, land and local materials. A sustainable water future depends on appropriate prices and the necessary resources need to come from project consumers (World Bank water Demand Research Team, 1993; Whittington, 1998). In developing countries, the major causes of water supply system failure are shoddy construction of drinking water supply system lacks for operation and maintenance, excessive administrative centralization and widespread corruption in supporting organizations (Howe and Dixon, 1993, Singh et al., 1993).

4.2 Institution involvement and financial overview

Government of Nepal, Department of water supply and sewerage (DWSS), and water users' committee are the stakeholders of the three studied sites. German government had invested to Dhulikhel drinking water supply project through German development Agency (GTZ), and Urban Development through local Efforts (UDLE) (see table 8). An agreement was signed between Government of Nepal, German Government and Dhulikhel Drinking Water User Committee before the initiation of the project work.

General assembly, water users' committee, VDC, municipality and management unit are the main institution after the handover of the projects. DWSS is a large support system the management of water supply system as it is umbrella organization mandated by Ministry of Housing and Physical planning to operate as a facilitator to implement water supply project through District water supply offices (DWSO). At local level, VDC and municipality play as increasing role in evolving and implementing water strategies and WUC are responsible in maintaining the water services. After the projects were handed to the water user committees, the committee has been fully responsible on its total management of the project which includes production and distribution of water, day to day maintenance of the system, financial, administrative as well as consumer relations.

In dhulikhel water supply system, technical and management unit have 17 paid staff while Bhakundebesi have only 2 paid staff and that of Panchdhara have 10 paid staff to take care of day to day operation and maintenance of the system.

Community participation in the different phase of the project is very important because it builds a sense of ownership and commitment among the local people (IRC, 2003). In all of the studied area, people were actively participated in the different phase of the project such as planning, implementation, operation and maintenance. Some of the community members have been very actively contributing to make this project successful right from the very beginning. They have been considered as the founding members of the user committee.

When the Dhulikhel project began, a water users committee of 11 members' was formed from the various sectors of the community. Later user's committee comprises 21 people chairman 1, vice chairman 2, secretary 1, treasurer 1, 5 female members and 9 ward wise members. While in the Bhakundebesi and Panchdhara Water users committees have 11 members among them 2 are female from the beneficiaries' community. According to the drinking water regulations of 1998, water users' committee should have two women representatives among the total of nine members. Besides that, women can compete with men for other position. So as the water users committee also follows the regulation and the current committee has two female members and their role is effective. Nine members of water users' committee was formed from the water users group.

Local people are the initiator of this project and have been very actively contributing to make successful right from the very beginning. They have been considered as the founding members of the user committee. According to the Drinking Water Regulation 1998 (2055 BS), water users have certain responsibility in the water supply like have to maintain quality standards, repair and maintenance of the water supply system and have power to impose a service charge.

Table8: Institution Involvement and Financial Overview

Heads	Dhulikhel	Bhakundebesi	Panchdhara
Institution involved	GON, DWSS, GTZ and UDLE, WUC	GON, DWSS, VDC and WUC	GON, DWSS, VDC and WUC
Financial overview			
Total investment cost (NRs)	3,76,60,195 (378,722.79 USD)	3,00,00,000 (301,689.45 USD)	1,16,53,442 (117,190.68USD)
Total income cost (NRs)	18,927,536 (Est) (190, 341.27 USD)	56,06,200 (56,252.13USD)	58,86,527 (Est) (59,156.46 USD)
Total expenditure cost (NRs)	19,557,000.0 (Est) (196,537.95 USD)	20,51,000 (20,611.52 USD)	21,27,800 (Est) (21,383.33 USD)

Note: 1 NPR= 0.0100495 USD

The total cost of the Dhulikhel water supply project was NRs 37,660,195 of which 94.8% of the total cost was covered by German Government/ GTZ and rest of the cost was covered by Government of Nepal. While the total cost of the Bhakundebesi water supply was NRs 30,000,000 of which 85.33% of the total cost was covered by Government of Nepal and rest of the cost was covered by DWSS and that of Panchdhara water supply project was NRs 11,653,442 of which 80% of the total cost was covered by Government of Nepal (DWSS) and 20% covered by the community. Before the committee raised certain amount from the community as an operation and maintenance (O and M). In order to collect the fund, committees have charged a connection fee of NRs 6600 with an applicant in Dhulikhel water supply system, NRs 25,000 in Bhakundebesi water supply system to all consumers. But the case is different in Panchdhara, committee has charged a connection fee of NRs 5000 with old inhabitants, NRs 13,000 from those helped in project and NRs 25,000 for new migrates. As the connection rate is different for consumers, most of the new migrates expressed that this is discrimination between old and new people. Similarly, the some of the respondents from Bhakundebesi also expressed that the connection rate is high and most of the female respondent expressed that “though the rate is high we get water at our home and save time that we spend fetching water”.

From the source provided from the WUCs, the main income source for the committees are water tariff, connection charge meter charge, interest from bank deposits and fine/penalty. In Dhulikhel water supply system, water tariff is the dominant income source covering around 91 % of revenue during the period 2004/05- 2006/07 and 87.13% during the period of 2011/12 (Annex 3). And second main source of income is the interest from bank deposit. The estimated total cost of the committee is NRs 1, 89, 27,536. The amount of income of the committee has increased from 4.0 million in 2004/05 to 18.9 million in 2012/13. There is consistent increase in the revenue from water tariff from 2004 to 2007. But the revenue from water tariff is decreased over the period 2012/13 and consistent increase in interest from bank deposit.

