A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

Multiple-Use water Service (MUS): Cost Effectiveness and Contribution towards Poverty Reduction. A case study of Nepal

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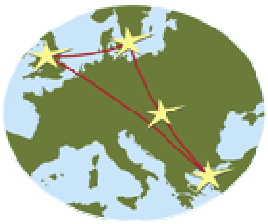
Erasmus Mundus Masters Course in Environmental Sciences, Policy and Management

MESPOM



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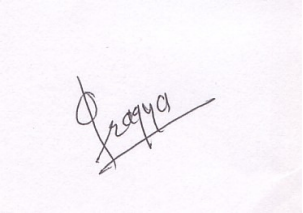

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ABSTRACT OF THESIS submitted by: Pragya SHRESTHA

for the degree of Master of Science and entitled: Multiple-Use water Service (MUS): Cost Effectiveness and Contribution towards Poverty Reduction. A case study of Nepal

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Multiple- Use water Service (MUS), a participatory, integrated and poverty-reduction focused approach, is a pivot of meeting three major needs of any agricultural developing countries: accessible safe drinking water, agriculture development via irrigation and poverty reduction. This study aims to analyse MUS in terms of its cost effectiveness in domestic water supply services and conduct poverty impact analysis, taking a case study of Nepal. The study conducts Net Present Value (NPV), Discounted and Net Benefit Cost Ratio (BCR_d and BCR_n respectively), Payback period and Financial Internal Rate of Return (FIRR) calculation, which shows that the investment in the MUS is highly profitable in financial terms. The NPV, BCR_d, BCR_n average values were found 45,345 US $, 1.5 ratio and 50% respectively. The payback period was found 13 months on average and the FIRR to be 58%. With access to productive uses of water, there are significant improvement in income level, food security, household nutrition, health, sanitation and women's empowerment among the MUS users. The study provides evidences like saving a certain amount in saving and credit groups, getting luxury items, initiating other income generating sources such as shops, building new houses, investing in children's education, having a good meal everyday with fresh vegetables etc, which shows the fact that the MUS helps enhancing living standard of the poor. This hence supports solving multi-dimensional poverty issues of the people. The study verifies that the MUS is not only a financially profitable investment, but is also beneficial in terms of social reform and development. There is a high potential for the MUS in developing countries like Nepal, if its challenges are addressed.

Keywords: *Multiple-Uses water Services (MUS), Poverty reduction, Benefit cost analysis, Nepal.*

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ABBREVIATIONS

AEC	Agricultural Enterprise Centre
BCA	Benefit Cost Analysis
BCR	Benefit-cost ratio
BDS-MAPS	Business Development Series- Marketing and Production Services
CBS	Central Bureau Statistics
CDB	Central Development Bank
CDR	Central Development Region
CEDAW	Convention on the Elimination of all Kinds of Discrimination against Women
CEAPRED	Centre for Environmental and Development
COV	Coefficient of Variation
CP-MUS	Challenge Program- Multiple Use Water System
CPRC	Chronic Poverty Research Council
CRC	Convention on the Rights of the Child
CWN	Concern Worldwide Nepal
DDC	District Development Committee
DoLIDAR	Department of Local Infrastructure Development and Agriculture
DoA	Department of Agriculture
DoI	Department of Irrigation
EDR	Eastern Development Region
FWDR	Far Western Development Region
FIRR	Financial Internal Rate of Return
GWP	Global Water Partnership
HDI	Human Development Index
IMF	International Monetary Fund
ICECPR	The International Covenant on Civil and Political Rights
ICESCR	The International Covenant on Economic, Social and Cultural Rights
IDE	International Development Enterprise
IWRM	Integrated Water Resource Management
I/NGO	International/ Non-Governmental Organization
lpcd	Litre per capita per day
MDGs	Millennium Development Goals

MWDR	Mid western Development Region
MUS	Multiple-Use water Service
NEFEJ	Nepal Forum of Environmental Justice
NLSS	National Living Standard Survey
NPC	National Planning Commission
NPV	Net Present Value
NUCPI	National Urban Consumer Price Index
PRSP	Poverty Reduction Strategy Paper
SaPPROS	Support activities for the Rural Poor
SIMI	Smallholder Irrigation and Market Initiative
SU	Single Use
UDHR	Universal Declaration of Human Rights
UNDP	United Nations Development Programmes
USAID	United States Aid for International Development
VBM	Value Based Management
VDC	Village Development Committee
WAN	WaterAid Nepal
WDR	Western Development Region
WHO	World Health Organization

CHAPTER 1 INTRODUCTION

1.1 Background

1.1.1 Water as a basic need

Water is a basic need and human right of people. People in households need water for various purposes ranging from drinking, cooking, sanitation, irrigation and small enterprises. Besides domestic use, they concurrently need water for other diversified livelihood including cropping, gardening, livestocks, food processing, fisheries, aquaculture and other small enterprises (Soussan 2003; Koppen *et al.* 2006). Most of the peri urban and rural areas of the developing world, whose major occupation is agriculture, depend upon water for their livelihood (Soussan 2003; Renwick *et al.* 2007). Table 1.1 shows the need for water for their daily life in rural context.

Table 1.1: Various uses of water in rural households of developing countries

Water demand characteristics of a hypothetical rural household (eight persons; a cow, a donkey and six goats or sheep in a hot climate).

Characteristics of demand and benefits	Drinking-Humans	Drinking-Livestock	Bathing and sanitation	Washing	Fish culture	Irrigation	Enterprise
How frequently is water needed?	Daily	Daily	Daily to weekly	Daily to weekly	Continuous	Weekly	Varies
How much water is needed per year? (m^3)[1]	12	30[2]	45[3]	45	6,000	8,000[4]	Varies
How critical is good water quality?	Very, especially organic pollution and certain chemicals	Quite, less than for people	Not	Not, except for hardness	Hardly	Hardly, except for salinity	Varies
Elasticity of water use w.r.t. supply	Very low above minimum requirements	Very low above minimum requirements	Low	Low	High	Very high	High
Site of use	Homestead	Homestead, near distant, pastoralist	Homestead or near	Homestead or near	Homestead near or distant	Homestead near or distant	Homestead near or distant
Benefits	Health/hygiene	Food, income, draught power, asset	Health/hygiene/ sanitation	Health/ hygiene	Food/income	Food/income	Income
Monetary costs of water provision	Medium	Medium	Medium	Medium	Medium-High	High	Varies

Notes:

[1] Calculations based on daily requirements for people at 4 lppd (Howard and Bartram 2003); for cattle 27 lpcd, sheep 5 lpsd, donkey 16 lpdd (FAO 1986); for bathing (including sanitation) and washing 15 lpcd each (Thompson et al. 2001).

[2] This is water only for drinking. Water may also be used for bathing and cleaning of stables.

[3] One hectare of land with 0.5 ha rice requiring 8 mm/day during 120 days (4,800 m^3), 0.5 ha vegetables requiring 5 mm/day during 120 days (3,000 m^3) and a rain-fed crop during the rest of the year.

w.r.t. = with regard to; lppd = liters per person per day; lpcd = liters per cow per day; lpsd = liters per sheep per day; lpdd = liters per donkey per day.

Source: (Koppen *et al.* 2006, p 3)

1.1.2 Single use approach versus multiple uses

Single Use (SU) approaches by definition involve design, finance and management of water services for a single intended use, either for irrigation or for domestic use (Renwick *et al.* , 2007). In general practice, water service delivery in most of the countries is concerned with single use service only, either for domestic or for irrigation. Each service sector hence plans and designs its water supply scheme for its single water use only and thus is termed as Single Use (SU) approach (Koppen *et al.* 2006; Renwick *et al*, 2007). The domestic water supply scheme focuses on water supplies for household water usage, like drinking, cooking, washing and sanitation. Similarly, a separate water supply system is provided for irrigating agricultural land by the irrigation sector. In most of the cases, people are not getting both of those services, mainly in poor and undeveloped areas. Hence people of those areas have to depend on single use system to fulfil their multiple water need for their subsistence (Koppen *et al.* 2006; Smiths *et al.* 2010).

It is also a universally observed fact that such single use planned scheme for multiple purposes raises many problems. In some cases it can damage the hardware of the system. In many cases of domestic water supply scheme, there has been reduced water pressure in the tail end users' tap-stand and hence those tail end users do not get water access perpetuating a conflict among the users (Soussan 2003; Renwick *et al*, 2007; Merry and Sibanda 2008; Mikhail and Yoder 2008; Koppen *et al.* 2009).

1.1.3 Multiple-Use water Service (MUS) approach

Multiple-Use water Service (MUS) is water supply system designed for both domestic and productive uses of water according to consumers' need and demand (Moriarty *et al.* 2004). MUS hence incorporates integrated water services for multiple domestic and productive uses from the designing and planning phase of the system using participatory approach (Renwick *et al.* 2007; Faal *et al.* 2009; Smiths *et al.* 2010). The services that MUS can provide in most of the countries are domestic water supply service (drinking, cooking, sanitation etc), productive water service (irrigation, food processing other small enterprises) and functional service (fisheries, flood protection, recreation etc (Moriarty *et al.* 2004). Koppen *et al.* (2006) has defined MUS as a participatory, integrated and poverty-reduction focused approach in poor rural and peri-urban areas, which takes people's multiple water needs as a starting point for providing integrated services, moving beyond the conventional sectoral barriers of the domestic and productive sectors.

MUS is considered within the framework of Integrated Water Resource Management (IWRM). This involves planning, finance and management of integrated water services and meets the multiple water and livelihood needs of users (Renwick *et.al.* 2007; Faal *et.al.* 2009). The Global Water Partnership, a key global network on IWRM, also refers to MUS approaches as "appropriate forms of IWRM in poor areas with backlogs in infrastructure development" (GWP 2004).

The major philosophy of the MUS approach is to provide effective water services that are well suited to the context of rural people's livelihood and improve their lifestyle reducing rural poverty (Koppen *et al.* 2006).

The major elements of the MUS approach are

I) Assessment on the need of the users

II) Integration of the water supply services (domestic and productive services together)

III) Supply the demands of the users within an integrated framework

Generally there are three major ways for MUS implementation (Mikhail and Yoder 2008).

1. Upgrading the existing system by installing an "add-on" to it such as drinking water scheme upgraded by adding irrigation system which is termed as "Upgraded Domestic+ MUS" or irrigation water scheme upgraded by adding drinking water system termed as " Upgraded Irrigation + MUS"
2. Single plus system in which phase expansion is planned from the start and later can be upgraded.
3. MUS by design where services are designed for multiple use i.e. for both domestic and irrigation from the start, which is also termed as New domestic + MUS or New Irrigation + MUS.

1.1.4 Areas where MUS is promoted

MUS has been applied mostly in peri urban and rural settlements of South Asian and Sub Saharan African countries where there a high concentration of rural poor with inadequate access to water for both domestic and productive purpose (Smiths *et al.* 2010). It has been promoted as action research project since 2003 in Thailand, Nepal, Bangladesh, India and Vietnam of South Asia as well as in Cameroon, Zimbabwe, Morocco, Bolivia, Nicaragua and Bolivia of South Africa as shown in Fig. 1.1. The action research project is named as ""Models for multiple water-use water supply systems for enhanced land and water productivity, rural livelihoods, and gender equity" (Moriarty *et al.* 2004; Smiths *et al.* 2010). This action research helps to generate better understanding and action to scale up MUS and supports to advance MDGs (Koppen *et al.* 2006).

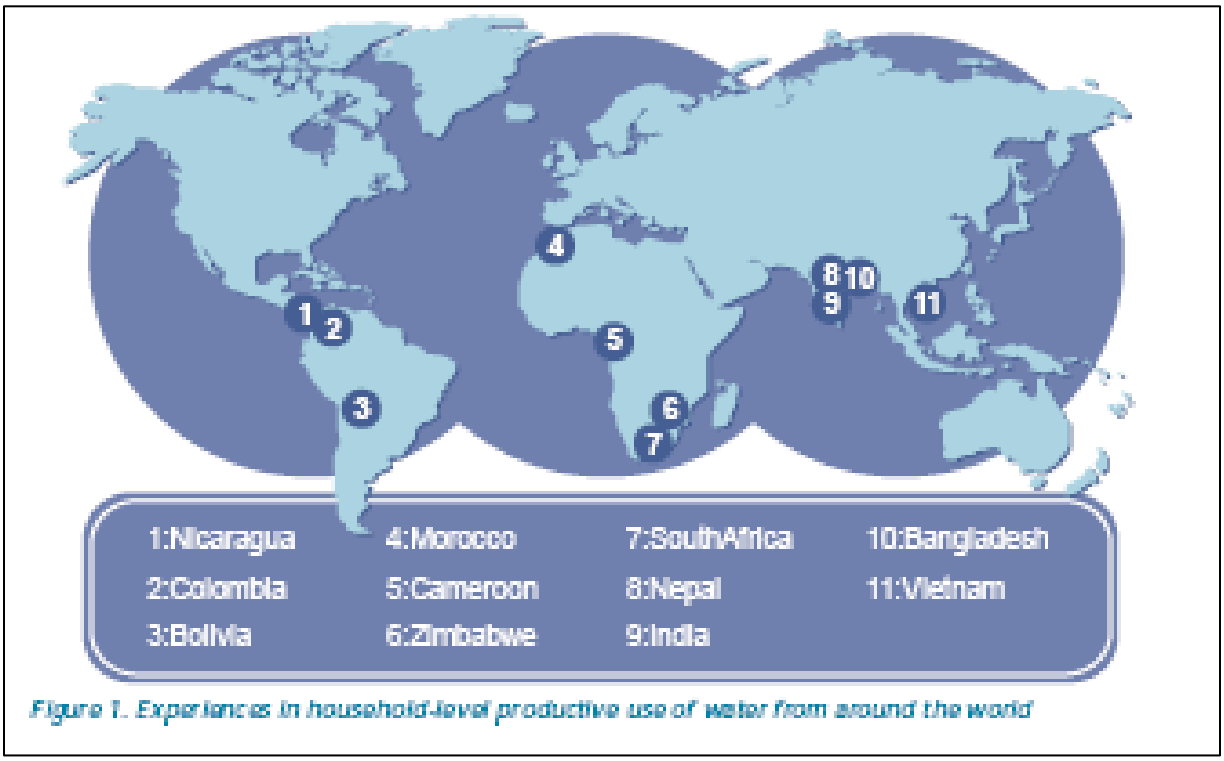

Fig. 1.1. Countries with MUS action research

Source: (Morairty *et al.* 2004, p 21)

1.1.5 Steps required to climb the ladder from single use to multiple uses

A framework of different water service levels is given in Fig. 1.2. Most of the domestic water supply schemes are designed to fulfil basic domestic service level and misses the productive uses of water which can uplift people's livelihoods (Soussan 2003). There is necessity of climbing the water ladder as shown in Fig. 1.2 and reaching higher level for getting economic benefit of water (Renwick, *et.al.* , 2007).

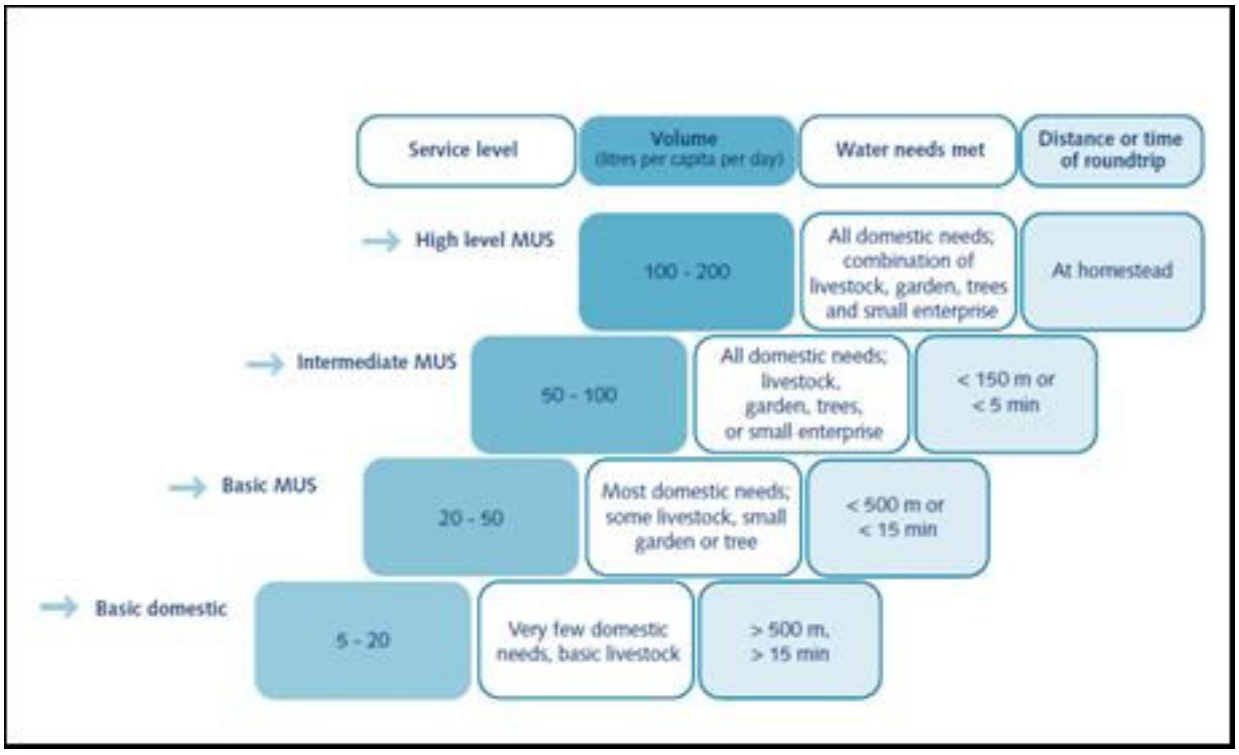

Fig. 1.2. Water service level framework

Source: (Smith *et al.* 2010, p 109)

The basic steps required to construct MUS system in water supply scheme is same as that of SU water service schemes, illustrated in Fig. 1.3. The only difference is the water quantities via designs and infrastructure to supply additional water for smallholder irrigation and providing separate irrigation water outlets along with domestic water outlets, in case of domestic + MUS (Polak *et al* 2003). For irrigation + MUS, improvement in water quality reliability and source distance should be taken into consideration (Renwick *et al.* 2007).