The total expenditure is increasing over the year. Out of the total cost 8.1 million in the year 2011/12, the expenditure in salary is sharing highest 45.09% followed by donation 30.31%. A comparison of the income and expenditure of the system shows that Dhulikhel Drinking Water System is operating surplus. Thus the total income balance and expenditure of the committee of the fiscal year 2011/12 was NRs 1, 27, 86,722.57 and 81, 58,824.89. The committee has fully recovered operation and maintenance cost from its own cost. The committee has successful to balance NRs 46, 27,897.68 at the end of the year 2011/12.

Similarly, Bhakundebesi water users committee have also water tariff as a dominant source of income covering around 49.61% of revenue during the period 2007/08 and 56.9 % during the period of 2008/09 but it is decreased in 2011/12. The second main source of income is the interest from bank deposit (Annex 4).The total internal income cost of the committee is NRs 56, 06,200.

The expenditure of the committee was increasing on operation and maintenance because of the rising price of the materials in the markets. A comparison of the income and expenditure of the committee shows that the system is operating surplus. The total income and expenditure of the committee was found to be NRs 56, 06,200 and NRs 20, 51,000 respectively in the fiscal year 2011/12 and committee successfully balances NRs 35, 55,200. While in Panchdhara , installation charge with user contribution was found to be the main income source of the committee covering the 63.57 % of revenue during the period 2010/11 and 50.97% during the period 2008/09 followed by water tariff. The committee has estimated the total income cost as NRs 58, 86,527

and total estimated expenditure cost as NRs 21, 27,800 (Annex5). The total expenditure is increasing over the year. But it was decreased during the period 2009/10. Out of the total expenditure cost over the year, the expenditure in salary is sharing highest which is followed by operation and maintenance head.

4.2.1Water tariff

The water tariff rates set by three WUCs are given in the table 8. The lifeline monthly rate for 10 cubic liters of water is NRs 125 in Dhulikhe while with the same liter of water Bhakundebesi WUC set minimum rate of NRs 200. And Panchdara WUC set the minimum rate of NRs150 for 15,000 liters of water. From the household survey, it was found that 93% , 77% and 82% of respondents are paying minimum rate of NRs 125 water bill and rest are paying in between NRs 125 to NRs 300 per month. The right to increase water tariff lies with the general assembly which hold once a year. In order to increase the water tariff, users' committee has to propose to general assembly mentioning the clear reasons. It had been proposed to increase the water tariff by 10 percent at an interval of two years to meet the increasing operation and maintenance cost.

Table 9: Rate of water tariff

	Dhulikhel	Bhakundebesi	Panchdhara
Units	Rate of water tariff in NRs	Rate of water tariff in NRs	Rate of water tariff in NRs
Up to 10,000 liters	125 per month	200 per month	150 per month up to 15,000 liters
10,000 – 25,000 liters	17 per 1,000 liters	22 per 1,000	20 per 1,000 liters
25,000 – 50,000 liters	25 per 1,000 liters	25 per 1,000	25 per 1,000 liters

The proposal was passed by general assembly. The management and technical unit under the users' committee are responsible for collection of revenue.

Water tariff is progressive. The timely paying consumer receives rebate of NRs 10. According to provision, the consumer should pay water tariff within 60 day from the first day of month. Those who pays within 45 days they can get rebate/discount of NRs 10. Consumer failing to pay within this period has charge which range from 5% to 48 %. If the consumer unable to pay the bill

within the time limit then, the management of users' committee can disconnect the water tap of the defaulter at any time giving notice or without notice. After disconnection the costumer can connect the tap paying all dues including fine as per the rule of the user committee.

From the survey, all of the respondents from three sites reported that they are willing to pay for water they use because the project brought water to their own house. The committee has not face much problem in collecting the water tariff.

All the respondents from the studied areas reported that they are willing to pay for water they use. Only 7% of the respondents from the Bhakundebesi felt that the tariff was high. While in the Dhulikhel and Panchdhara, all the respondents interviewed were content about the charge and they were found satisfied to the water charge.

As mentioned above a comparison of income and expenditure of the all studied sites show that the system is operating surplus. The surplus of the system indicates the healthy situation to operate viably. The availability of money enables committee to operate system effectively. This is a fundamental basis for the sustainability of the project. The collection of sufficient fund for operation and maintenance was possible because the users' were satisfied to the quality of services that they are achieving. Bhandari and Grant (2007) reported in their paper that level of users' satisfaction has a major influence on the willingness to pay for water.

Among three water supply system, Dhulikhel water supply system is old and advanced system constantly operating since the last 24 years. Bhakundebesi and Panchdhara are operating since last 7 years. Brikkr (2002), a water supply system is sustainable if its operation, maintenance and administrative cost are recovered at local level and can be operated and maintained at local level with limited but need feasible external support and also provide quality of water. These three schemes able to recovered operation and maintenance cost at their own resources and DWSS is also support in case of major operation and maintenance and also able to provide a good quality of water to the consumer. As Barnes and Ashbolt (2010) concluded that when local communities participate directly in the planning their own water supply system, these systems are more likely to be sustainable, in all 2 schemes, local people participate in different phase of the project. These systems are likely to be sustainable because they have adequate financial and administrative capacity for system operation and maintenance (Montgomery et al. 2009).

4.3 Social Characteristics

Respondent's background affects on water use, demand and collection in the households. Education, occupation, income and expenditure, household size determines the water use and demand. The average household's size of respondents is found to be 7, 6.5 and 6 people average monthly income of the family NRs25, 000, NRs 26,000 and NRs 15,000 in Panchdhara, Dhulikhel and Bhakundebesi respectively. Respondents pursued a variety of occupations including government, private sector and agriculture to sustain their livelihood. The main income source of respondents in Panchdhara and Dhulikhel is business covering 58% and 61% respectively (figure 5). While, in Bhakundebesi, 35% of respondents are depend on agriculture to sustain their livelihood.

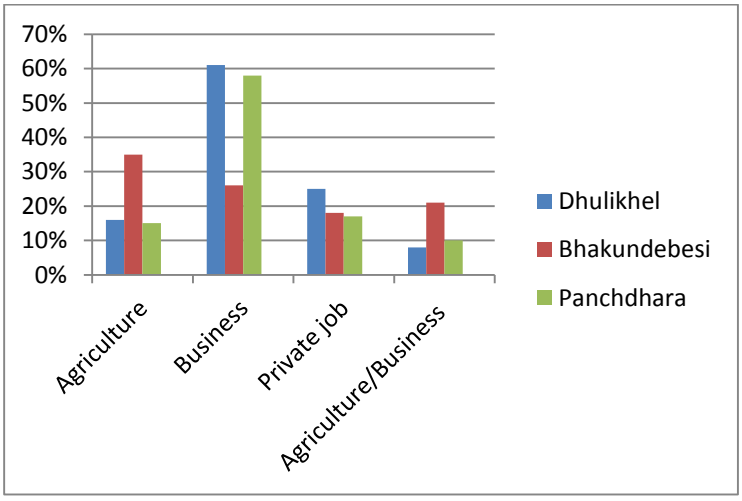

Figure 5: Occupation of the Respondents.

Residence has a significant effect on the education and occupation. Dhulikhel and Ichangu is close to urban area and tourist attraction point has better opportunities for education and many professions. From the given figure 6, 48 % respondents from Dhulikhel and Panchdhara have university level of education while, in the Bhakudebesi, 40% of the respondents have secondary level of education.

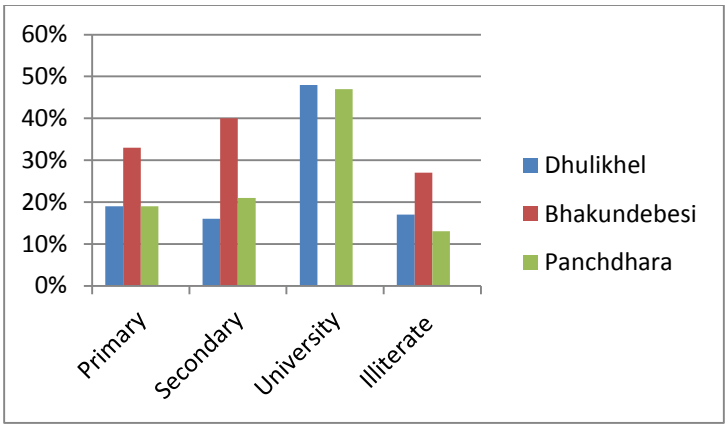

Figure 6: Level of Education

4.3.1 Use of Water Facility and Purposes

The main use of water in households are drinking, cooking and washing clothes, cleaning including personal hygiene and other activities. The average household use of water in Bhakundebesi is approximately 120 liter/day. 90% of respondents said that this amount of water is enough for drinking, cooking and other purposes and rest of the other respondent said that, sometimes it is not enough amounts for household purposes. In that case, they fetch water from natural source to fulfill the gap. However, the respondents said that in dry season, average households use of water is approximately 80-85 liter/day. And they expressed that it is very difficult to fulfill the demand but they are happy that they have enough amount of water for drinking and they are satisfied. Similarly, in Dhulikhel and Panchdharea, the average use of water is approximately 200 liter/day and all most all respondents reported that this amount of water is enough for domestic purposes. Some of the respondents from panchdhara, said that, when this amount is not enough, they fetch the water from the source.

4.3.2 Water Quantity

All respondents' families from three sites had access to piped drinking water facilities supplied by Drinking Water Supply System. The water quantity available was difficult to estimate as the visit was at the day time. So, values were taken from the users' committee.

The design pumping rate and designed water demand of Bhakundebesi was 4.0 liter per day and 172802 liter per day for design population of 6688 respectively. However, even it was working on designed pumping rate 4.o liter per day; it would not cover the increased water demand of

present population 4108. This pumping rate coupled with high demand of water and brings problems of operation; the reservoir had to be full before water is discharged, in order to ensure maximum pressure. The reservoir was not full at the time of visit.

In Dhulikhel, the high pumping rate of 25.46 m^3/h was observed since the beginning of the functioning of the system. It exceeded the design planned rate of 22.96 m^3/h by 2.54 m^3/h. The intake pumping rate of 46 m^3/h is observed. Though the water quantity is enough now, the committee is still working on intake unit to increase the flow of water. Whereas in Panchdhara, the average pumping rate and the water demand was 4.5 liter per second and 348800 liter per day for design population 4360. In 2008, 254000 liter per day was collected in rainy season and 199000 liter per day in dry season. 254000 liters of water was supplied to 541 private tap in a day but discharge of water is only 569 liter per day per private tap in rainy season which was not enough for 541 private tap and the water was supplied in every alternate day for only 1 hour. Whereas, the committee couldn't able to supplied 367 liter per day per tap even 1 hour in a dry season so committee construct collection and reservoir tank of 65,000 liter and 1,00,000 liter respectively. With the efficient pumping rate of 4.17 liter per second, 360000 liter of water was collected within 24 hours. Still this amount of water was not enough so, water was supplied from 5 public tap for minimum 1-2 hours in morning and evening time. The present pumping rate is 7 liter per second which exceed the designed pumping rate by 2.5 liter per second. Community supply 3,000,000 liter of water in a day to the community which meets present demand of 2,560,000 liter per day.