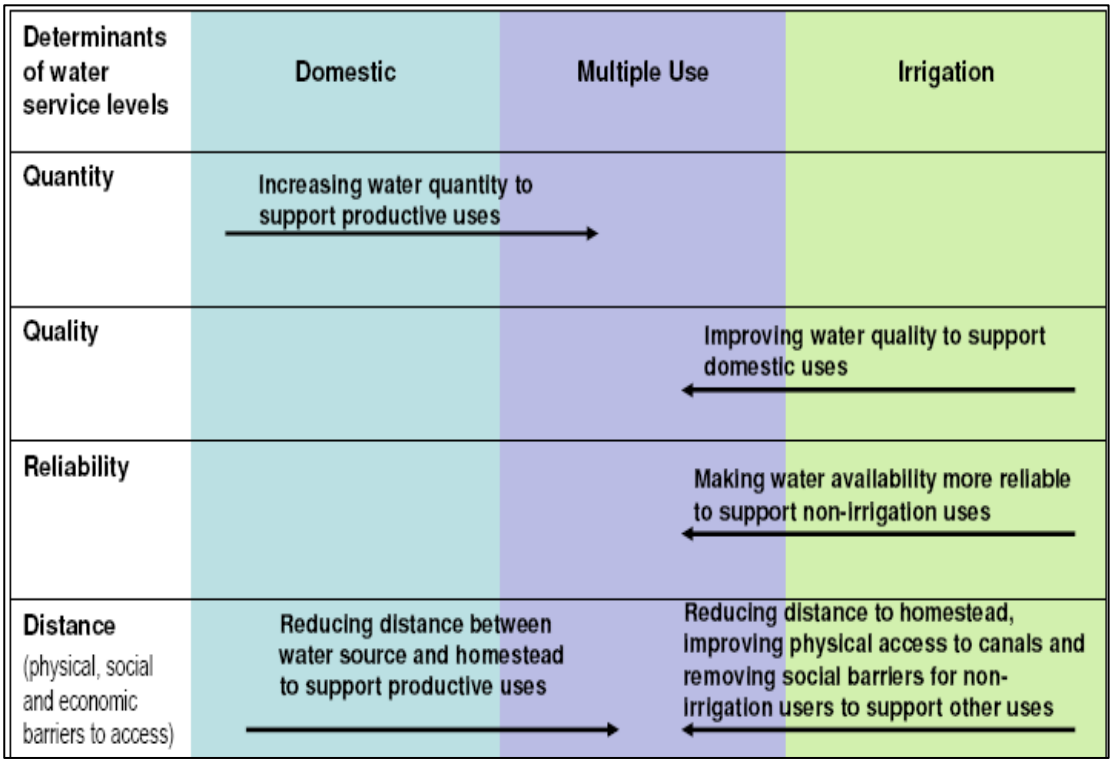

Fig. 1.3. Water service level to support MUS

Source: (Renwick *et al.* 2007, p 24)

1.1.6 Multiple-Use water Service and Millennium Development Goals

MUS can provide numerous benefits which can support achieving Millennium Development Goals (MDGs) (Soussan 2003; Koppen *et al.* 2006). MUS in the beginning aimed to advance MDGs by identifying and promoting useful guidelines, tools for improving and scaling up water supply services to meet the real needs of the people (Koppen *et al.* 2006; Smiths *et al.* 2010). The MUS potentiality of tackling all MDGs is shown in Fig. 1.4.

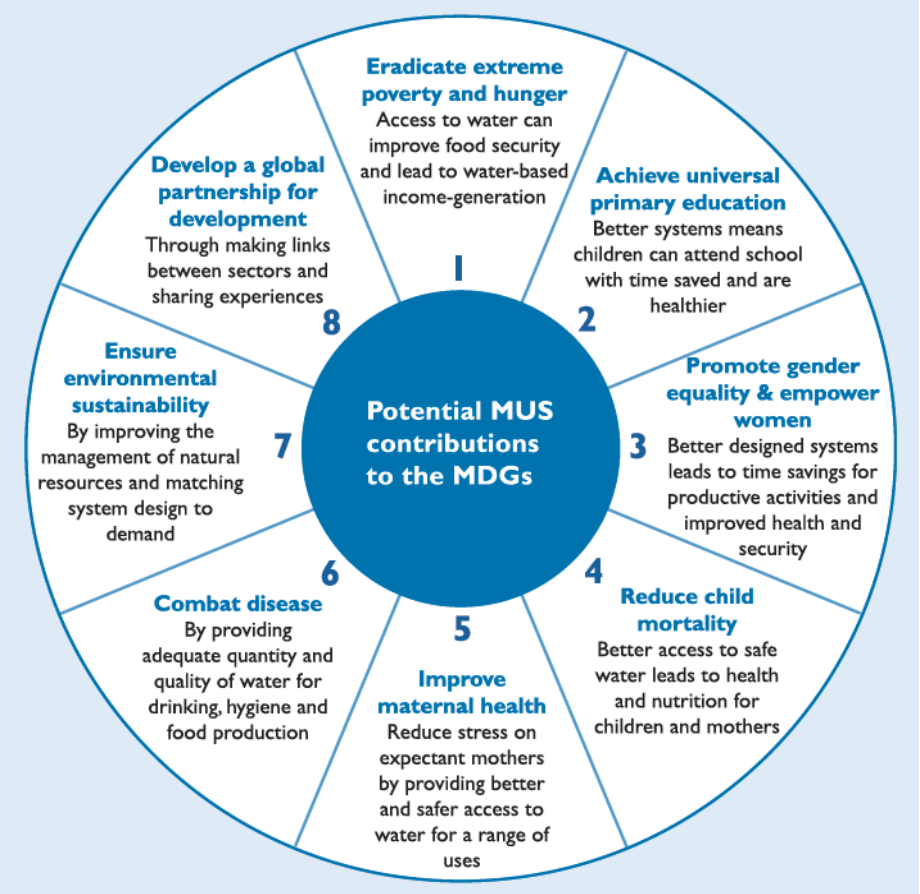

Fig. 1.4. MUS potential for tackling all MDGs through an integrated approach

Source: (Faal *et al.* 2009, p 3)

1.1.7 MUS, poverty alleviation and sustainable livelihoods

Poverty does not mean low income only. It can be characterized by other human development indexes, like hunger, mal- nutrition, lack of education and basic facilities like water, sanitation services, which is termed as multidimensional poverty (CPRC 2008; Maxwell 1999). MUS approach is considered as one of the effective means for reducing both money metric and multi dimensional poverty in developing countries (Faal *et.al.* 2009; Koppen *et.al.* 2009).

MUS provides productive uses of water at household level and provides the poor people a range of opportunities that help them to produce food, fruits and vegetables, increase their agricultural production, initiate livestocks or other small water base enterprises like brick making, food

processing, etc to generate income and hence improves their living condition (Soussan 2003; Moriarty *et al.* 2004; Koppen *et al.* 2006). Robinson (2003) showed Zimbabwe's poor farmers' opportunities of producing and marketing exotic crops (garlic, asparagus, mushroom etc), export crops (sweet corn, paprika, baby corn, fine beans, black eyed beans, mangetout, granadilla etc) as well as local vegetables and fruits after upgrading their domestic water supply to productive uses. He also showed increment of irrigated land form 0.03 ha to 0.24 ha per household and hence estimated gaining cash income of $105 to $525 per annum, just from the export crops. It has been found that communities with high water services have more homestead garden, higher number of livestock and larger number of small scale enterprises with diversified livelihood activities (Renwick *et al.* 2007; Smiths *et al.* 2010).

The most important factor of poverty is lack of opportunity (Moriarty *et al.* 2004). Hence, access to productive water supplies opportunities and helps in reducing the poverty level of the household (Butterworth *et al.* 2003; Soussan 2003; Koppen *et al.* 2006).

The MUS not only helps the poor generating income, it also increases their food security, improves health condition, saves time of fetching water and thus comprehensively addresses the multidimensional aspect of poverty (Moriarty *et al.* 2004; Koppen *et al.* 2006; Butterworth *et al.* 2003; Smiths *et al.* 2010). According to the study of Renwick *et al.* (2007), MUS or upgraded water supply service has promoted food security/ improves nutrition, health, reduces vulnerability and livelihood diversification and social equity and empowerment which ultimately contribute towards sustainable livelihoods. The MUS thus, improves various aspects of wellbeing in a virtuous circle helping the poor out of their poverty.

Table 1.2 Benefits of MUS over SU in regard with poverty dimension

Poverty Dimension	Single use water service (Domestic water supply)	MUS
Income	Indirect impact due to saved water fetching time which can be used for income generating activities	Direct impact through productive activities like vegetable farming, other water based small enterprises
Nutrition	Indirect impact due to less diarrheal cases and less nutrition loss	Direct impact due to increase consumption of fresh vegetables from their own garden.
Health	Direct impact due to less water borne diseases	Less water borne disease and better health condition due to nutrition.
Food security	No contribution	Enhance food security due home garden possibility as a result of productive uses of water

Source: (Adapted from Renwick *et al.* 2007)

1.1.8 MUS and Health

Improved water and sanitation are closely related with beneficial health impact. With improvement of water and sanitation, a significant improvement in water borne diseases like diarrhoea, dysentery, worm infection, bilharzias, scabies etc, has been reported by many studies (WaterAid 2001). Such benefit in reduction of water borne diseases and time spent in fetching water can be obtained also from SU approach providing safe drinking water and sanitation. But, in case of the MUS, there are additional benefits including improvement in nutrition level and sanitation condition of household along with their livelihood which helps improving the health condition of the people (Renwick *et al.* 2007). The health benefit is important factor for enhancing the living condition of the poor as it can reduce sickness, medical expenses and ultimately provide working days (Redhouse *et al.* n.d.)

The action research projects on the MUS have reported healthy food consumption by poor families after the MUS project (Faal *et.al.* 2009). As one of the successful case studies in Nepal, farmers of Senapuk village showed increased vegetable consumption from a very limited 2-3 kg per week to almost 1 kg per day at present. The study also showed many reports of malnutrition among children

due to lack of minerals before the project (Mikhail and Yoder 2008). Better nutrition with consumption of healthy and nutritious food decreases susceptibility to many diseases and hence improves the health of the people. A survey of 45000 households in Bangladesh showed a higher intake of Vitamin A and C among the households with home garden which quantifiably reduces night blindness and diarrhoea in those areas (Renwick *et al.* 2007).

Besides healthy food, the study also showed reduction of time spent in fetching water for domestic and livestock needs, which allows especially women and girls to take a rest (Renwick *et al.* 2007; Khawas and Mikhail 2008). Similarly women can spend their time taking care of children, attending health and hygiene trainings which also help in reduction of disease among children. Such health impact can be seen in most of the MUS projects implemented in different parts of South Africa and Asia (Moriarty *et al.* 2004).

But to get these health benefits, training on quality of water, household water treatment, safe hygiene and sanitation should be supplemented as a package of MUS programme, in addition to adequate supply of water. Better planning with community ownership shows proper operation and maintenance of the system, which will keep the water source clean, which also reduces health risk from water diseases. Hence, more health impacts can be brought by MUS than SU supplies for domestic uses, if health issues are explicitly and properly addressed (Boelee 2008).

1.1.9 MUS and sustainability of the system

In order to meet daily water need for domestic and productive uses in households, unplanned multiple uses of single use domestic or irrigation water systems are widespread. These unmanaged and unplanned or illegal uses result in breakdown of the systems, community conflicts and even failure of the system (Koppen *et al.* 2006). This, hence, threatens sustainability of water services. The MUS caters for real needs of the users and better meets various water demands of the communities and hence decreases the users conflict over water usage and also minimizes damage to infrastructure of the water system caused by illegal and unplanned uses and increases community ownership and investment and enhances sustainability of the water system (Koppen *et al.* 2006; Renwick *et al.* 2007).

Besides, MUS offers significant advantages in generating more income, saving time and improving the health, nutrition, food security of the people (Moriarty *et al.* 2004; Koppen *et al.* 2006; MUS

groups 2007). This MUS hence helps generating enough income and other non financial benefits, which increases their ability and willingness to pay for investment for improving water services and hence motivates them to invest in the operation and maintenance cost of the water system, which promotes its sustainability (Renwick *et al.* 2007). According to Koppen *et al.* (2006), higher willingness and ability to pay for the water systems help in full cost recovery and thus attain higher financial and technical scheme sustainability.

However there are only demonstration projects on MUS which has been promoted since 2003. Hence, there is very limited evidence available on long term sustainability of MUS. More research and time is essential for further assessment of sustainability of MUS (Renwick *et al.* 2007).

1.2 Aim and objectives of the study

The major aims of the study were to analyse whether the MUS is cost effective option in domestic water supply services and whether it can contribute towards poverty alleviation of the developing countries, taking a case study of Nepal. The following are the specific objectives of the study.

- Conduct cost benefit analysis of the MUS to determine cost effectiveness of the MUS.
- Calculate Net Present Value (NPV), Benefit-cost ratio (BCR), Payback period and Financial Internal Rate of Return (FIRR) of the MUS.
- Conduct poverty impact analysis by assessing direct and indirect benefits of MUS besides income benefit.

1.3 Justification of the study

MUS approach is an emerging approach in domestic water supply services sector. It is a pivot of meeting three major needs of any agricultural developing countries: accessible safe drinking water, agriculture development via irrigation and poverty reduction. Despite having a plethora of benefits, the MUS approach has not been promoted extensively. This system is still in demonstration stages. In most of the countries, this MUS approach has been promoted only by the INGO and NGO sectors. The governments are still reluctant to promote MUS approach over single water services approach, which is a traditional approach in any water supply system. The main reasons for this might be an additional initial cost compared with that of the SU approach. However, this additional cost required could be covered by its enormous social and economic benefits within a certain period

of time. There are only a few studies conducted on cost benefit analysis and hence there is still insufficient knowledge and awareness regarding cost and benefit aspect of the MUS approach (Merry and Sibanda 2008).

Hence, the main goal of the present study is to analyse the MUS in terms of its cost effectiveness via benefit cost analysis and assess its impact in relation to multi dimensional poverty reduction. The study was done taking the case study of the application of the MUS approach in Nepal, a south Asian country situated in between India and China. In case of Nepal, the concept of the MUS approach was introduced in the year 2003 (Mikhail and Yoder 2008) and until today only a few projects including both government and INGO led projects have incorporated the MUS approach in their domestic water supply schemes.

This study will thus help to add information to the cost effectiveness of the MUS along with different cases of its impact on the livelihood of its users. It will provide important information to the governmental authorities as well as other sectors and might help in advocating to incorporate the MUS approach in their domestic water supply scheme. This may open an opportunity to move from the SU water service approach to the MUS, which will improve the livelihood of the people, contributing towards poverty reduction agenda of the country.

CHAPTER 2 STUDY AREA DESCRIPTION AND MUS IN NEPAL

2.1 Study Area

2.1.1 Geographical location of Nepal

Nepal is a small landlocked developing country in South East Asia with an area of 147,181 square kilometres. It has approximately a 23 million population with a growing rate of 2.27% per year (CBS 2007). It is bordered by China in the north and India in south east and west of the country. The location of Nepal in South East Asia is shown in Fig. 2.1.

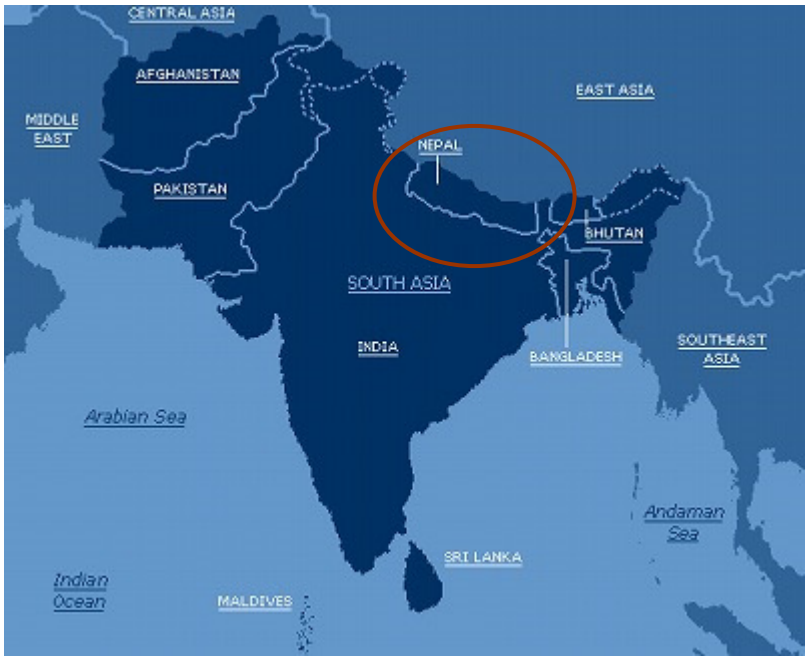

Fig. 2.1. Location of Nepal in South East Asia.
Source: (JUGEM 2009)

In general the area of Nepal is divided in three ecological regions: Mountain, Hilly and *Terai* region. These ecological regions extend from east to west and are intersected by Nepal's major river. The *Terai* region is a lowland plain and is located in the south part of the country and is border to India. The Hilly region, which is also termed as *Pahad,* is located in the middle part of the country in between *Terai* and Mountain regions and lies in an altitude of 800 to 4000 meter above sea level. The Mountain region also termed as *Parbat,* is located in the northern part of the country on the border

with China. This region contains the world's eight highest peaks including Mount Everest, the highest peak of the world.

Nepal has five development regions; Eastern Development Region (EDR), Central Development Region (CDR), Western Development Region (WDR), Mid western Development Region (MWDR) and Far Western Development Region (FWDR) as an administrative boundary with 14 zones and 75 districts. The MUS projects in Nepal are distributed only in rural areas of the Hilly regions of the country. MUS system has already been implemented in 16 districts of the country in all development regions except the EDR (Mikhail and Yoder 2008).

2.1.2. Major occupation of Nepal

Agriculture is the major occupation of the country. Around 80% of people's subsistence depends on agriculture (CBS 2007). Hence water is one of the important parameters for the development of the country. The Poverty Reduction Strategy Paper (PRSP) of Nepal also considered agricultural growth as a major impetus for reducing poverty in the country. The PRSP has emphasized improved agricultural / irrigation facilities in addition to improved rural road and other facilities. It has a target to increase the total irrigated areas from 1121.4 to 1417 thousand hectares from the year 2001/02 to 2007/08 (IMF 2003).

2.1.3 Poverty situation in Nepal

Poverty in Nepal is deep rooted and has existed for decades. It is one of the poorest countries in South East Asia. It has a rank of 144 in Human Development Index (HDI) with a value of 0.553 (UNDP 2009). The poverty situation throughout the country is not the same. There is a high disparity in development and poverty reduction trend in rural and urban areas. The poverty distribution is very high in rural areas, especially in Mountainous and Hilly regions of the country. The National Living Standard Survey done in 2003 showed that the poverty reduction based on head count ratio from 42% in 1994/95 to 31% in the year 2003/04 (IMF 2007). However, this decline in poverty is mainly in urban areas. Around 90% of the poor live in rural areas and hence Nepal's poverty is basically rural based.

Nepal is facing multi dimensional poverty due to high illiteracy, poor access to basic services like roads, water, sanitation, health, high child malnutrition, low agricultural productivity and biased social

structure (IMF 2003; UNDP 2006). The poverty is deeper and more severe among women, backward social and ethnic groups living in hilly and remote areas. The country has hierarchical social structure of high castes (Brahmins, Chhetris and Newars) and the lower and untouchable occupational castes or *Dalits* (shoemaker, blacksmiths, tailors etc). There is a high discrimination against untouchable caste groups, which is making them even poorer. Those excluded people are trapped in a vicious cycle of problems like the loss of confidence as a result of humiliation, distrust by the community, lack of opportunities and services and suffer from chronic poverty (UNDP 2006; Pokharel and Cater 2007).

2.1.4 Water accessibility status

According to Central Bureau Statistics of Nepal (CBS), the safe drinking water coverage in Nepal is 82% (81% in rural and 89% in urban), which showed a drastic improvement from 36% in 1990 to 82% in 2000. However the reliability of this data has been questioned by different developmental organizations. This coverage would be reduced drastically if, water accessibility within 15 minutes distance for a round trip is considered along with its quality and service level (WAN 2004; NPC 2005, NEFEJ 2004). According to WaterAid Nepal (WAN) estimate, there was only 30% water coverage in 1990, which increased to 48% in 2000 and has to be increased to 66% by 2015 to attain MDG's target on drinking water (WAN 2004).

In order to achieve national aims of reducing poverty, increasing irrigated land and improving safe drinking water access, this MUS approach can be a pivotal point.

2.2 Development history and trend of MUS in Nepal

2.2.1 Policy and regulation on water resource management in Nepal

Under international law (The Universal Declaration of Human Rights 1948 (UDHR), The International Covenant on Economic, Social and Cultural Rights (ICESCR) 1966 and the International Covenant on Civil and Political Rights (ICCPR) 1966, the Convention on the Elimination of all Kinds of Discrimination against Women (CEDAW) 1979 and the Convention on the Rights of the Child (CRC) 1989), water is considered as a basic human need and right (WAN 2005). Also, the Target 2 in MDG targeted to halve by 2015 the proportion of people without access to safe drinking water and without access to hygienic sanitation. Nepal is a signatory member to all

the above international laws and declarations and hence is bound to enact it in its national legislation for its effective implementation.

The Water Resource Act, 1992 is a main legislation in relation to the water sector in Nepal. It is considered as umbrella legislation, leading drinking water and other uses of water along with water resource management in Nepal (WAN 2005). Similarly the Water Resource Strategy 2002 (2058 BS) also states that "Every Nepali Citizen, now and in future, should have access to safe drinking water and appropriate sanitation as well as enough water to produce food and energy at reasonable cost"(DWaF 2004). These acts govern the rational and effective utilization, conservation, management and development of water resources that are available in the country.

The act of 1992 sets the order of priority of water use as follows (WAN 2005):

1. Drinking water and domestic uses
2. Irrigation
3. Agricultural uses such as animal husbandry and fisheries
4. Hydroelectricity
5. Cottage industry, industrial enterprises and mining uses
6. Navigation
7. Recreational uses
8. Other uses
9.

Hence the Water Resources Act 1992 (2049 BS) places water for drinking water and domestic purposes and for irrigation as given priority simultaneously over any other uses of water.

2.2.2 MUS in Nepal

MUS in Nepal was introduced as Challenge Program- Multiple Use Water System (CP-MUS) project by the Smallholder Irrigation and Market Initiative (SIMI) with International Development Enterprise (IDE), Winrock International and other partner organization; Agricultural Enterprise Centre (AEC, Support Activities for the Rural Poor (SaPPROS) and) Centre for Environmental and Development (CEAPRED) in the year 2003 (Mikhail and Yoder 2008).

2.2.3 MUS design and system component

The system consists of water source as springs or small stream diversions from where water is collected by gravity flow via plastic pipe in either one or two reservoir tanks depending on whether it is single tank one line distribution system or double tank two line distribution system. The water is then distributed via two kinds of outlets: tap stand for domestic water use and outtakes for

irrigation. This MUS system usually provides services to 10-100 rural households. The domestic water need is calculated based on the assumption of water demand of 45 litre per capita per day (lpcd) and that for irrigation is calculated assuming a need of 400-800 litres per day per household with consideration of evapo-transpiration rate in the Hilly region of the country (Mikhail and Yoder 2008). A basic MUS design and concept in Nepal is demonstrated in Fig. 2.2.

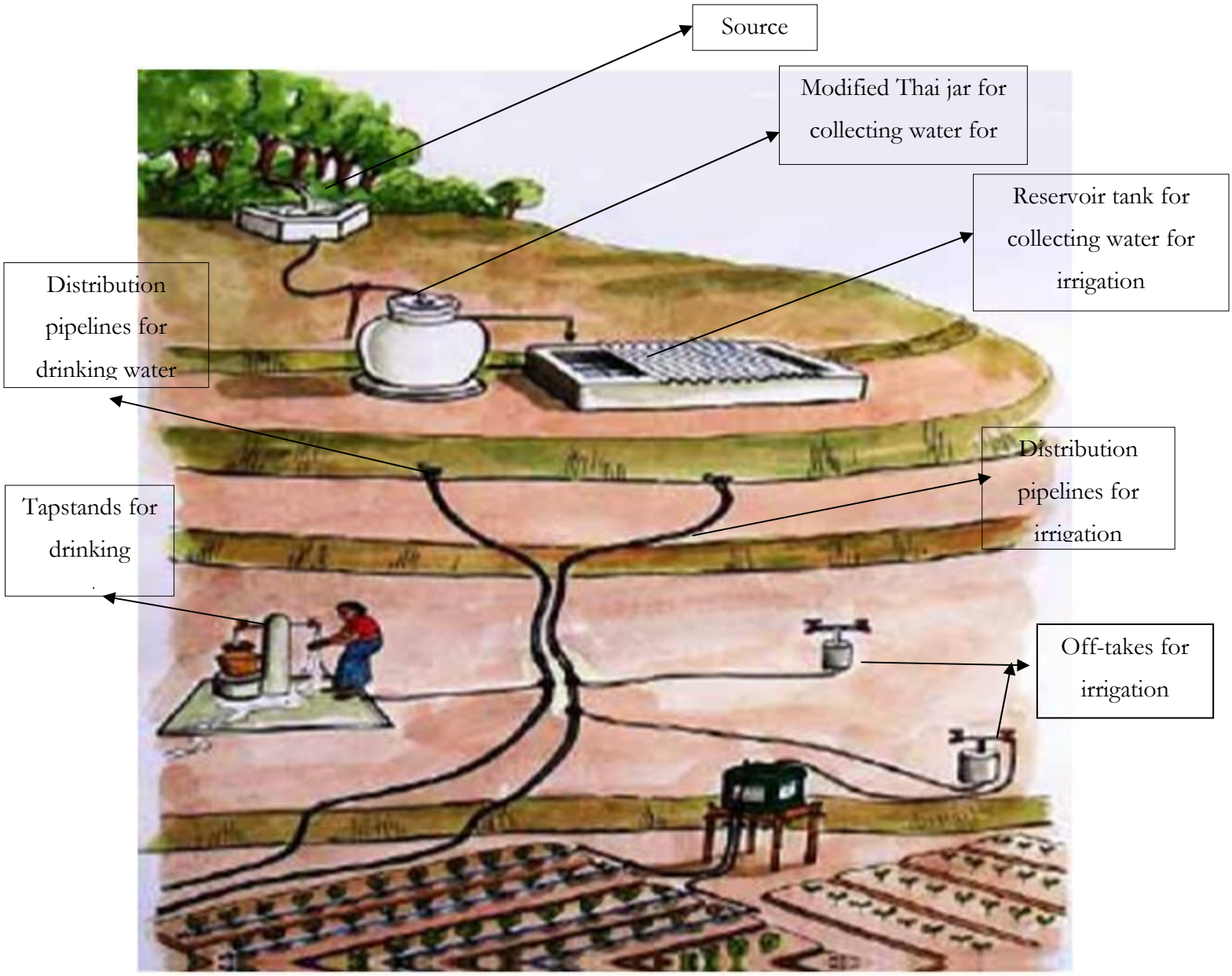

Fig. 2.2. MUS scheme design in Nepal

Source: (IDE n.d.)

2.2.4 Single tank one line distribution system and double tank two line distribution system

In case of Single tank one line distribution system, water from the source is conveyed in a modified Thai jar (shown in Fig. 2.2), which later on is distributed to both domestic tap-stand and off-takes for irrigation as shown in Fig. 2.3. A thai jar is made up of ferro cement and rein- enforced by wire netting and usually of 1000,1500 to 3000 litre capacity (Mikhail and Yoder 2008)

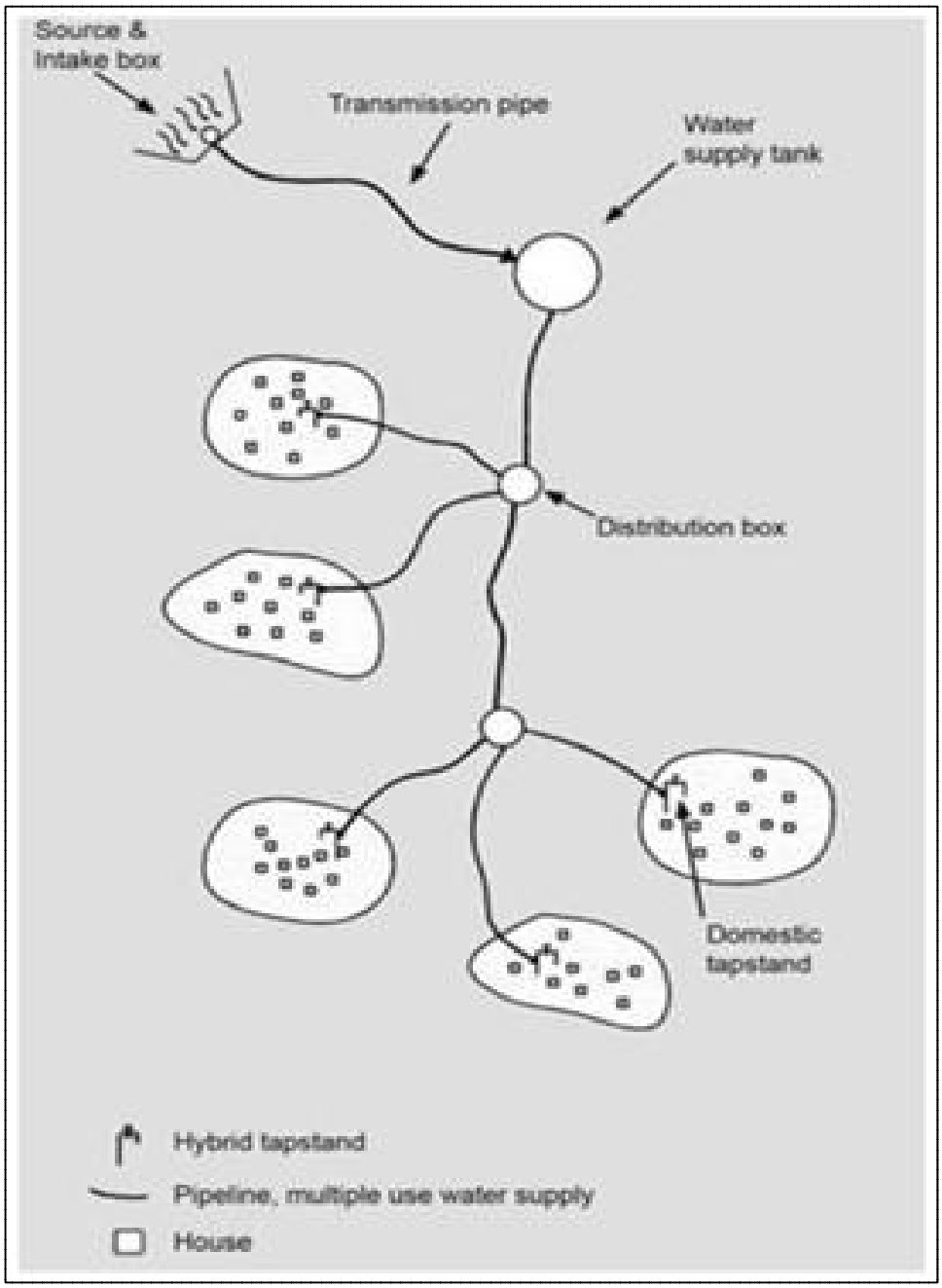

Fig. 2.3. Single tank one line distribution system

Source: (Michael and Yoder 2008, p 35; IDE n.d.)

In case of double system, water from the source initially filled up the drinking water tank usually modified thai jar. Only after filling up the drinking tank (Modified thai jar), water overflows to a soil cement lined reservoir of usually 6000 to 10000 litre capacity for irrigation. Such reservoir is constructed below the land surface (Mikhail and Yoder 2008). There are different distribution lines for the drinking water pipeline and irrigation water as shown in Fig. 2.2 and 2.4.

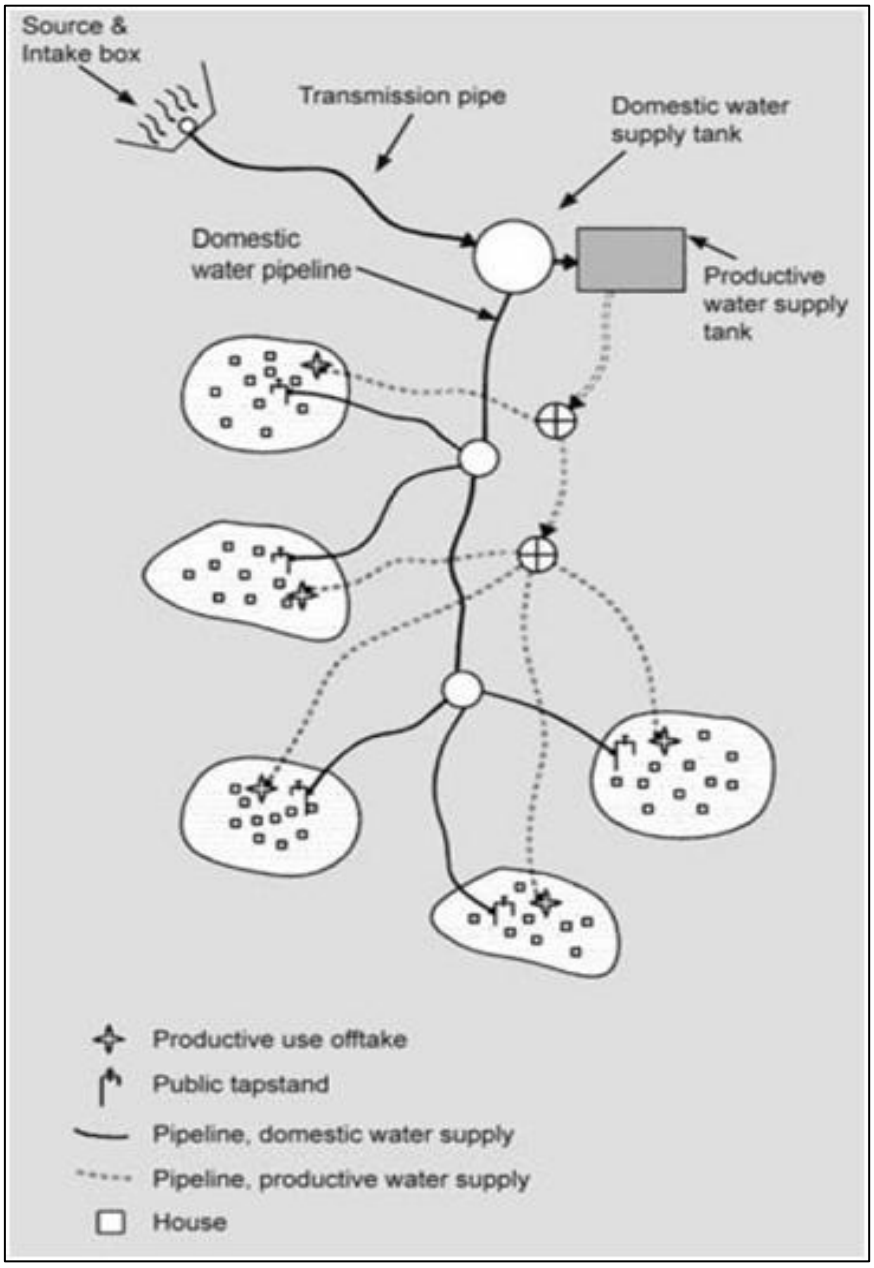

Fig. 2.4. Double tank two line distribution system

Source: (Mikhail and Yoder 2008, p 35; IDE n.d.)