About quantity of water supplied to the community, most of the respondents have different opinion from three sites. Most of respondents from methikot, Bhakundebesi and respondents from ward no. 1, 4, 6 and 7 of Dhulikhel municipality have expressed that the water supplied is not sufficient for domestic purposes and they have to rely on other source of water after the implementation of the project also. Whereas in Panchdhara, respondents were quite satisfied with the quantity of water supplied to them. Majority of the respondents was relied on the natural source of water, 92% relied on community dug well and 8% on spring water and they have to walk more than 30 minutes to fetch the water as there are no other sources of water at close vicinity. After the project, all the population covered by the project is benefited by drinking water. They do not need to walk far distance to fetch water especially women and girl. So

women are happy with the project that they don't need to walk to fetch and can utilized that time to household work and other income generation. 18% of the respondents from Bhakundebesi and 15% from Dhulikhel said that, water supplied from the project is sufficient only for drinking and have to rely on other sources for other purposes like washing, for domestic animals etc.

4.3.3 Water Quality

A majority of respondents interviewed in three sites were satisfied to quality of water and reported to drink directly from tap supply. Though the water is of good quality, some of the respondents from Dhulikhel were complaining about the chemical odour and taste of the water supplied, blaming an over dosage of chemicals in the treatment. But, it could also be matter of habits: the acceptance of treated water by consumer often been a problem because people are not used to the 'new' taste of water and prefer a usual taste of water they have before. Whereas in Bhakundebesi and Panchdharea, respondents don't have any complain regarding to water quality. Among the respondents, 75%, 61% and 84% of respondents from Dhulikhel, Bhakundebesi and Panchdhara respectively expressed that the quality of water is good (figure 7).

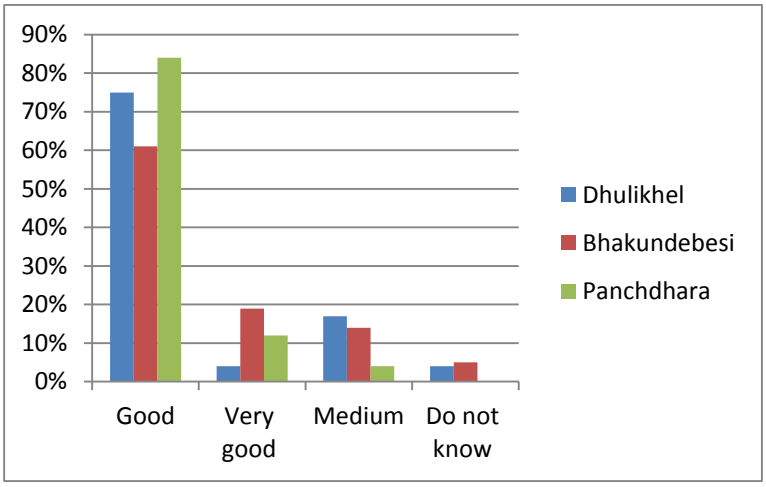

Figure 7: User Perception of Water Quality

4.4.4 Reliability and Adequacy of Water Supply

Reliability is measured in terms of water supply by Water Supply System as per the schedule provided. About 98%, 93% and 87% of the respondents from Bhakundebesi, Dhulikhel and Panchdhara reported water supply has been regular accordingly. As per the schedule, water is supplied 2 times a day, morning and evening for about 1-3 hours each time, 1 hour in dry season

in Dhulikhel and 1-2 hours in Bhakundebesi and Panchdhara. Some of the respondents from all of the sites interviewed reported that water supply is not regular; sometime they get more than schedule and sometime less.

Adequacy is measured in terms of water availability for meeting domestic purposes including drinking, sanitation and washing purposes. More than 90% of the respondents from all sites said that the water supplied is adequate. User satisfaction level in term of water service in term of water quality, reliability and adequacy are given in the below figure 8.