2.2.5 MUS projects implementation

Up to 2008, there are 81 MUS projects being implemented in Nepal. Table 2.1 shows the MUS projects in Nepal by year.

Table 2.1 Breakdown of MUS project in Nepal till 2008

Year of implementation	Implementation organisation	Districts of promotion	Year wise number of projects
2003-04	IDE Dutch grant, SIMI	Palpa, Syanja, Surkhet,	14
2004-05	SIMI	Syanja, Palpa, Surkhet, Kaski	9
2005-06	SIMI, BDS Maps, Ujjyalo	Syanja, Palpa, Surkhet, Kaski, Lalitpur, Gulmi, Agrakhachi, Lamjung, Salyan, Pyuthan, Doti, Dadheldhura	29
2006-07	SIMI, BDS MAPS, LEMI	Syanja, Palpa, Surkhet, Kaski, Lalitpur, Dhading, Makwanpur, Kavre. Udaypur	16
2007-08	SIMI, RPI	Syanja, Palpa, Surkhet, Kaski, Lalitpur, Dadheldhura	13

Source: (Adapted from Mikhail and Yoder 2008)

For efficient use of water resources, the project also promoted small scale drip irrigation system along with hybrid seeds and high value crops for agricultural production. This not only saves water, but also decreases work load of farmers and enhances productivity in the farmland. Besides hardware construction, the project provided many software programmes on efficient water use, high value crops, hybrid seeds, off seasonal vegetable production and other health and sanitation issues. This showed rapid change in the project area and became a motivating factor to promote the MUS approach among farmers (Mikhail and Yoder 2008). With a success of MUS in the place, it was then promoted in partnership with different other NGOs: BDS-MAPS (Business Development Series-Marketing and Production Services, Ujjyalo and LEMI.

CHAPTER 3 BENEFIT COST ANALYSIS LITERATURES

3.1 Benefit cost analysis

Benefit cost analysis is an evaluation and decision making tool which uses set of procedures to define, compare and analyse cost and benefits of any intervention. It is a set of procedures which define and compare costs and benefits. It is also termed as Cost benefit analysis (CBA). There are 3 types of CBA which are Ex ante CBA, Ex post CBA and in medias res and Ex Ante/Ex Post. Ex ante CBA is done before any project or intervention, which assists in the decision about any program, policy, project or regulation. Ex post analysis is done at the end of the project to measure its effectiveness in terms of cost and benefit, which helps in learning actual value of the specific project and its use in further intervention in similar type of projects. In medias res analysis is conducted during the project lifetime (Boardman *et al.* 1996).

There are different ways of doing financial analysis via BCA including Net Present Value, benefit cost ratio, internal rate of return and the payback period. The formulae of NPV, BCR_n, BCR_d and payback period are taken from Zerby and Dively (1994).

Net Present Value: It is a widely used method in financial analysis. The NPV of a project is calculated by summing up its discounted cash flows. If the NPV is greater than zero, then the project will enhances the real wealth and hence is accepted. The NPV can be calculated using the following formulae (Zerby and Dively 1994.

$$\text{NPV}= \sum_{t=0}^{n} \frac{B_t}{(1+r_t)^t} - \frac{C_t}{(1+r_t)^t}$$

where, B_t = benefit derived from the project in period t

C_t = the cost of the project in period t

n= lifespan of the project

r = effective interest rate for period t (discount rate)

Benefit Cost Ratio (BCR)

It provides relationship between the cost and benefits of a project which helps in deciding whether the project is a good investment or not. There are 3 kinds of BCR. The undiscounted BCR is a ratio

of total benefit and the total cost of the project, without using any discounting rate and is not widely used method.

$$BCR_U = \sum_{t=0}^{n} \frac{B_t}{C_t}$$

Discounted BCR is the ratio of the total benefit and the total cost using discount rate and is widely applied in the project decision making process.

$$BCR_d = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r_t)}}{\sum_{t=0}^{n} \frac{C_t}{(1+r_t)}}$$

The net BCR is a ratio of the discounted net benefits and costs expressed in percentage, which is calculated as:

$$BCR_d = \frac{NPV}{\sum_{t=0}^{n} \frac{C_t}{(1+r_t)^t}} * 100\%$$

The net BCR shows the increased percentage in real wealth generated by the project. Any project with the BCR greater than one is beneficial and accepted (Broadman *et al.* 1996; (Zerby and Dively 1994)

.

Payback period

It is defined as the time required for a project to recover or pay off its total investment. This information helps for making decision of the project (Zerby and Dively 1994). It is mostly used in energy conservation analyses. It is calculated by using the formulae below:

$$\text{Payback period} = \sum_{t=0}^{p} \frac{X_t}{(1+r_t)^t}$$

where X_t is the cash flows in period t, Xt is cost if negative and benefit if it is positive P= payback period.

In the simplest form, it can be calculated as

Payback period = Initial cost of investment/Annual net cash flow

Internal Rate of Return (IRR)

It is the most popular techniques in BCA. It is the discount rate for which a projects benefit equals its cost and also known as "Break-even" point. The NPV value of a project is zero at this point. It is calculated by computing break-even rate of return, the discount rate at which the value of cash outflow equals the value of cash inflows. There are different methods of calculating IRR, one of which is Trial and Error Method (VBM 2008). For this, discount rate and cash inflow and outflow are necessary. In this method, the difference between the NPV and original cost is determined and based on the data obtained; IRR for lower discount rate is calculated. If the discounted rate gave positive NPV, higher discounted value was tried till it gets zero or negative value. When the NPV value was negative at a certain discount rate, the discounted rate values between the ones resulting positive and negative NPV values were used to calculate the IRR (VBM 2008). The formula used is:

$$IRR = Lower\ rate + \frac{NPV\ at\ lower\ rate}{NPV\ at\ lower\ rate\ -\ NPV\ at\ higher\ rate} * (Higher\ rate\ -\ Lower\ rate)$$

3.2 Benefit and cost analysis of MUS approach from the literatures

Renwick *et al.* (2007) conducted a research on MUS in terms of assessing its relative cost, benefits and poverty impacts over SU approach and evaluating its potential market on South Asia and Sub-Saharan Africa. The study analysed cost and benefit of new domestic + MUS and upgraded existing domestic and irrigation services with different level of water services as shown in Fig. . The study emphasized that MUS service though has higher cost over SU services; it generates greater income and reduces poverty level of people.

For a new domestic + MUS, the intermediate MUS level optimised benefits over the cost. The repayment period is also found to be 6-30 months. A detail calculation is shown in Table 3.1.

Table 3.1 Incremental costs and benefits, repayment periods and BCR of new MUS

Water Service Level	Technology	Capital investment costs (hardware plus software)	Annual income net of recurrent costs	Repayment period (months)	Benefit-cost ratio (10% discount rate)
Level 1: Basic domestic	**Range**	**$63-$91**	**($9-$13)**		**(negative)**
	Piped systems, dispersed standpipes	$70	($12)		
	Shallow wells w/ hand pumps	$63	($9)		
	Boreholes w/ hand pumps	$91	($13)		
Level 2: Basic multiple uses	**Range**	**$98-$116**	**$8-$9**	**147-155**	**.66-69**
	Piped systems, some standpipes	$98	$8	147	.69
	Boreholes w/ hand pumps & add-ons	$116	$9	155	.66
Level 3: Intermediate multiple use	**Range**	**$56-$105**	**$42-$51**	**13-30**	**3.4-7.8**
	Piped systems, frequent standpipes	$105	$42	30	3.4
	Piped gravity-fed spring systems	$56	$51	13	7.8
	Hand-dug household wells: protecting & adding improved lifting devices	$102	$47	24	3.4
Level 4: Highest multiple uses	**Piped schemes, household connections**	**$140**	**$21**	**80**	**1.28**

Source: (Renwick *et al.* 2007)

Upgraded existing system analysis was also conducted for 3 water systems; pipe systems, communal boreholes with hand pumps and household hand dug wells shown in Table 3.2. For the first and third options, the benefit cost ratio was found at the intermediate MUS level whereas for the communal boreholes, it was found at basic MUS level. The repayment period for intermediate level is found to be 7-22 months which also depend on the situation and condition of the location (Renwick *et al.* 2007).

Table 3.2 Incremental costs and benefits, repayment periods and BCR of upgraded MUS

Water Service Level Upgrade	Technology	Capital Investment costs (hardware plus software)	Annual income net of recurrent costs	Repayment period (months)	Benefit-cost ratio (10% discount rate)
		per capita			
Level 1 to Level 2: basic domestic to basic multiple uses	Boreholes w/ hand pumps: in-situ add-ons to support livestock, bathing and community gardens	$25	$22	12	**5.4**
Level 1 to Level 3: basic domestic to intermediate multiple uses	**Range**	**$32-$84**	**$46-$58**	**7-22**	**4.7-8.6**
	Piped systems: increasing quantity and density of standpipes, adding some yard taps	$84	$46	22	4.7
	Hand-dug protected household wells: add improved lifting devices to increase quantity - treadle pump	$32	$58	7	8.6
	- rope pump	$56	$54	13	6.1
Level 2 to Level 3: basic multiple uses to intermediate multiple uses	Piped systems, increasing quantity and adding standpipes & yard taps to expand productive activities	$56	$26	25	3.9

Source: (Renwick *et al.* 2007)

CHAPTER 4 METHODS AND METHODOLOGY OF THE STUDY

4.1 Methods for data collection

This research was based on review of the existing literature for secondary information and household's interviews, site observation, visiting organizations and expert consultations for primary information.

4.1.1 Secondary information review

Available literature in the form of research reports, journals, books, conference proceedings, unpublished materials have been reviewed to extract information related to water supply systems especially focused on MUS approach. Basically information reviewed on the concept of MUS approach, its technology type, its benefits, its various cases of design and implementation from different parts of the world and its cost benefit analysis study were utilised to plan the research as well as to support the result of the research.

4.1.2 Visiting organisations and expert consultations

The organizations promoting MUS approaches were consulted before the field visit was made. The major key informant for the study was IDE Nepal. There were only a few organizations promoting MUS approach in Nepal. Concern Worldwide Nepal (CWN) has just started the MUS concept as "Domestic PLUS" from 2009 as their demonstration projects. It has been implementing four water supply schemes as "Domestic PLUS". There are very few projects on MUS from the governmental sector, Department of Local Infrastructure Development and Agriculture Roads (DoLIDAR). Similarly District Development Committee (DDC) of Syanja is now also starting MUS approach as a large scale governmental project from 2010. Hence the organizations promoting MUS approach in Nepal are

- International Development Enterprizes (IDE) Nepal
- Concern Worldwide Nepal (CWN)
- Department of Local Infrastructure Development and Agriculture Roads (DoLIDAR), environmental section
- District Development Committee (DDC) of Syanja.

While visiting those organizations, a key person responsible for MUS promotion was consulted. The consultation was a formal interview based on the questionnaire, which is given in Appendix 3. The expert consultations basically provided information on MUS initiation process in Nepal, its detailed cost including capital, operation and maintenance cost, software cost, its general benefit and its prospects and challenges for scaling up in Nepal and elsewhere.

4.1.3 Household interviews and site observations

Structured questionnaire for household interviews was prepared to collect primary information on demography, cost, benefit and impact of the project from selected households of the sites. The field study including visiting organizations, expert consultation, household interviews and site observations was conducted from 10th February 2010 till the 19th March 2010. A questionnaire used for household interviews is attached in Appendix 2.

The information on household demography, cost and productive benefit of the projects were utilised to determine Net Present Value (NPV), Benefit Cost Ratio (BCR) and payback period of the MUS . This contributed assessing the cost effectiveness of the project, which is a prime objective of the study. The other information on time saving, health improvement, women empowerment and other impacts of the MUS projects were analysed to assess the MUS approach in terms of poverty reduction which are the other specific objectives of the study.

Besides household interviews in the field, MUS design and its impact in the villages were also observed to verify the information provided by the interviewees, organisations and the experts.

4.2 Methods for selecting districts and households for a field work

The districts and the MUS schemes for household survey were selected by consulting IDE Nepal, a major MUS promoter in Nepal. The selected sites were from Lalitpur district of Central developmental region and Syanja and Kaski districts from western Development Region, which is shown in Fig. 4.1.

The district and the schemes selection criteria adopted following principle:

1. Nepal from development perspective is divided into five development regions elongated along east to west (Eastern Development Region, Central Development Region, Western development, Mid

Western Development Region and Far Western Development Region. Districts were purposively selected from Central and Western Development regions as it comprises major market hobs and many implemented MUS programmes from agencies are centred around these regions.

2. While selecting district and schemes due consideration was given to length of the project. MUS is relatively new intervention to Nepal as such purposively it is maintained to have sample schemes spread across five years (base year 2003 as old project to current year 2009 as new project)

3. Consideration was also attached on time limit of three weeks visit and risk managing of uncertainty of Nepal *bandh* and closures due to political events

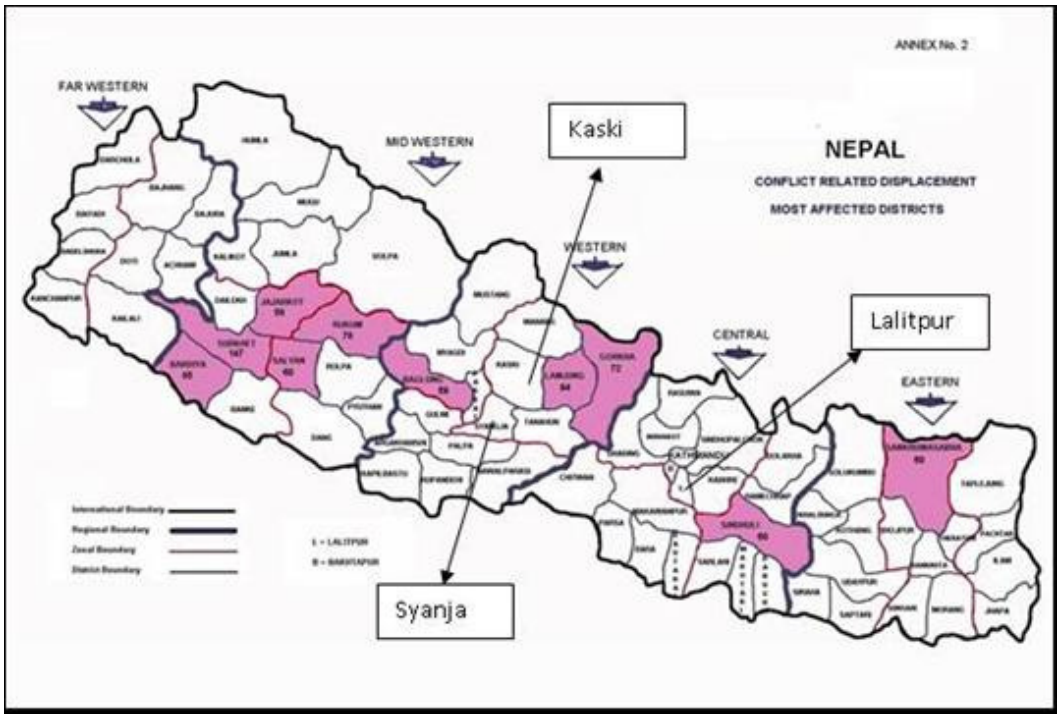

Fig. 4.1. A map of Nepal showing districts selected for the field visits
Source: (Adapted from USAID 2002)

Three MUS schemes in Kaski, two in Lalitpur and Syanja were visited for household interviews and field observations. In total seven MUS schemes were visited during the field work. However, detailed household interviews were conducted in five MUS schemes. In case of two schemes, one from Kaski and another from Syanja, information was extracted by conducting informal discussion

with key informants of that village, as those schemes are having problem due to the fact of drying up of the source this year. Information on their current situation, problems, and challenges were collected from those two schemes. The list of schemes visited is given in Table 4.1.

Table 4.1 MUS schemes visited during field works

S.No	Name of the scheme	District	VDC and ward No	Remarks
1	Salyan MUS	Lalitpur	Chapagaun-9	Household interview, site observation
2	Armala MUS	Kaski	Armala	Household interview, site observation
3	Dharapani MUS	Kaski	Dharapani-6	Household interview, site observation
4	Malewasbasne MUS	Syanja	Walling-7	Household interview, site observation
5	Saurabhanjyan MUS	Lalitpur	Lele-9	Household interview, site observation
6	Ganeshpur MUS	Syanja	Putalibazar municipality-6	Informal discussion with a key informant and site observation
7	Odare MUS	Kaski	Lekhnath Municipality	Informal discussion with a key informant and site observation

4.3 Sampling method for selecting households for interviews

4.3.1 Determining total sample size

The sampling size was determined using Z-value at 95% confidence level, Coefficient of Variation in % (COV) and Degree of detection Error in %. The different sampling size was calculated using 95% confidence level, 5% degree of detection error with 10 to 20 % coefficient of variation, which is given in Table 4.2. Initially, the sample size chosen was 61, taking 20 % as COV. Later on the field survey showed repetition of information, thus later changed the sample size to 50.

The sampling size is calculated using the formulae (McClave and Sincich 2003) below:

$$N = \frac{Z^2 pq}{d^2}$$

Where ,

Z = Z value at 95% confidence level

Pq= Coefficient of Variance in percentage.

d = Degree of detection error in percentage

Table 4.2 Calculation of sample size with different COV

Z-value at 95% confidence level	1.96	1.96	**1.96**	1.96
Coefficient of variation in %	10	15	**18**	20
Degree of detection error in %	5	5	**5**	5
Sample size	15	35	**50**	61

4.3.2 Determining household's sample size for each scheme

Proportionate allocation method was used to determine scheme wise household sample size. It was calculated by using a formula as below:

Scheme wise sample size= (Total number of household in the scheme/ Number of household from all the selected schemes in total)* Total Sampling size(N).

*For example: Sample size taken for Salyan MUS= (47/182)*50 = 12.9 =13*

Similarly the calculation was done for the other scheme.

4.3.3 Determining households for the interviews

Systematic Random sampling system was used for selecting household of the area. Systematic Random sampling is the process of selecting every n^{th} number of the households arranged in a list using sampling interval. In this type of sampling, all the households are initially listed in a sequential number. The first sample in this method is selected randomly and the remaining samples are taken in a calculated sample interval.

A sampling interval is calculated using a formula (McClave and Sincich 2003)

Sampling interval= (Total Number of household in a given scheme)/ (Sample size need to be taken for that scheme)

For example ,

Sampling Interval for Salyan MUS = 47/13= 3.6 = 4

Sampling interval was calculated for each scheme and households were selected accordingly.

4.4 Data analysis and interpretation

The quantitative data obtained from the household interview was tabulated in excel sheet for analyzing and interpreting the results. For the qualitative data personal judgment, expert comments, literatures and results of key informants' interview were used as a basis for its analysis and interpretation. After analysis the data have been compared with the available literatures for discussion.

4.4.1 Analysis of cost effectiveness of the MUS projects

The following steps were followed for analysing benefit cost analysis of the MUS scheme

Assessment of the type of MUS: It was assessed whether the MUS promoted is

a. Single tank one line system (Domestic + MUS by design)

b. Double tank two line system (Domestic + MUS by design)

c. Upgraded Domestic MUS

Determination of the income generation from productive uses of the system

- The information on income generation was collected from the household interviews. The household interviews provided their last year's (2009) income via vegetable farming as their productive uses of water. Information on their own annual vegetable consumption was also determined from the interviews. Thus Gross Annual Income was calculated by adding up annual income from vegetable selling and cash equivalent to their own vegetable consumption.
- Since the income from the vegetables depends on the size of the farm, the Gross Annual Income per *ropani* (1 *ropani* = 508.6 square meter) was estimated. Outliers, which are values below and above 3σ normal distance are identified and not considered to have the values normalized.
- The total annual income from vegetable farming for the current year (2009) was then estimated multiplying Gross Annual Income per *ropani* and the total farm available for vegetable farming.

- The total annual income values were reported based on the fiscal year 2009, while project costs are available at the project initiation year. To make Fig.s comparable, the total income values of the base year were calculated using a discount rate as given by National Urban Consumer Price Index (NUCPI) from Central Development Bank (CDB) of Nepal,
- The other benefits like time saving and health benefits were not included in the benefit cost analysis of the MUS project as the saved time here has been ultimately used for the productive activities.

Determination of the total cost of the MUS project

- The total cost of the MUS project was collected from IDE Nepal.
- In general any water supply scheme involves the following three types of costs
    - Capital Cost: This includes the expenses involved in the construction of the system from its design phase. The cost consists of all the hardware construction cost including land.
    - Operation and Maintenance cost: This includes annual and recurrent operation costs like caretaker salary, source maintenance etc for a smooth operation of the system. Similarly the expenses for minor or major maintenance of the system are also included in this category. In the case of MUS, the annual expenditure for vegetable farming was also estimated considering labour, seed, fertilizer, pesticide costs, since these are the operational cost to get the benefit from it.
    - Software cost: This includes partner support cost, trainings, demonstrations, meetings, farmer exchange visits etc.
- Hence the total cost of the MUS project was determined using capital, operation and maintenance and software cost. The information of the cost was provided by IDE Nepal.

The amount obtained for the both income benefit and cost were in Nepalese rupees (NRs) which was later converted to US dollar (US $) with a conversion rate of NRs 75 per 1 US $.

Calculation of Net Present Value (NPV), Discounted Benefit Cost ration (BCR_d), Net Benefit Cost ration (BCR_n) , Internal Rate of Return (IRR) and Payback period of the MUS schemes using formulae below:

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+r_t)^t} - \frac{C_t}{(1+r_t)^t} \quad \text{(Zerby and Dively 1994)}$$

$$BCR_d = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r_t)}}{\sum_{t=0}^{n} \frac{C_t}{(1+r_t)}} \quad \text{(Zerby and Dively 1994)}$$

$$BCR_n = \frac{\frac{NPV}{\sum_{t=0}^{n} \frac{C_t}{(1+r_t)^t}}}{} * 100\% \quad \text{(Zerby and Dively 1994)}$$

where, B_t = benefit derived from the project in period t

C_t = the cost of the project in period t

n= lifespan of the project = 10 years

r = effective interest rate for period t (discount rate) = 10%

$$\text{Pay back period} = \frac{Total\ cost}{Total annual benefit} \quad \text{((Zerby and Dively 1994))}$$

$$IRR = Lower\ rate + \frac{NPV\ at\ lower\ rate}{NPV\ at\ lower\ rate\ -\ NPV\ at\ higher\ rate} * (Higher\ rate\ -\ Lower\ rate)$$

(VBM 2008)

4.4.2 Poverty impact analysis

The poverty impact was assessed using the primary information collected during household interviews. The poverty assessment included analysis of various benefits of MUS like diversified livelihood, food security; health and nutrition, time saving, social equity which helps enhance the living standard of the users. The assessment was supported with different case studies on voices of the Poor. Also, permission was granted from the interviewees to take and publish their pictures and case studies.

CHAPTER 5 -RESULT AND DISCUSSION

5.1 Description of the technology and design of the MUS in the study areas

In general, there are two types of technology; double tank double distribution line system and single tank single distribution line system, which is explained in Section 2.3.4. The scheme can also be an upgraded MUS or a new MUS by design. An upgraded MUS is upgrading of the existing drinking water supply scheme by adding up the water quantity required for productive uses. A new MUS by design is a system constructed for both domestic and productive water uses from a start point. Despite different designs and technologies, all of the schemes have a common goal of providing income generation from the productive uses of water on top of domestic water supply.

The present study was conducted in one upgraded MUS and the remaining in a new MUS design. Similarly, all the studied schemes are of double tank double distribution line system except the one at Dharapani. The technology and design type of the MUS in the study areas are given in Table 5.1. Altogether 50 households were selected and interviewed from the following five schemes to fulfil the objectives of the study.

Table 5.1 Technology and design type of the study schemes

S.No	Name of the scheme	Design	Technology	Water supply system
1	Salyan MUS	New MUS by design	Double tank double distribution line system	Gravity flow water supply system
2	Armala MUS	New MUS by design	Double tank double distribution line system	
3	Dharapani MUS	New MUS by design	Single tank single distribution line system	
4	Malewasbasne MUS	Upgraded MUS	Double tank double distribution line system	
5	Saurabhanjyan MUS	New MUS by design	Double tank double distribution line system	

5.2 Poverty impact analysis

5.2.1 Occupation of the studied households

Agriculture is the major occupation in all the study areas. Out of 50 households surveyed, 39 households depend only on agriculture for their subsistence, 6 households have daily waged work, 3 households have an additional service and the remaining two have other unspecified work in addition to agriculture. The household occupation category in the studied households is shown in Fig. 5.1.

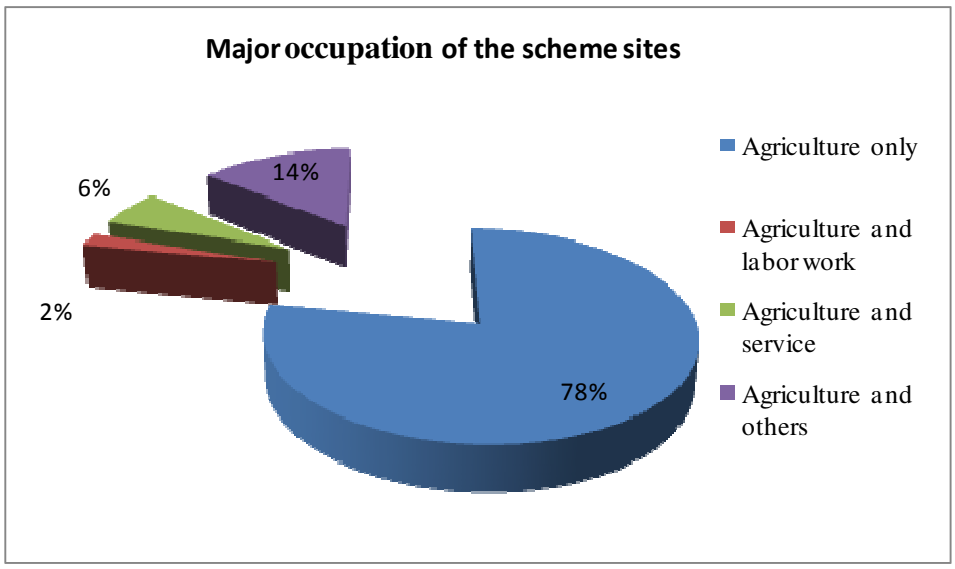

Fig. 5.1. Major occupation of the study areas

5.2.2 Uses of water from MUS

The MUS users mainly use water for doing household chores, sanitation, irrigation of their homestead garden and making bricks for their own use. Out of 50 households surveyed, 35 households utilize the MUS water for vegetable production in their homestead garden besides domestic activities and sanitation. Similarly, three households use it only for irrigation and the two uses for making bricks to construct their new house, which is shown in Fig. 5.2. The interviews showed that water required for domestic activities ranges from 20 to 200 litres per day, depending on family size and number of livestocks. In case of irrigation water, drip irrigation with pipe is applied for irrigating their garden. Hence the respondents could not give the exact amount of water they use from the MUS for their vegetable production. But they said that the water from the MUS is enough only for 1 *ropani* (508.74 square meter) of land in dry seasons, when water flow is low.

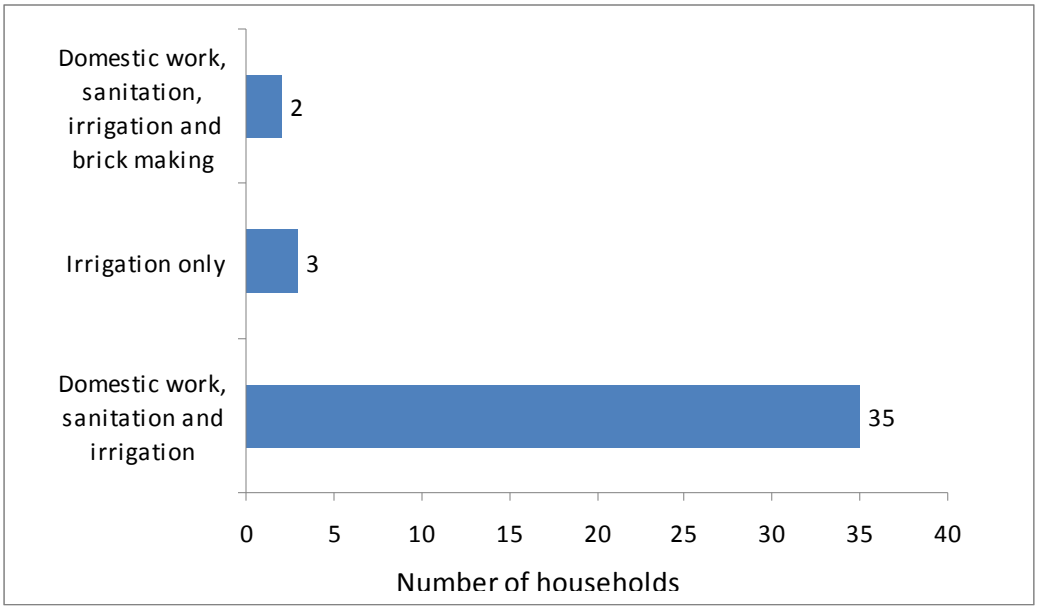

Fig. 5.2 Water usage from the MUS

5.2.3 Time saving in fetching water

From the household interviews, it was found that most of the households in the MUS sites did not have accessible water even for drinking purposes before the MUS. None of the households used to fetch water for irrigating their homestead garden except one. In most of the families, female members were responsible for fetching water from a distance source. The time required for water collection ranged from 5 to 60 minutes per trip depending on the distance and the geographical features of the area. The average time for water collection was 25 minutes per trip. The water required for domestic usage was not enough if they made one trip. The households were found to take 3 to 13 trips per day, spending 1 to 8 hours to fulfil their household water needs. The number of trips of each household depends upon family size and number of livestock. Thus, female members in a family were engaged in fetching water almost the whole day. The time spent in fetching water per day before the MUS is shown in Fig. 5.3.

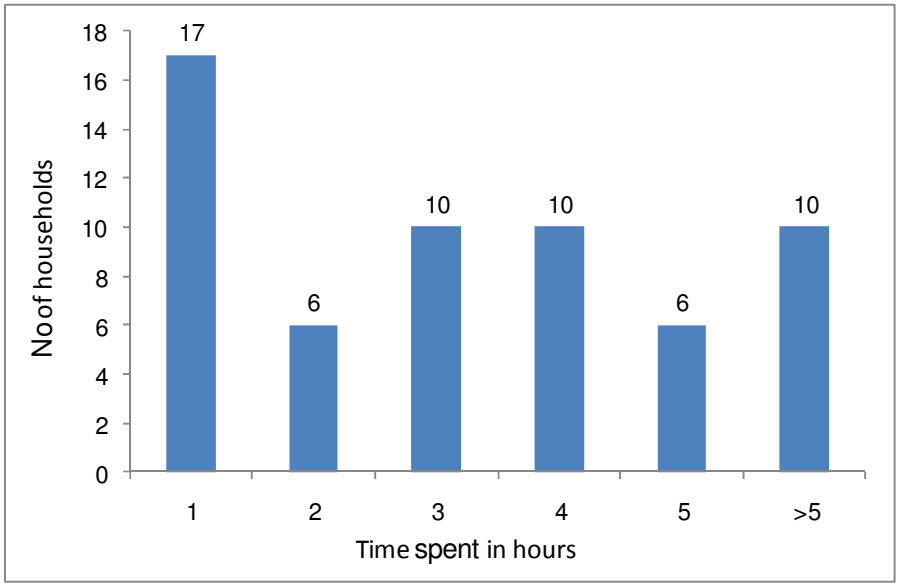

Fig. 5.3 Time spent in fetching water per day prior to the MUS

However after the MUS, all the households get water access within a distance of 5 minutes, which helps significantly in saving time, especially of female members. The time spent in fetching water per trip before and after the MUS is given in Table 5.2.

Table 5.2 Time spent in fetching water per trip before and after the MUS

S.No	Time spent per trip	No of households	
		Before	Now
1	1-5 minutes	0	47
2	5-15 minutes	20	0
3	15-30 minutes	23	0
4	30-45 minutes	0	0
5	45-60 minutes	4	0

The time saved as a result of fetching water is used doing productive activities like vegetable farming, other small businesses, household chores, taking care of their children, taking a rest, attending entertaining programmes, trainings and meetings. World Health Organization also estimates a total gain of 5.6 billion working days and 443 million schooldays as a result of time savings and reduced sickness with a universal access to safe water and sanitation (Redhouse *et al.* n.d)

Case Study 5.1

"I would not have been talking to you like this if I had to fetch water like before"

Shanti Nepali of Dharapani VDC

Shanti Nepali, female, around 45, of Dharapani Village Development Committee (VDC), Kaski district, is a mother of three daughters and one son. She used to spend around 3-4 hours every morning and evening just fetching water for household chores. Just after fetching water, she had to prepare food for her family. In the day time, she had to look after livestocks and do cleaning. She did not even have time to take care of her children. Neither did she have time for herself. But after the MUS, she felt changes in her life. She said, "I now don't have to wake up so early to fetch water as I now have water access in front of my house. Fetching water used to be my responsibility only. Now, every member in my family fetches water as it is very easy and near the house. I now have time to take care of my children. I can help them taking a bath and washing their clothes. Also I have time for myself. I can take a rest if I get tired. To tell you the truth, I would not have been talking to you like this if I had to fetch water like before. I now have time to attend trainings, meetings held in the village. It helps me develop my personality and communication skills."

5.2.4 Food Security and improvement in household nutrition

Nutrition level and lack of food security are indicators of poverty. The Poverty Reduction Strategy Paper (PRSP) of Nepal has focused on the targets of food security and improvement in nutrition level to reduce poverty in the country (NPC 2005; IMF 2007). These targets are equally crucial to achieve Nepal's targets of Millennium Development Goals (MDGs).

With access to productive uses of water, all the surveyed households have started vegetable farming in their homestead gardens as an income generating activity. They have started both seasonal and off seasonal vegetable farming using drip irrigation and hybrid seed. Such drip irrigation helps conserving water and hybrid seeds help in increasing the production. The vegetable production in their own homestead garden helps the poor save the money required to buy vegetables for their own consumption. Besides household consumption, they also sell their vegetable products to the vegetable collection centre, which is operated along with MUS project. This may be the best option for raising the income level of the poor and ensuring food security and improvement in household nutrition.

Prior to the MUS and its training on income generating activities, the same farmers (now the MUS users) used to cultivate and grow only less water consuming crops like maize, millet, mustard etc and a few seasonal vegetables during the rainy season. They also had to keep their land barren for two to three months due to lack of irrigation water. They had only one to two seasonal crops per year prior to the MUS. All the respondents reported that the production before was not enough even for their own consumption. They had to buy vegetables for their daily consumption and only few households could afford vegetables in their meals.