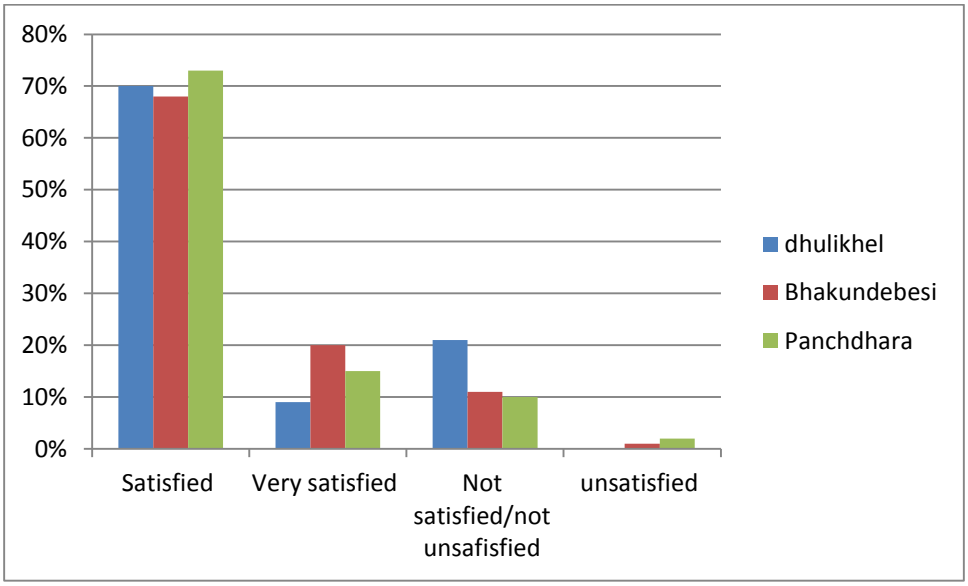

Figure 8: User Satisfaction Level

From the above figure, among all respondents, 70%, 68% and 73% of respondents from Dhulikhel, Bhakundebesi and panchdhara are satisfied in term of water service provided to them by committee. So, the user satisfaction is also of the most important factor of the sustainability.

4.5.5 Sanitary Survey

A sanitation facility is considered as adequate if it hygienically separates human feces from human contacts. The technologies that meet these criteria are flush to piped sewer system, flush to septic tank; flush/pour to pit; composting toilet; VIP latrine; pit latrine with slab (WHO and UNICEF, 2006). In the study areas, open defecation was not in practice. In Bhakundebesi, 97% of the respondents use flush toilet and 3% use ventilated improved pit latrine. Whereas, in

Dhulikhel and Panchdhra, all respondents interviewed use flush toilets. It seems like that the people are aware of sanitation which is good symptoms for personal hygiene also.

Solid waste management is one of the major environmental issues in Nepal. Government of Nepal enacted the solid waste management Act of 2011 and its main objective is maintaining a clean and healthy environment by minimizing the adverse effects of solid waste on public health and environment (ADB- Report). For management of solid waste, local bodies like municipality, community based organization, private sector have been made responsible for management of waste. Among the three study area, Dhulikhel and Panchdhara have facility of management of waste by the municipalitywherea in Bhakundebes, people manage solid waste come from home with their own knowledge of technology and resources (fig9 a and9 b).

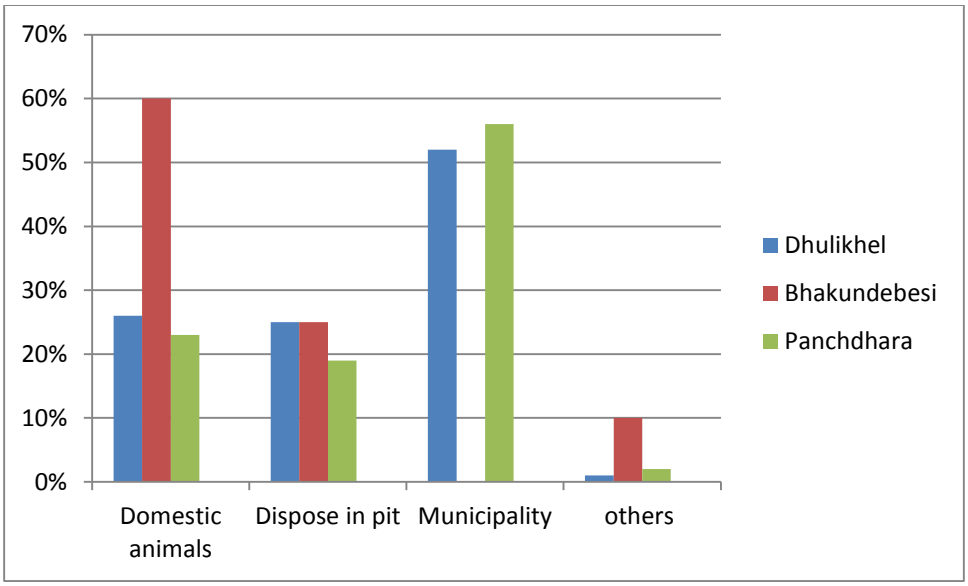

Fig (9a): Management of Organic Waste in three Sites

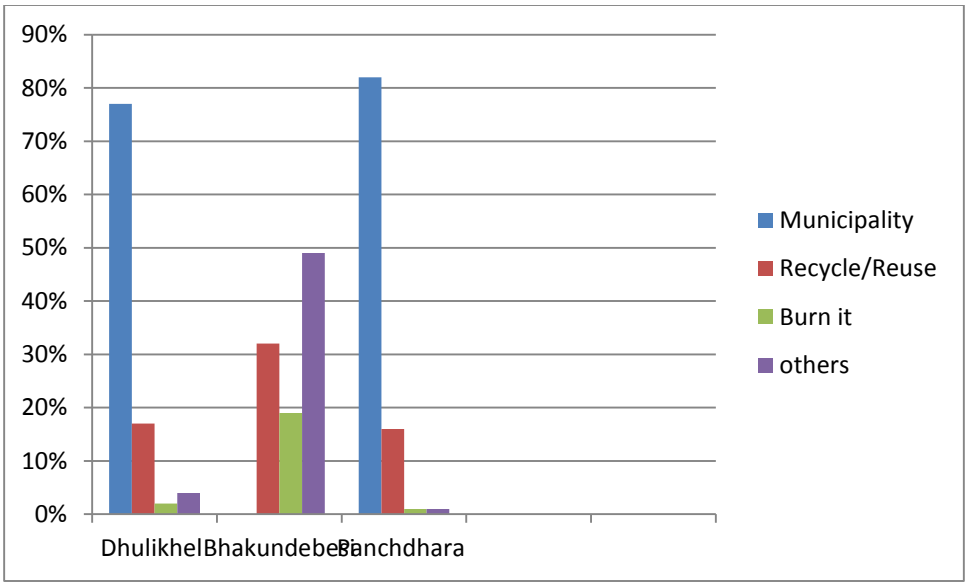

Fig (9b): Management of inorganic waste in three sites.

From the above figure, in Bhakundebesi 60% of the respondents manage their food waste by giving it to domestic animals and other said they buried in pit to make a compost fertilizer. Similarly, 32% of respondents reuse/recycle the inorganic waste and 19% respondents burn the inorganic waste. Whereas in Dhulikhel and Panchdhara, more than 50% respondents said that municipality collect waste.

From the focus group discussion, it can be concluded that they were asked to participate in WUC and informed about the water committee meeting also. All the members have right to choose the person responsible for the operation and management of the water system. The committee take care about the problems related to the water supply system very carefully and able to operate and maintain the water supply system very effectively. But, one of the participant complain that the committee didn't informed about the problems related to water supply and they cut water supply immediately for some days.

4.6.6 Water Quality Analysis

Biological parameter: Water supplied to the community from Dhulikhel and panchdhara drinking water supply found not to be contaminated with E. coli and total coli forms while water supplied to the community from Bhakundebesi drinking water supply system was contaminated with E. coli and total coli form. The absence of E. coli clearly indicates that the supplied water is

free of fecal contamination in two sites. But in the Bhakundebesi, the level of total coli form is increasing from source to distribution point and this may due to the influence of animals or birds around the area and the source is near agricultural land and more influence of animals and people. Scholz, 2000, states that feces are not only responsible for microbial contamination; naturally they exist in the water and environment. According to IRC (2002) as cited by Michael H., (2006) risk classification indicates the incidence of total coli form could be classified under high risk. So the water supplied to the community from Bhakundebesi drinking water supply system does not meet the WHO guideline and National drinking water quality standard (2062 BS) and categorized under high risk. While water supplied to community from Dhulikhel and Panchdhara was safe and good quality as it meets both WHO guidelines and National drinking water quality standards (2062 BS).

In general, total coliform level was higher than E. coli level for all sampling points (table 10).

ANOVA analysis was performed to determine the differences between the sampling points for each of the water quality parameters. The results of water quality analysis along the distance are given in the table 10 below.

The table 10 below compares the concentrations of the tested parameters in all three sites. The PH values of sampled waters ranges from 5.75 to 8.2. The National Drinking Water Quality Standards requires PH to be between 6.5 and 8.5 (Government of Nepal 2002). The PH value of Dhulikhel drinking water supply was 7 and that in Bhakundebesi and Panchdhara drinking water supply system was 6.5 at consumer point.

The National Drinking Water Quality Standard and the WHO guideline for EC, Turbidity, Total hardness as $CaCO^3$, Fluoride, Ammonia, Nitrate, Iron (Fe),and Manganese (Mn) are 1500, 5(10), 500, 0.5-1.5, 1.5, 50, 0.3(3) and 0.2 respectively. All of the parameters tested for three sites were never above the National Drinking Water Quality Standard and WHO guidelines. Thus the final water quality parameter at consumer point meets the National Drinking Water Quality standard and WHO guidelines. The treatment systems have substantially improved the water quality. There seems to be no deterioration of water quality in the distribution system and distribution system is well maintained. All three drinking water supply system able to produce high quality water.

Table 10: Test value and P value for each parameter

	Dhulikhel					Bhakundebesi					Panchdhara			
Water quality parameter	SP1 (Avg)	SP2 (Avg)	SP3 (Avg)	SP4 (Avg)	P- value	SP1 (Avg)	SP2 (Avg)	SP3 (Avg)	SP4 (Avg)	P-value	SP1 (Avg)	SP2 (Avg)	SP3 (Avg)	P-value
Temperature	19.5	20	18.5	19.5	0.513	20	19.5	20	20	0.891	19	19	20	0.516263
PH	5.75	7.5	8.2	7	0.108	6.5	6.5	6.5	6.5	0.666	6.5	6.5	6.5	0.739032
Turbidity	< 1	<1	<1	<1	-	10	5	2	1.5	3.783	<1	<1	<1	
Electrical conductivity	205	215	212.5	253.5	5.79E	206	216	215	219	0.160	421.5	441.5	426	0.187897
Total hardness	121	116	116	124	0.0008	76	76	80	80	0.001	226	220	222	0.471466
Fluoride	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	0.604938
Iron	<0.05	<0.05	<0.05	<0.05	-	1.65	0.75	0.1	0.1	0.007	<0.05	<0.05	<0.05	0.680194
Ammonia	<0.05	<0.05	<0.05	<0.05	-	0.4	0.2	<0.05	<0.05	3.77	<0.05	<0.05	<0.05	0.79400
Nitrate	1.4	1.3	1.2	1.2	-	<0.2	<0.2	<0.2	<0.2	0.666	24.9	25.2	25.1	0.475229
Manganese	<0.05	<0.05	<0.05	<0.05	-	0.3	0.35	<0.05	<0.05	0.021	<0.05	<0.05	<0.05	0.680194
Total coliform	190	3400	0	0	-	136	15	239	184	-	20	40	-	-
E.coli	80	0	0	0	-	16	0	62	10	-	0	0	0	-

Chapter (V) Conclusions and Recommendations

5.1 Conclusions

Among three water supply system, Dhulikhel water supply system is old and advanced system constantly operating since the last 24 years. Bhakundebesi and Panchdhara are operating since last 7 years. Moreover, Dhulikhel water supply system started from a fund of NRs 0.3 million in the beginning, now the WUC has NRs 18.9 million. Similarly, Bhakundebesi and Panchdhara WUC have now NRs 56, 06,200 and NRs29, 23,633.