But after the MUS, a significant change in the crop pattern was found in all the surveyed villages. They now have three to four seasons' cultivation per year, focusing on vegetable production rather than cereal crops. They have started growing seasonal and off seasonal vegetables, which raised their economic level. From the survey it was found that 38 households out of 50 used to buy vegetables occasionally, only two their households used to sell products and 12 households did not consume any vegetables at all, prior to the MUS. But later with implementation of the MUS, the users started doing vegetable production. So all the households have sufficient vegetable production for own consumption and hence are saving money. The number of households selling vegetables

increases from two to forty after the MUS. Now, there is no household which does not consume fresh vegetables for their meal. The result is illustrated in Fig. 5.4.

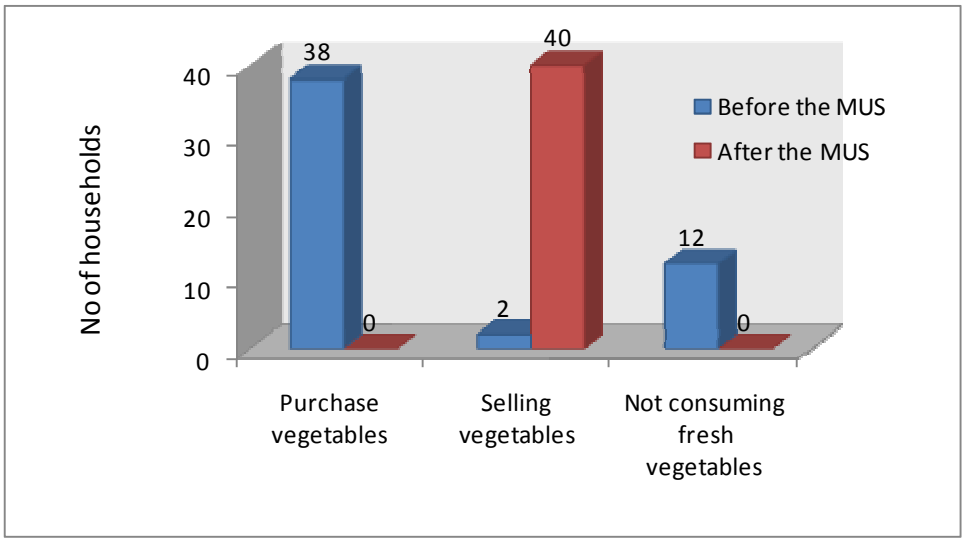

Fig. 5.4 Vegetables consumption, purchase and sell before and after the MUS

The change is also found in the food habits of the users. They regard that they were not used to eating fresh vegetables normally in their meal and were dependent mostly on *gundruk*, fermented and dried vegetables and maize. The social mobilizers of the area reported many children suffering from mal nutrition in those areas due to poor nutrition and minerals. But after vegetable cultivation, all the users consume fresh vegetables from their own gardens. This has contributed to improving their nutrition level.

Case Study 5.2

"I am feeling more healthy and fresh after consuming lots of fresh vegetables, and so is my family."

Moti Lal Poudyal of Tori danda

Mr. Moti Lal Poudyal, male, 50, a resident of Tori danda of Syanja said "I didn't know that we have to eat fresh vegetables daily. I thought that fresh vegetables are only for the rainy season when we have our own production. I never bought vegetables from the market. Even if I saw vegetables sold in the market, I did not have money to buy them. Our family used to consume gundruk and maize as a heavy meal most of the times". He then happily explained how his family's food habits changed after the MUS. His wife added that the condition has changed now. She continued, "We now cannot eat our meal without fresh vegetables, grown in our own homestead garden. I am feeling more healthy and fresh after consuming lots of fresh vegetables, and so is my family."

5.2.5 Improved income level and living standards of the users

The improvement of the income level and living standards of the poor are well supported by the survey data. There are many cases verifying this statement. Entire households in the surveyed areas depend on agriculture. However, they had not started doing agricultural production as their income generating activity till the MUS was introduced. They were growing food only for their own household consumption. After the MUS and extensive trainings on vegetable farming, almost all households started vegetable farming as their income generating activity. This vegetable farming hence is an additional source of income in their family. The average annual household income from vegetable farming is shown in Fig. 5.5

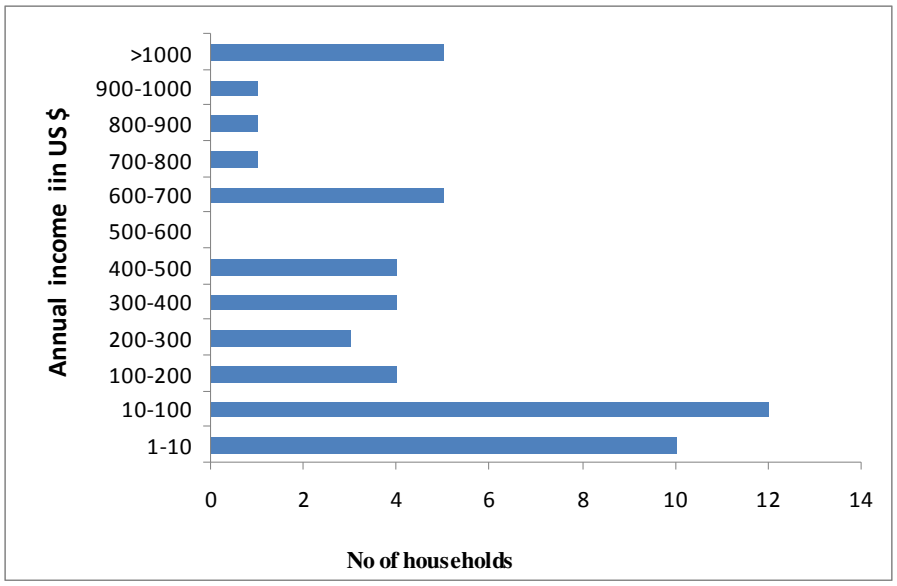

Fig. 5.5 Household level annual income from vegetable farming

Out of 50 households surveyed, 10 households do vegetable farming just for self consumption rather than for a profit. However 40 households involve vegetable farming as their income generating source. Their household level income ranges from 11 to 2000 US $ per year, which depends on the land size they have for vegetable production and the family size. The larger the family, the more vegetables are for their own consumption and the lesser the products sold.

They invest their additional income mainly in their children's education. Around 70% of the households admitted that the vegetable farming helps them to support their children education. Similarly, around 50% of households reported taking a loan to survive before starting the vegetable

business. However these days, they do not have to take any loan. Instead they are saving at least 2-10 US$ a month in their saving and credit group. Many respondents also mentioned adding up luxury items like television, radio and other household accessories, which indicates their enhancement in living condition. Out of total respondent, two households from Salyan VDC of Lalitpur and one household from Tori danda are building their house and they considered that vegetable farming has helped them to a certain extent to save money for building the house.

Case Study 5.3

An inspiring story of a woman whose husband is abroad

Durga Paudyal of Tori danda

Durga Paudyal, 40, female of Tori danda, Kaski district said, "I had to depend on my husband for my living and children's education. My husband is working abroad and I had to wait for my husband's money to do anything. But now, after doing vegetable farming, I, myself, am earning a certain amount of money for my family. I am also using the money that I earn for my son's tuition fee. Last year, my daughter got married and I didn't have to buy any vegetables for a feast. This covered a large amount of expenses of wedding. Till now, I have saved around US $ 400 to invest in making my new house and the rest needed to complete the house will be sent by my husband.

Case Study 5.4

"Woman involved in handicraft besides vegetable production"

Asta Maya and his husband making a doko

Asta Maya Nagarkoti, 55, female of Salyan Village Development Committee (VDC), Lalitpur, used to spend her whole day in fetching water, 30 minutes down the hill. She did not have time to do any other work which would help her family to raise the income directly. But now she said that, "I have a tap-stand just two minutes away from my house. I don't have to think about fetching water anymore. Now I also get water from the MUS for irrigating my homestead garden. Before, I used only kitchen waste water to grow a few seasonal crops in my garden. But now I am growing different seasonal and off seasonal vegetables and my family is now earning around 200 US$ a year from the vegetables. We also don't have to buy any vegetables for our meal. This helps saving our money. Besides vegetable farming, my family has been engaged in making handicraft from bamboo (*doko*) for a long time and selling it locally. Now I also help my family in making the handicraft. The MUS scheme helped a lot in raising my family income level". She added proudly, "I should admit that I had already paid back my loan that I took before the MUS and I also sent my son abroad without taking any loan.

Case Study 5.5

"Vegetable farming and brick making help me construct my new house"

"This year I am going to construct my new house", said Mr Kancha Bahadur Tamang happily. Mr. Kancha Bahadur Tamang is a hardworking and dedicated farmer and has been in the business of vegetable faming for long. But he didn't get such high profit from vegetable production before as he is getting now. Before the MUS, he along with his family members used to carry water from a domestic tap, 10 minutes walk up the hill, to irrigate his homestead garden where he used to grow vegetables for sale. He now has an off-take pipe for irrigating his land. He no more spends time in fetching water. On average, he generates an annual income up to 1427 US $. This year he has reduced his vegetable production because he wants to construct his new house. He is spending more time in making bricks using water from the MUS off-take tap, while his wife works in vegetable farming. He said that he will save around US $ 4000 as he does not have to buy any bricks for the construction of his house.

Mr and Mrs. Tamang showing their tap-stand

5.2.6 Improved in health and sanitation

According to the health motivators of the study areas, there has been an improvement in health and sanitation conditions after the MUS. The interviewees also reported changes in their health after having access to the MUS. In case of Salyan Village Development Committee (VDC), the users said that they used to have severe diarrhoea and jaundice cases among children. They reported a significant reduction of such water borne diseases in their area after the MUS. The users also considered that they now consume hygienic and healthy food along with fresh vegetables and clean drinking water which makes them healthier.

Out of 50 households surveyed, 47 households are using water from MUS even for their sanitation purposes, mainly for cleaning, taking a bath, washing clothes and using the toilet. The respondents before had to travel to a river or a main spring source to take a bath and wash their clothes. Hence, taking a bath and washing clothes were not frequent activities for them. But now having the MUS, they have sufficient water in their house for cleaning activities.

Case Study 5.6

"MUS helps in promoting clean and hygienic behaviour"

Mangala Biswakarma with her daughter

Mangala Biswakarma, 35, is from a low caste family. She is living with her husband and three children in Dharapani Village Development Committee (VDC) of Kaski district. She said that the sanitation condition of her household has improved significantly after having sufficient water access in front of her house as the MUS. She said that she had to go to a far away *kuwa* (spring water), 30 minutes away from her house, to wash clothes and take a bath. Before, due to the poor economical condition of the family, she also had to go for a whole day labour work. When she returned from work, it was almost dark and she was afraid to go to the kuwa to wash her family's clothes. She had to take a day off from work to wash clothes and she lost one- day payment. But now she felt very easy due to having water in front of her house. She happily added that she can wash clothes any time she wants. Now even after coming back from work, she has energy and resources to wash her family's clothes. She finally regarded that the MUS helps them practice clean and hygienic behaviour.

5.2.7 Women's empowerment

The MUS directly and indirectly supports empowering women of the study areas. Much evidence can be found in support of women empowerment. All the surveyed households regarded that the MUS programmes have helped women and socially backward people improve their life. All the women respondents reported an improvement in their communication skills and decision making status in the family. They told that they are invited for trainings, meetings, discussions etc, which makes them gain confidence in themselves and speaking up in the public. They also said that they now equally participate in household discussion and their thoughts are now considered by other family members.

Besides, women themselves are involved in vegetable production and selling activities after the MUS. The women in rural parts were not allowed to go outside the house and were limited to be involved in household chores like cooking, fetching water, cleaning, taking care of children etc. But now, women in the house are more involved in the vegetable business and they even go out to the market to sell their products. As a result, women themselves have cash in their own hands. They now do not have to depend on the male member of the family for money. They feel of empowered and proud mainly due to having cash in their hands. However they do expenses only after consulting their husband.

Women in Nepali society have a custom to put on red *tika* (a round shape red structure put on the forehead of married woman) and red glass bangle (*rato chura*) as a symbol of being married. It costs only 0.40 US $ for a dozen of such bangles and 0.05 US $ for a tika. All the women interviewed shared that they had to ask for the money even to buy such small things like tika and bangles. But now they have cash in their hands and can buy things they need. However, most of the women are found to spend their earnings in children's education, providing them with necessary materials for study.

Case Study 5.7

Self confidence of Dhan Kumari Gurung

Dhan Kumari Gurung and her husband in their homestead garden

Dhan Kumari Gurung, 50, female, from Armala VDC of Kaski district has found self development within herself after a year. She said, "I am now confident to speak with anyone. It am not the same woman as before, who used to hesitate talking with a stranger like you. I can feel change within myself. I can express my feelings freely and with confidence. I should be a woman to make change in my village now. I should be exemplary to all". She also mentioned, "My income has increased this year by doing vegetable production. I earned around US $ 667 within three months off seasonal tomatoes. I am happy to have such profit within a year of vegetable farming".

Case Study 5.8

Women key informant in the village

Hari Maya Tamang of Saurabhanjyan, a key informant of MUS

Hari Maya Tamang, female of around 40, has started her own shop after making profit from vegetable farming. She is one of the key informants on MUS in her village, Saurabhanjyan. She said that she did not have any decision making power in her family and her husband decided everything for the family. Her husband even did not allow her to go out of the house except for labour. She added that now her husband has changed and he now realises importance of the women empowerment for a development of the family. She said that her husband now encourages her to attend meetings, trainings and other outside activities besides the household chores, as the MUS has brought a change in their life. She said that she felt self confident and improvement in her family's living standard after the programme.

5.2.8 Summary of the poverty impact of the MUS

Poverty does not mean low income only. It can be characterized by other human development indexes, like hunger, mal- nutrition, lack of education and basic facilities like water, sanitation services, which is termed as multidimensional poverty (CPRC 2007). MUS thus is considered as one of the effective means for reducing both money metric as well as multi dimensional poverty in developing countries (Faal *et.al.* 2009; Koppen *et al.* 2009).

The current study also supports this statement. The MUS in the study area provides enough water for domestic and productive activities such as people has started vegetable production in their homestead garden, which sustains their life. The study shows that the MUS not only helps saving water fetching time especially of women, it also provides opportunity of small water based businesses like vegetable production for income generating activities for each household.

The study presents that the number of households who start selling vegetables and earning money increase significantly after the MUS. The users in the study area earn from 11 to 2000 US $ per family annually by the vegetable business. With this additional income generation, significant improvements in their lifestyle including food habits, sanitation, hygienic behaviour, women empowerment can be observed in those areas, which can be seen from the case studies presented beforehand. Renwick *et al.* (2007) also showed an improved year round productivity, food security, nutrition and subsistence benefits for the poor with improved water supply systems i.e. MUS in their study areas. The study provided different examples from different parts of the world to support its statement. It showed that the poorest households in Nicaragua receive the highest food security and nutrition benefits from the MUS. Robinson (2003) also showed increased income of the poor farmer in Zimbabwe from US $ 105 to 525 per annum after having productive water facilities in addition to domestic water.

However, in case of Nepal, local vegetable farming is the only option that has been promoted to the MUS users. There is a possibility of providing opportunities of producing and marketing exotic and export quality crops in addition to local vegetables as promoted in Zimbabwe, presented by Robinson (2003). This will enhance the motivation as well as income of the local farmers. Similarly there is a scope of livestocks promotion in those agricultural areas. This will further help providing

organic fertilizers for vegetable production along with other income and nutrition benefits. According to Renwick *et al.* (2007), the increased water quantity helps improving livestock's health, productivity and reducing morbidity rate and it enhances ability to fulfil food and protein needs of the poor. Hence livestocks can be an option for income generating activities in addition to vegetables.

5.2 Benefit cost analysis of the MUS

The benefit cost analysis of the MUS only considers a direct income from vegetable production. It excludes the other benefits like saved time, health improvement etc in the calculation. The calculation of the total income benefit and cost of the MUS is given in the following sections 4.2.1 and 4.2.2 respectively. On the basis of the total income and cost calculated, the benefit cost analysis was conducted. The calculation of various methods; Net Present Value (NPV), Benefit Cost Ratio (BCR), Financial Internal Rate of Return (FIRR) and Payback period, used in benefit cost analysis is provided in Section 4.2.3.

5.2.1 Income benefit calculation

A benefit from the vegetable production was determined based on the land size instead of per capita as given in Renwick *et al.* (2007), since the benefit depends on the land productivity. The information on annual income from vegetable production, vegetable cultivated land size and their own annual vegetable consumption were collected from the household interviews. The metric system *ropani* is used for the calculation as it is the widely used metric system for land in Nepal. The calculation of annual income based on land size and per capita from the MUS projects is provided in Table 5.3.

Table 5.3 Annual income per ropani land of the MUS schemes

Name of the Scheme	Sample household population after omitting outlier cases	Amount in US dollar ($)				
		Gross Annual Income from selling vegetables	Cost equivalent to self vegetable consumption	Annual income	Income per ropani	Per capita Income
Salyan MUS	49	5253	2385	7638	720	156
Armala MUS	68	1697	3309	5006	507	74
Dharapani MUS	47	283	2287	2570	410	55
Malewasbasne MUS	24	667	292	959	630	40
Saurabhanjyan MUS	10	333	195	528	519	53
Average		**1647**	**1694**	**3340**	**557**	**75**

The household interviews showed that the annual income per ropani of land ranges from 410 to 720 US $, shown in Table 5.1. Similarly, the per capita net annual income of the MUS varies from 40$ to 156$. The annual income benefit differs depending on the land used for vegetable cultivation, human resource and their market accessibility for the sale. In case of Salyan and Malewabasne MUS, all the users are very active and professionally involve in vegetable production as they have good market access and human resource within their family. Besides they do not have any other source of income besides agriculture. However in case of Dharapani MUS, most of the males of the households are abroad or in city work as labour and there is a lack of human resource within the family to devote their time for vegetable production and hence most of them considered vegetable farming for their own consumption rather than a profit making business. On average the annual income per ropani of land is US $ 557.

Based on the income obtained per ropani of land, the total additional income from the vegetable production for the year 2009 was calculated. With this total income of 2009, the base year was determined using a yearly price index change percentage as a discount rate. This price index is referred from National Urban Price Consumer Index (NUCPI) of Central Development Bank (CDB) of Nepal. The NUCPI is provided in Fig. 5-6.

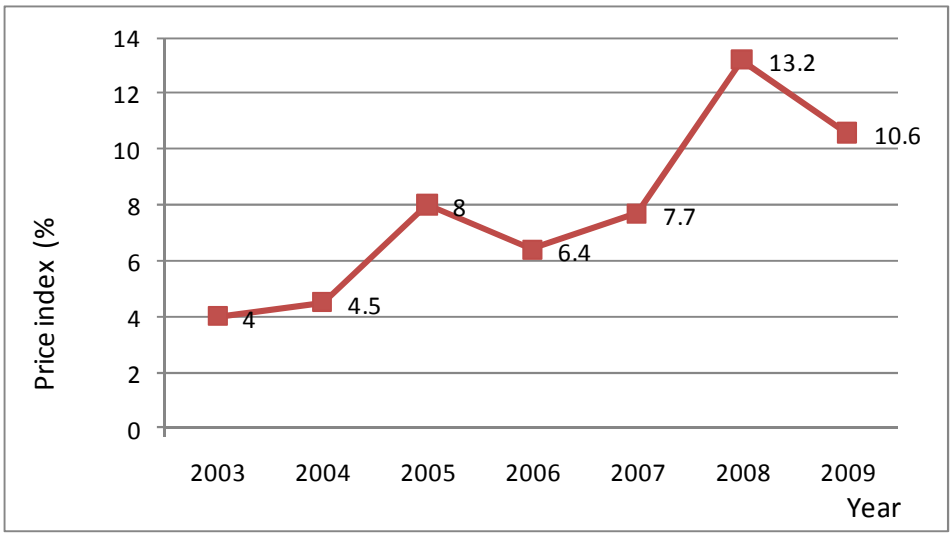

Fig. 5.6. Yearly National Urban Consumer Price Index of Nepal from 2003 to 2009

Source: (Adapted from CDB, 2009)

The calculation done to obtain base year income is given in Appendix 5. Table 5.4 shows the total income generated for the year 2009 and the base year. From the calculation, the total income in 2009 varies 9,449 to 41,956 US $ which on average is US $ 24,166. The base year income was found in a range of US $ 6,745 to 32,344, which on average is US $ 19,171.

Table 5.4 Scheme wise total income from the vegetable farming for 2009 and the base year

Name of the Scheme	Year of Implementation	Population to sample ratio	Sample area for vegetables	Estimated total area	Income per ropani	Total income for 2009	Total income for base year
Salyan MUS	2006	3.64	16.00	58.24	720	41,956	32,344
Armala MUS	2009		16.38	59.61	507	30,223	30,223
Dharapani MUS	2005		9.38	34.13	410	13,993	9,988
Malewasbasne MUS	2003		11.00	40.04	630	25,209	16,557
Saurabhanjyan MUS	2005		5.00	18.20	519	9,449	6,745
Average						**24,166**	**19,171**

5.2.2 Calculation of the total cost of the MUS

Capita cost and software cost:

Table 5.5 shows the fixed total cost of the MUS schemes, which is obtained from the organization IDE Nepal. The cost included both the hardware and the software cost. The table also illustrated cost contributed by different government, I/ NGOs, governmental bodies and the community itself. The table shows that the total cost of the MUS varies from US $ 3,080 to 11004, depending on the project scale, geographical location and construction year. The total cost of Armala MUS was found to be extremely high compared to the rest as it was constructed for a population of 241 of the hilly region in the year 2009, while, the other schemes are constructed before the year 2006. Similarly the per capita scheme cost also varies from US $ 137 to 512, which is shown in Table 4-3.

Table 5.5 Total project cost of the MUS

Name of the scheme	District	Cash in US dollar ($)						Kind	Total hardware cost	Software cost	Total Project cost	Per capita Scheme Cost
		IDE Nepal	GOs	DDC /VDC	I/NGOs	Community	Cash in total					
Salyan	Lalitpur	751	2,600	0	0	67	3,418	1,927	5,345	3,290	8,635	184
Armala	Kaski	2,000	800	1,333	0	1,011	5,144	2,849	7,994	3,010	11,004	512
Dharapani	Kaski	533	0	0	467	340	1,340	591	1,931	2,030	3,961	137
Malewa basne	Syanja	939	0	210	0	113	1,261	348	1,610	1,470	3,080	147
Saurah bhanjyan	Lalitpur	884	1,333	0	0	0	2,217	1,667	3,884	2,940	6,824	162
Average cost									**4,153**	**2,548**	**6,701**	**228**

Note: GOs: Governmental organization, DDC: District Development organization, VDC: Village Development Committee, I/NGOs: International/ Non governmental organizations.

5.2.2.2 Operation and Maintenance cost (Annual recurring cost):

Besides the hardware and software cost, the MUS project requires annual operation and maintenance cost along with agricultural cost to obtain the benefits from productivity. These are recurring annual costs. The operation and maintenance cost required is obtained from IDE Nepal. Similarly the annual agricultural expenditure cost was estimated based on the household interviews and discussions from the agronomists of the site. The annual agricultural cost includes the expenditures for seeds, fertilizers, pesticides and human resources (labour cost). The labour cost required for vegetable production was also included as it is their opportunity cost. Table 5.6 provides the total cost of the MUS.

It should also be noted that there is no any charge or tariff for the MUS. The water provided by the MUS is totally free.

Table 5.6 Total cost of the MUS including annual recurring amount

Name of the scheme	District	Number of households	Amount in US dollar (US $)				
			Total beneficiaries	Project cost	Annual O/M cost	Annual agricultural cost	Estimated Annual cost
Salyan	Lalitpur	47	202	8,635	67	15,958	24,659
Armala	Kaski	43	241	11,004	67	16,332	27,403
Dharapani	Kaski	29	180	3,961	67	9,350	13,378
Malewa basne	Syanja	21	121	3,080	67	10,971	14,118
Saurah bhanjyan	Lalitpur	42	210	6,824	67	4,987	11,878
Average cost				**6,701**	**67**	**11,520**	**18,287**

Hence the total cost of the MUS varies from US $ 11,878 to 27,403 for the initial year. On average the cost is calculated to be US $ 18,287.

5.2.3 Benefit cost analysis of the MUS projects

The BCA was conducted by calculating Net Present Value (NPV), discounted Benefit Cost Ratio (BCR), Net BCR, Financial Internal Rate of Return (FIRR) and Payback period or say Break-even Point (BEP). Any project having positive NPV and BCR greater than 1 are considered as beneficial projects. In case of FIRR, any project having FIRR greater than the discount rate used is considered profitable.

The life of the MUS projects is constructed considering ten years. Hence the BCA of the schemes were determined taking 10 years of time period. The discount rate used is 10%, on the assumption that no development infrastructure shall have a discount rate less than 10%, especially used in road infrastructures supported by the World Bank or regional banks.

5.2.3.1 NPV calculation

NPV is the sum of the discounted cash flows (Zerby and Dively 1994). It is used to discount future net cash flows into present value terms with the entity's cost of capital. It is used to analyze the profitability of an investment project as it compares the value of a dollar today to the value of that same dollar in the future, taking inflation and returns into account (VBM 2008). NPV for the investment projects are calculated using the following formula (Zerby and Dively 1994):

$$\text{NPV}= \sum_{t=0}^{n} \frac{B_t}{(1+r_t)^t} - \frac{C_t}{(1+r_t)^t}$$

The final result of the calculation of NPV is given in Table 5.7. A detail calculation of NPV and BCR for each scheme is given in Appendix 6.

Table 5.7 Net Present Value (NPV) of the MUS

Name of the schemes	Income Benefit (US $)	Total Fixed cost (US $)	Recurring annual cost (US $)	NPV (US $)
Salyan MUS	32,344	24,659	16,025	92,422
Armala MUS	30,223	27,403	16,399	74,938
Dharapani MUS	9,988	13,378	9,417	24,516
Malewasbasne MUS	16,557	14,118	11,038	31,112
Saurabhanjyan MUS	6,745	11,878	5,054	4,185
Average				**45,435**

The NPV of all the studied MUS were found to be positive, ranging from US $ 4,185 to 92,422. This shows that the MUS projects are highly profitable as it provides a present value benefit of 45,345 on average. Salyan MUS showed the highest NPV value showing the most profitable investment among the schemes.

5.3.3.2 Benefit Cost Ratio (BCR)

The two types of BCR; discounted BCR and net BCR were calculated for the analysis. The discounted BCR provides a relationship between the cost and benefits of a project which helps in deciding whether the project is a good investment or not. It is calculated using the formulae

$$\text{BCRd} = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r_t)}}{\sum_{t=0}^{n} \frac{C_t}{(1+r_t)}}$$

The net BCR is a ratio of the discounted net benefits and costs expressed in percentage, which is calculated as:

$$\frac{NPV}{\sum_{t=0}^{n}\frac{C_t}{(1+r_t)^t}} * 100\%$$

BCRn =

The net BCR shows the increased percentage in real wealth generated by the project. Any project with the BCRn greater than zero is beneficial and accepted.

The BCR calculation is given in Table 5.8.

Table 5.8. Benefit Cost Ratio of the MUS

Name of the schemes	Income Benefit (US $)	Total Fixed cost (US $)	Recurring annual cost (US $)	Discounted BCR	Net BCR (%)
Salyan MUS	32,344	24,659	16,025	1.87	87
Armala MUS	30,223	27,403	16,399	1.68	68
Dharapani MUS	9,988	13,378	9,417	1.40	40
Malewasbasne MUS	16,557	14,118	11,038	1.44	44
Saurabhanjyan MUS	6,745	11,878	5,054	1.11	11
Average				**1.50**	**50**

Since all the studied schemes showed the BCR greater than 1, the MUS schemes can be considered a beneficial investment. The BCR was found the highest in the Salyan MUS and the lowest in the Saurabhanjyan MUS. The Net Benefit Cost Ratio was found in a range of 11 to 87 % respectively, which implies that for an investment cost of $1 there is a potential of benefit of US $11 to 87. On average the MUS was found to provide a benefit of US $ 50 for an investment of US $ 1.

5.2.3.3 Payback period:

The payback period is the length of time required to recover the cost of an investment from the net cash flows (undiscounted) it generates, this is the period of time needed for an investment to pay for itself. It is calculated using the simple formulae,

Payback period = Initial cost of investment/Annual net cash flow

The payback period result is provided in Table 5.9.

Table 5.9. Payback period of the MUS

Name of the schemes	Income Benefit (US $)	Total Fixed cost (US $)	Recurring annual cost (US $)	Payback period (months)
Salyan MUS	32,344	24,659	16,025	9
Armala MUS	30,223	27,403	16,399	11
Dharapani MUS	9,988	13,378	9,417	11
Malewasbasne MUS	16,557	14,118	11,038	10
Saurabhanjyan MUS	6,745	11,878	5,054	21
Average				13

The payback period of the MUS was found to be 9 to 21 months. The study conducted by Renwick *et al.* (2007) showed 6 to 30 months as the payback period for the new MUS and on average 13 months for piped gravity flow MUS. The present study was conducted only in gravity fed water supply system and showed the repayment period, 9 to 11 months for a new MUS except for Saurabhanjyan. The repayment period was found to be high for Saurabhanjyan compared to the other schemes and the average payback period given by Renwick *et al.* (2007). In case of Saurabhanjyan, the income they provided was for the year 2009 when most of the users have pest problem in their vegetables. This might have increased the repayment period of the scheme. In case of upgraded MUS, the study done by Renwick *et al.* (2007) showed 7 to 22 months as a repayment period and in the case of Malewabasne MUS, which is upgraded MUS, the present study also shows a payback period of 10 months, supporting the study done by Renwick *et al.* (2007).

5.2.3.4 Financial Internal Rate of Return

FIRR is used to determine the actual rate of return. It provides the rate of return that balances net present value to original project cost. It is the true interest yield expected from an investment project

expressed as percentage. It is the time adjusted rate of return, where the discount rate that results in a net present value of zero for a series of future cash flows (VBM 2008). FIRR is calculated by computing break-even rate of return, the discount rate at which the value of cash outflow equals the value of cash inflows. FIRR for this study is calculated using Trial and veil method in which the difference between the original cost and NPV was calculated using different discount rate (from lower to higher) till it reaches from positive to zero or the negative value. The discounted rate values between the ones resulting positive and negative NPV values were used to calculate the FIRR. The formula used is:

$$IRR = Lower\ rate + \frac{NPV\ at\ lower\ rate}{NPV\ at\ lower\ rate\ -\ NPV\ at\ higher\ rate} * (Higher\ rate\ -\ Lower\ rate)$$

The FIRR result is provided in Table 5.10. A detail calculation is given in Appendix 7.

Table 5.10 FIRR for the MUS

Name of the schemes	Income Benefit (US $)	Total Fixed cost (US $)	Recurring annual cost (US $)	FIRR
Salyan MUS	32,344	24,659	16,025	79
Armala MUS	30,223	27,403	16,399	74
Dharapani MUS	9,988	13,378	9,417	43
Malewasbasne MUS	16,557	14,118	11,038	66
Saurabhanjyan MUS	6,745	11,878	5,054	26
Average				58

The FIRR was found to be in a range of 26 to 79%, which is higher than the discount rate used. On average the FIRR is 58 which implies that for every 100$ investment, the financial return is $158, showing a high feasibility of the MUS projects.

5.2.4 Summary of the BCA

The Benefit Cost Analysis hence shows that the investment done for the MUS is highly beneficial in financial terms. There is a high amount of financial return of the investment. Even the payback period is less, ranging from 9 to 21 months. The MUS shows a high benefit even though, the present benefit cost calculation only considers a direct income benefit from the MUS. If the other indirect benefits like time saving, health and nutrition improvement etc are considered in monetary terms, the MUS will be of much more value, providing a high financial return in the society. Hence the study provides the evidence of a high financial profit from the MUS. In conclusion, the MUS can be an appropriate cost effective water supply technology in the developing world.

CHAPTER 6. CHALLENGES

6.1 Challenges of vegetable farming as an income generating source

Despite vegetable farming having a numerous income benefits along with other multi dimensional health, sanitation, nutritional benefits, there are a few challenges that should be considered while promoting vegetable farming and the MUS. The main three challenges are drying up of the water source, pests and need for daily work in vegetable farming, which are discussed in the following points.

Drying up of the source:

This is a major problem, not only in the MUS schemes but also in most of the water supply schemes of the country. This might be the effect of climate change. There is no research conducted on the number of water supplies drying up before its design lifetime. However, most of the experts working in the field of water supply sectors reported the fact.

The Odare MUS and Ganeshpur MUS schemes (the schemes which are observed to understand the problems and challenges of the MUS) face a serious problem as the source of their water has already dried up. In case of the Odare MUS, the water level of the river has been diverted away and has gone down due to the previous year's heavy flood and the users have water scarcity even for drinking and most of the users now have stopped vegetable farming due to lack of water. They are now back to their daily wage work for survival. Similarly in case of Ganeshpur, the source began to dry up after previous year's dry season and the water they get from the MUS is just enough for drinking. This has reduced the irrigation possibility in dry seasons in those areas. Even for washing clothes and taking a bath, they now depend on their old source, which is around 30 minutes away from their village. The villagers are now working out how to increase the source water amount by adding up other available sources.

Similarly to the other studied MUS, people are experiencing reduced water quantity in dry seasons more than before, except for the Malewabasne MUS. However they are managing by supplying water only in the morning and evening time. This kind of management is also helpful in conserving

precious water resources, as the users are irrigating their land only in the morning and evening which reduces the evaporation rate from the land and conserves water resources.

Pests in vegetable farming:

The users in a few sites considered a very good production in the initial three to four years of the farming and have experienced pests after three years continuous production of the same kind of vegetables. Hence they are unable to do vegetable production in the same way as earlier. They said that they need more training on pest control to continue good production. They regarded that they had a marvellous production in the first year of vegetable production. However, a few farmers have stopped vegetable production for a few months due to their ignorance in tackling the pest problem. This is a case from Saurabhanjyan where the users stopped vegetable farming for two to three months in 2009. This reduces their income opportunity. The experts in this field explained that the users should change their cropping pattern every two to three years to tackle the pest and the villagers now are doing so from this year.

Need for daily work in vegetable farming:

Unlike maize and millet production which are traditional crops of the study areas, vegetable farming needs two hours daily for good production. Though there is an income benefit, there has been a price fluxuation in the vegetable market and risks of pest and production. This year the price of vegetables could not go higher compared to the previous year. Hence, a few users, especially the poorest people are discouraged to allocate two hours time each day to vegetable production and hence they grow vegetables for their own consumption. They explained that there is always some risk in agricultural production due to natural weather change, pest problems and market price of their production, which are major challenges of the vegetable business among the poorest. However they prefer to have vegetable production for their own use as they can consume fresh and healthy vegetables every day.

6.2 Challenges for the MUS promotion in national level

The MUS in Nepal is still in demonstration stage. Although the MUS helps improve the life of the poor providing them both domestic and productive water, its promotion has not been scaled up. The formal interviews with the MUS expert showed three major challenges for its promotion in Nepal.

Those are lack of defined policy, lack of expertise and lack of long term experience on the MUS (Khawas pers.comm ; Sharma pers. Comm..).

Lack of defined policy:

There is no defined policy in the government for promoting the MUS. MUS is a multipurpose oriented project. The MUS that has been promoted in Nepal has an integration of micro-irrigation, drinking water supply and marketing components. There are no responsible governmental bodies which can integrate this combination, as defined by the policy. The Department of Agriculture (DoA) of Nepal focuses on agricultural production and its marketing components, but does not consider domestic water use and sanitation. Similarly the Department of Irrigation (DoI) emphasizes on providing irrigation and does not look upon marketing components of the production. However in case of DoLIDAR, it can have this combination of the MUS and has been promoting it for a few years.