A water supply system is sustainable, if it can provide safe water can recover the cost of operation and maintenance locally for instance through water tariff. All the three schemes studied are able to recover operation and maintenance cost at their own resources and also provides a good quality of water to the costumer. DWSS support is sought only in case of major operation and maintenance. When local communities participate directly in the planning their own water supply system, these systems are more likely to be sustainable, in all schemes, local people participate in different phase of the project. These systems are likely to be sustainable because they have adequate financial and administrative capacity for system operation and maintenance.

Financially, all three water users' committees are self sustained. There are no problem in the collection of water tariff in the entire studied site and it can be said that willingness to pay (WTP) for quality drinking water is high among the people. WTP can be construed as an indication of the demand for improved services and their potential sustainability. Annual bank balance of 3 WUS is growing and interest from the bank is accumulating and has been the one of the major revenue for meeting the operation and maintenance cost. Quality of the water provided to the consumers from 3 WUC is a good quality and meets the WHO guideline and National Drinking Water Quality Standards (2062 BS).

Technically Dhulikhel and Panchdhara water supply systems are self reliant while Bhakundebesi water supply system depends upon Dhulikhel water supply system as well as DWSS. Though, Dhulikhel and Panchdhara water supply system are self reliant DWSS provide major technical assistance. Thus all of the studied areas are supported by DWSS. DWSS is acting as an umbrella

organization that provides technical aid to the water supply system in the case problems cannot be solved at local level. Hence all of the water supply system seems to be smoothly operating without financial, technical or institution problems with in water supply system and the community. Thus, it can be concluded that three water supply systems are providing quality drinking water to the people.

5.2 Recommendations

Following are the major recommendations suggested based on the discussions with WUCs and observations of the study area.

- Community level training should be provided during the implementation phase to create awareness on sanitation.
- In all studied sites, water quality monitoring was not as set by national Drinking water Quality Standards and Directives, 2005, so water quality monitoring should be done.
- WUCs should be assured for equal distribution of water.
- Bhakundebesi Water supply System should hired skilled technician.

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Annexes

Annex 1: Questionnaire for Household Survey

Household survey

Water user committee……

Village…….

Household No. …….

Date…

Information about Respondent

1. Name of Respondent
2. Sex of Respondent a) male (1) b) female (2)
3. Age of respondent
4. Education level
   a) Illiterate(1)
   b) Primary (2)
   c) Secondary (3)
   d) University (4)
5. Marital status
   a) Single
   b) married
6. Total household members……..
7. What are the main sources of income to sustain the livelihood for the family?
   a) Agriculture
   b) Service
   c) Business and Private jobs
   d) Others
8. How many years has your family lived in this house?
   a) Less than 1 year

b) More than 1 year

9. What is the type of construction of house?
    a) Permanent
    b) Semi permanent
    c) Temporary
10. What is the type of roof?
    a) Concrete roof
    b) Zinc roof
    c) Tile roof
    d) Others

11. What is the monthly expenditure of your family?

What is the environmental condition of the study area, at water source, the state of toilets and how waste is managed?

12. Do you have separate kitchen?
    a) Yes
    b) No

13. What is the place for washing dishes?
    a) Outside the kitchen
    b) Inside the kitchen
14. Where do you dispose the organic wastages?
    a) Dispose it in garden
    b) Give it to the domestic animals
    c) Dispose it in the pit
    d) Other (collect by municipality)

15. Where do you dispose the inorganic wastages?
    a) Burn it
    b) Dispose it in river

c) Recycle or reuse it

d) Other (Dispose it in dumping area\ collect by municipality)

16. Which type of fuel do you use for cooking?

a) Gas

b) Biogas

c) Electricity

d) Kerosene

e) Woods

f) Others

17. What kind of toilets are you using?

a) Flush toilets

b) Ventilated Improved pit latrine

c) Composting toilet (eco- san)

18. What are different sources of water that your households use before the project?

a) Community Dug Well

b) Spring water

c) River\ stream

d) Tube well

e) Stone spouts

f) Private tap

19. What are different sources of water that your households use after the project?

a) Community Dug Well

b) Spring water

c) River\ stream

d) Tube well

e) Stone spouts

f) Private tap

20. Is the amount of water that you use before the project is enough for your household purposes?
    a) Enough
    b) Sometime enough, sometime not enough
    c) Not enough
    d) Don't know
21. Is the amount of water that you use after the project is enough for your household purposes?
    a) Enough
    b) Sometime enough, sometime not enough
    c) Not enough
    d) Don't know

22. In your opinion, what is the quality of water that the system supplied to community?
    a) Very good
    b) Good
    c) Medium
    d) Bad
    e) Very bad
    f) Don't know
23. Do you treat drinking water in any way to make it safer to drink?
    a) Always
    b) Often
    c) Sometimes
    d) Hardly ever
    e) Never

23 i). What you usually do to the water to make it safe to drink?

    a) Filter
    b) Boiling
    c) SODIS

24. How much time do you spend to fetch water for drinking and other purposes before and after the project?
    a) 15- 30 mins
    b) 30- 60 mins
    c) More than 60 mins

25. How much water does your household use compared to before the project?
    a) More
    b) Less
    c) Don't know
26. Is the drinking water available every day in a year?
    a) Yes
    b) No
27. How many hours the water is available in your tap in a day?
    a) 1-3 hours
    b) 3-6 hours
    c) 24 hours
    d) Every alternate days
28. Do you think other household get more water than you?
    a) Yes
    b) No

How much people pay for water supply and sanitation either directly or by coping costs?

29) How much you pay?

    a) 125
    b) 150
    c) 200

29 i) Do you pay monthly or annually?

a) Monthly
b) Annually

30) Is there any provision for the complaint regarding any problems with water supply?

a) Yes
b) No

31) How long did the committee take to respond for complaint?

a) Less than a week
b) 2-3 weeks
c) A month

32. Are you satisfied with the water services that were brought by project to your community?

a) Very satisfied
b) Satisfied
c) Not satisfied, not unsatisfied
d) Unsatisfied
e) Very unsatisfied
f) Don't know

Annex 2: Focus group discussion questions

1. Do you know about the water user community?
   a) Yes
   b) No
2. Are you asked to participate in the WUC?
   a) Yes
   b) No
3. Are you informed what happens in the committee meeting?

a) Yes
b) No

4. Before construction, are you asked to choose who would be responsible for the operation and management of the water system?
   a) Yes
   b) No
5. In your opinion, how much do you take care of the problems of water supply system?
6. Do you think WUS is able to maintain and operate the water system?
   a) Very much/ much
   b) Little/ very little
   c) Don't know
7. Can you explain why you think the WUC is able to maintain and operate the water supply system?
8. Who would you contact if there is any problem in water supply?
9. What have been the greatest difficulties that the water committee has encountered in the operation and maintenance of the system?
   a) Collecting the tariff
   b) Accounting
   c) Organizing meeting
   d) Physical repairs
   e) Technical capacity

Annex 3: Main Income Source of Dhulikhel Water Supply System

	2004/05 (FY)		2005/06		2006/07		2011/12		2012/13 (est)	
Heads	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%
Water tariff	3,659,583.6	90.5	4,069,861.8	91.4	4,650,435.7	90.7	11,141,787.97	87.14	13,587,836.0	71.79
Meter charge	39,600.0	1.0	37,400.0	0.8	56,900.0	1.1	279,000.0	2.18	460,000.0	2.43
Instillation charge	15,000.0	0.4	20,000.0	0.5	21,100.0	0.4	130.000.0	1.02	400,000.0	2.11
Maintenance and miscellaneous	19,736.0	0.5	12,274.0	0.3	14,262.0	0.3	67,100	0.52	115,000.0	0.61
Interest from deposit	308,340.7	7.6	288,758.2	6.5	385,069.0	7.5	1,168,834.60	9.14	1,364,700.0	7.21
From DWSS									2,500,000.0	13.21
Deposit from new applicant									500,000.0	2.64
Total	4,042,260.3	100	4,428,294.0	100	5,127,767.6	100	12,786,722.57	100	18,927,536.0	100

Annex 4: Main Income Source of Bhakundebesi Water Supply System

	2007/08(FY)		2008/09		2009/10		2010/11		2011/12	
Heads	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%
Water tariff	363,600		456,000	91.4	456,000	90.7	604,800	87.14	631,200	71.79
Meter charge	20,000		24,400	0.8	56,000	1.1	90,000	2.18	95,300	2.43
Instillation charge	15,000.0		20,000.0	0.5	21,100.0	0.4	130.000.0	1.02	400,000.0	2.11
Maintenance and miscellaneous	19,736.0		12,274.0	0.3	14,262.0	0.3	67,100	0.52	115,000.0	0.61
Interest from deposit	308,340.7		288,758.2	6.5	385,069.0	7.5	1,168,834.60	9.14	1,364,700.0	7.21
From DWSS									2,500,000.0	13.21
Deposit from new applicant									500,000.0	2.64
Total	4,042,260.3	100	4,428,294.0	100	5,127,767.6	100	12,786,722.57	100	18,927,536.0	100

Annex 4: Main Income Source of Panchdhara Water Supply System

	2007/08 (FY)		2008/09		2009/10		2010/11		2011/12		2012/13(est)	
Heads	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%	Amounts (NRs)	%
Water tariff	69,400	3.47	14,56,000	36.62	15,90,000	32.36	17,30,780	24.84	16,40,000	56.09	19,43,933	33.02
Meter charge	1,54,000	7.68	1,54,700	3.85	1,86,000	3.79	1,87,284	2.69	1,32,001	4.52	147,350	2.50
User contribution and Instillation charge	9,15,000	45.65	20,48,650	50.97	24,58,900	50.04	44,29,000	63.57	2,85,929	9.78	26,43,500	44.91
Maintenance and miscellaneous	24,000	1.20	22,500	0.56	30,458	0.64	50,953	0.73	27,400	0.94	40,700	0.69
Interest from deposit	-		2,57,729.5	6.61	2,98,188.8	6.07	3,69,415	5.30	5,88,303	20.12	7,11,044	12.08
From DWSS and VDC	8,41,829.57	42.00	80,000	1.20	3,50,000	7.12	2,00,000	2.87	2,50,000	8.55	4,00,000	6.80
Total	20,04,229.57	100	40,19,579.5	100	49,13,546.8	100	69,67,432	100	29,23,633	100	58,86,527	100