Lack of expertise:

Working and promoting the MUS requires multi expertise. It requires the expert human resources in the field of water and sanitation, agricultural production, irrigation and marketing. However it is difficult to find such combination of expertise in any governmental or organizational bodies. Hence lack of professional expertise can be a major challenge for the governmental bodies to uptake the MUS concept and hence they are reluctant to promote it.

Lack of long term experience in the MUS:

The MUS has been promoted from the year 2003 and hence is not able to collect long term experiences. The governmental bodies, hence, still hesitate to promote the MUS over the traditional Single Use (SU) water supply systems. Besides the long term experience, the MUS has been promoted as a small scale project, benefitting around 20 -100 households. No experiences can be found of the large scale projects implemented for a large group of the population. For the governmental project, most of the water supply schemes are implemented for more than 500 households. However, a step has now been taken by DDC of Syanja. The DDC has already approved the MUS project implementation for 1000 households. The outcome of this project can be basis for further promotion of the MUS in large scale.

CHAPTER 7- CONCLUSION AND RECOMMENDATIONS

Multiple-Use water Service (MUS) is a water supply system designed for both domestic and productive uses of water according to consumers' need and demand (Moriarty, et. al.; 2004). It provides productive uses of water at household level and offers poor people a range of small scale opportunities that support them to produce food, vegetables and fruits, enhance their agricultural production, livestocks, initiate other small water based enterprises like food processing, brick making etc. This helps generate income and simultaneously improve their living standard. Vegetable farming is the only productive activity that the MUS users in Nepal initiated extensively in their homestead garden with the implementation of the MUS.

The study considers the MUS as one of the cost effective water supply projects. The average annual cost and income benefit of the MUS, without discounting, has been found to be 18,287 and 19,171 respectively. The benefit cost analysis of the MUS projects illustrates that the MUS projects are highly profitable. The Net Present Value (NPV) of the MUS has been found to be higher than zero i.e. in a range of 4,185 to 92,422 US $. On average the NPV is US $ 45,345. This implies that the MUS project can provide a large amount of benefit in present monetary terms.

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The Benefit Cost Ratio (BCR) calculation also shows the MUS project to be beneficial as the BCR value obtained is higher than one, as any project whose BCR value is higher than one is taken as a good investment. The current study shows that the MUS on average can provide a benefit of US $ 50 for an investment of US $ 1. Hence the investment on the MUS projects can be considered a good decision.

The study calculates the payback period of the MUS projects in order to get the length of time to recover the investment cost. The payback period has been calculated as 9 to 21 months, while on average the payback period is 13 months. This finding are confirmed in line with the study conducted by Renwick *et al.* (2007) which determine a payback period of 13 months on average for the MUS with a gravity flow system. Considering the payback period of the MUS, it can be taken as a quick return investment.

For more strong support on BCA calculation, the Financial Rate of Return (FIRR) has also been calculated. The result of FIRR also shows that the investment in the MUS is highly profitable. The FIRR is found in a range of 26 to 79%, which is higher than the discount rate used. On average the study shows FIRR of 58%, which implies that there is a financial return of US $ 58 for every US $ 1 investment.

Hence, all the BCA analysis, including NPV, BCR, payback period and FIRR prove that the investment in the MUS is highly profitable in financial terms. The financial benefit will be much higher if the analysis includes other social benefits like time saving, women's empowerment, and health and nutrition improvements from the MUS.

Different case studies presented in Chapter five provide strong evidence in support of the MUS in solving multi-dimensional poverty issues nutrition, health, sanitation, gender equity etc. The study shows that with an improvement in water services either as MUS or upgraded MUS, it helps saving water hauling time especially of women, who used to walk up to an hour per trip for the water prior to the MUS. The users now have a water supply access within five minutes from their households. This significantly improves the life of women and girls. They now utilise the saved time doing productive work like vegetable farming, taking rest, going school, attending meetings and trainings.

With access to productive uses of water, there is improvement in the income level which ranges from 11 to 2000 US $ per year, deducing their own consumption of vegetables. The MUS users now also found change in their food habits. They now consume fresh vegetables for every meal which was not possible prior to the MUS. This has contributed to improving their nutrition level and health condition especially of the children.

The study also shows that the income generated is invested in their children's education, which improve literacy rate of the country and is equally important for tackling the chronic poverty. There is also a significant improvement in sanitation and hygienic behaviour among the users after having accessible water. Women's empowerment can also be observed as a major positive impact of the MUS due to having cash access in their hands, self development programmes etc.

Hence , the major outcomes of the MUS for the poverty reduction can be provided by the evidence like saving a certain amount in saving and credit group, getting luxury items, initiating other income generating sources like shops , building new houses, investing in children's education etc. This verifies that the MUS is not only a financially profitable investment, it is also beneficial in terms of social reform and development.

Even though the MUS shows both the financial and social benefit, it is not being promoted as vigorously as it should be. There are certain challenges for its scale up. The major challenges at national level are lack of defined policy at national level, lack of expertise in this multi dimensional approach and lack of long term experience in the MUS promotions. The study also shows drying up of the sources, pest problem, need for daily work for vegetable farming as major problems faced in the MUS promoted areas, which should be considered carefully in further MUS promotion.

In conclusion, the MUS is an appropriate and affordable option both financially and socially. It supports the food security and poverty alleviation issues along with improving water accessibility, which are crucial basic needs for the development of the poor and an agricultural country like Nepal. Furthermore, it also helps conserving precious water resources via drip irrigation, which is used for vegetable farming in the MUS. The MUS hence contributes to economic and social up-liftment by increased access to appropriate technology use, cash income, and social status for which appropriate design and follow up are essential .

Recommendations

Recommendations for the MUS promotion at policy level

- First and foremost there should be an appropriate policy to scale up the MUS at national level. There should be a defined policy regarding the responsible body to implement the MUS approach.

- As the MUS approach is still new intervention in Nepal, there is a necessity of more awareness and knowledge sharing programmes at local, regional and national level. Hence creating knowledge sharing platform on MUS and its scope is recommended.

- MUS being a multi purposed project, it requires expertise in many fields, including technical, marketing and software packages. Hence, human resources development should be focused

accordingly to scale up the MUS. For this, trainings and exposure visits for the concerned and responsible governmental and non-governmental organizations are recommended.

Recommendation for the MUS promotion at implementation phase

- Vegetable farming is the only options used as income generating activities from the MUS in the country. The income generating activities should not be limited to the vegetable business only. There is a high possibility of other productive uses of water like raising livestocks, fisheries, aquaculture, food processing, export quality crop production etc. Such options should be explored and promoted.

- Trainings on pest control and other potential risks of the vegetable production should be provided frequently.

- Monitoring visits from the experts should be conducted regularly in the MUS sites so that the users can share their problems and challenges with them. This will further help the users towards good production.

- Potential water conservation opportunities (like Rain water harvesting etc) at the local level to meet increased water volume demand or to prevent from potential risk of source dry up should be explored and promoted accordingly.

Recommendations for the further study

- Since MUS is a multi-dimensional approach, it relates to multi sectoral ministries like Ministry of Agriculture, Ministry of Agriculture, Ministry of Physical Planning and Works, Ministry of Local Development etc. There is still a big gap to develop strong co-operation and coordination among cross sector ministries. Hence, it will be useful to conduct a research on how cross ministerial work can be initiated and strengthened, for the successful implementation of the MUS at the larger scale.

- The study has showed drying up of the source as one of the major challenges in promoting the MUS and other water supply projects. There is no research conducted on this subject matter yet. Hence researches on the condition of the sources of water supply schemes should be conducted and mitigation measures should be explored if the sources are drying up with time.

- There is no tariff collection system in any of the MUS schemes in Nepal. If a certain amount of water tariff is collected, there is a chance of collecting revenues for further operation and maintenance of the scheme after its life period. Hence research on the willingness to pay and the community voices on it are highly recommended.

- MUS has been promoted in the hilly regions of Nepal as a gravity flow system. Based on the experience of India, prospect and challenges of the MUS project in the terai region via ground water abstraction should also be studied and pilot projects should be initiated, if it is feasible. The *terai* region of the country is more fertile and productive than the hilly region and hence can be more profitable.

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APPENDICES

Appendix 1 Photos

Village in the hilly region of Nepal having MUS

Double tank MUS technology in the village

Tapstands for domestic water usage

Offtake taps for irrigation purpose

Interviewing the MUS user in his garden

MUS users working in their vegetable garden

Vegetable production using MUS water

Social mobilizer helping in interviewing the MUS users

MUS users taking care of her livestock

MUS user doing extra productive activity in her spare time

Farmer ploughing his land for cultivation

Appendix 2 Questionnaire Format for MUS users

Name of the interviewee: …… District: House No:

Name of the owner of the house: …….. (Male/Female)

No of members in the family: Male……. Female…….

Major occupation: a. Agriculture b. Service c. daily wages d. others……

Name of the scheme: …….

Technology type: …….

Landholding area: ……. Garden …… field

General

1. When did you install this scheme? …… Year
2. What is the quantity of water you get from this scheme?
3. For what purposes do you use water from the scheme?

a. Household chores b. sanitation c. livestocks d. homestead garden

4. Is the water supply enough even in dry season? A. Yes b. No
5. Are you happy with the scheme? a. Yes b. No c. just ok
6. What are the benefits you are getting from this scheme?

……

……

……

……

Time saving analysis

Before the Scheme

1. Where did you go for fetching water before the scheme?

……

2. Did you use the same water point for both domestic purposes and for garden? A. Yes b. No
3. If No, where did you go for gardening and livestocks? ……
4. Was water sufficient for you? A. Yes b. No
5. For household chores

a.How much time did you require for a round trip to fetch water ? …….. minutes

b. How many trips you had to do in a day? ……. Trips

c. Who fetched the water? A. Male b. female c. both (sometimes)

6. For garden (bari) and livestocks

a. How much time did you require for a round trip to fetch water ? …….. minutes

b. How many trips you had to do in a day? ……. Trips

c. Who fetched the water? A. Male b. female c. both (sometimes)

After the Scheme

7. Mention time taken and number of round trips for you to fetch water after the installation of this scheme? …….. minutes ……. Trips
8. Is water sufficient for the whole year ? a. Yes, b. No
9. Who is responsible for fetching water now ?

For household chores: a. male b. female c. both

For gardening : a. male b. female c. both

For livestocks: a. male b. female c. both

10. Do you agree that the scheme save your time? a. Yes, b. No
11. If Yes, how do you spend your save time?

……
……
……

Income analysis

1. What type of economically productive activities have you started after the scheme?

……
……
……

2. Before the scheme

a. What did you grow in your garden ?

……
……
……

b. How many season in a year?
c. Was it enough to sell after self consumption?
d. Did u have to buy vegetables?
e. If yes, how much per month?

3. After the scheme?

a. What have you been growing in your garden ?
b. How many season in a year?
c. Was it enough to sell after self consumption?
d. Did u have to buy vegetables?
e. If yes, how much per month?

4. Did you get any other economic benefit from those activities? A. Yes b. No

5. Have you add on livestocks after the scheme? a. Yes b. No
6. If yes, how many and how much did u invest? …….
7. Have you add on land after the scheme? a. Yes b. No
8. If yes, how much did u invest on it? ……..
9. Any other assets add on or investment (loan payment, saving, education)

……
……
……
…….

Health status analysis

1. Did you feel any change in your health status before and after the scheme?

a. Yes b. No

2. If yes, in what way did you feel change?

a. Decrease in illness b. increase in nutrition level c. others

3. Can you please tell us the frequency of becoming ill before and after the scheme?

Before the scheme: …….

After the scheme: …….

4. Do you perceive that easy access to water services have reduced the following:

a. Back pain…….
b. Uterus prolapsed ……
c. Waterborne (diarrhea) diseases…….

Cost analysis of the scheme

1. How much did you invest for the scheme?

Cash:

Kind:

2. How much is organization contribution? …….NRs
3. How much do you have to pay monthly for the service? ……. NRs.

Management of the scheme

1. Is there any group responsible for the operation and maintenance of the scheme? A. Yes b. No
2. What is the name of the group? ……..
3. How many members are there in the group?..... male …… female
4. Are you a member of the group? A. Yes b. No
5. Do you have separate fund for the maintenance of the scheme?

Gender analysis:

1. HAS MUS brought any changes in women's empowerment? a. Yes b. No
2. If yes what are those?

a. Access to cash income

……
……
……
..

b. Dignity in the society

……
……
……
..

c. Decision making empowered

……
……
……
..

d. Any others (pls specify)

……
……
……
..

General views

1. Do you think such scheme should be promoted in other part of the country?

a. Yes b. No

2. Do you feel that you have increased your living standard after the installation of scheme?

a. Yes b. No

Suggestions

……
……
……
..

Appendix 3 Questionnaire Format for the Organization promoting MUS approach

Name of organization:

Location:

Pls. answer following questions. The answers will be kept strictly confidential and will not be used for other than the proposed study.

I am happy to share summary information if your organization is interested.

A. General Information:

1. When did your organization start promoting MUS approach? …….. Year
2. What were objectives of MUS?

……
……
……
……
……
……

3. What were expected outputs?

……
……
……
……
……
……

4. How many schemes had been implemented using MUS approach by your organization?

……

B. Project Information

5. Please provide the following information of the schemes being promoted by your organization?

S. No	Name of the scheme	District	Year of construction	No of Beneficiaries	Type of technology	Qty of water in lpd	Design life period in years	Capital cost		Operational cost	Maintenance cost	Total cost	Pay back period

7. Out of the total cost, how much is contributed by the organization and community respectively?

Organisation contribution (%)=
Community contribution (%)=

(Probe the areas of contribution e.g. total cost, hard ware, soft ware, Operation and maintenance)

8. Is the organization contribution as subsidy or loan? A. Yes b. No
9. If it is loan,
   a. What is the mechanism of payment? (Instalment—period)
   b. Is it interest free? A. Yes b. No
   c. If no, what is the interest rate? ……..
   d. What is the pay back time for a loan?.....
10. What is the expected payback period of the total project cost deducing annual and maintenance cost?.....
11. Has this expectation been made? A. Yes b. No
12. If yes, why is it successful?

.....
.....
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.....
.....

13. If no, why not?

.....
.....
.....
.....
.....
.....

14. What are benefits of MUS approach over SU approach?

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.....
.....

15. Do you think the MUS approach contribute to reduce poverty and if so, to what degree and in what way?

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.....
.....
.....
.....
.....

16. Do you think the MUS approach assist to the reduction of vulnerability and drought impact due to climate change?

.....
.....
.....
.....
.....
.....

17. Do you think the MUS approach enhance sustainability of the water service?

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.....
.....

18. What is the feedback from the end users? A. positive b. Just ok c. Negative

19. what is scope and demand of expanding MUS approach?

.....
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.....
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.....
.....

20. What are the major challenges to promote MUS approach in context of Nepal?

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Appendix 4: Calculation on Annual income per *ropani* of land

S.No	Family size	Gross Annual Income from selling vegetables	Cost equivalent of self consumption	Gross annual income	Area of vegetable farming (ropani)	Annual income per ropani
1	6	24000	21900	45900	1.5	30600
2	5	0	18250	18250	0.125	146000
3	3	45000	10950	55950	1.5	37300
4	4	36000	14600	50600	1	50600
5	4	107000	14600	121600	2	60800
6	7	15000	25550	40550	2	20275
7	7	60000	25550	85550	2	42775
8	8	25000	29200	54200	1.5	36133.33333
9	6	35000	21900	56900	1	56900
10	6	37000	21900	58900	1.5	39266.66667
11	4	25000	14600	39600	1	39600
12	3	12000	10950	22950	0.25	91800
13	4	12000	14600	26600	0.3125	85120
14	6	15000	21900	36900	0.3125	118080
15	10	900	36500	37400	0.5	74800
16	4	0	14600	14600	1	14600
17	6	13000	21900	34900	0.375	93066.66667
18	11	1800	40150	41950	1	41950
19	7	6000	25550	31550	1	31550
20	5	31260	18250	49510	1.5	33006.66667
21	11	3000	40150	43150	2	21575
22	12	80000	43800	123800	2	61900
23	7	1400	25550	26950	0.5	53900
24	6	150000	21900	171900	2	85950
25	8	800	29200	30000	1	30000
26	8	0	29200	29200	1	29200
27	1	3600	3650	7250	1	7250
28	5	6000	18250	24250	1	24250
29	5	0	18250	18250	0.5	36500
30	5	1200	18250	19450	1	19450
31	7	6000	25550	31550	1	31550
32	7	50300	25550	75850	1	75850
33	7	0	25550	25550	1	25550
34	8	10000	29200	39200	2	19600
35	6	0	21900	21900	0.3125	70080

36	5	0	18250	18250	1	18250
37	5	4000	18250	22250	1.5	14833.33333
38	4	0	14600	14600	0.3125	46720
39	5	0	18250	18250	0.25	73000
40	5	150000	18250	168250	2	84125
41	5	100000	18250	118250	2	59125
42	2	70000	7300	77300	2	38650
43	4	50000	14600	64600	1	64600
44	7	50000	25550	75550	2	37775
45	6	50000	21900	71900	2	35950
46	7	1500	25550	27050	1	27050
47	8	23000	29200	52200	1	52200
48	4	0	14600	14600	1	14600
49	6	15000	21900	36900	1	36900
50	4	25000	14600	39600	1	39600

Appendix 5: Total estimated income for the base year (in US $)

	2003	2004	2005	2006	2007	2008	2009
Salyan				32344	34414	37063	41956
Armala			21573	23298	24790	26698	30223
Dharapani			9988	10787	11478	12361	13993
Malewaba	16557	17219	17994	19434	20677	22270	25209
Lele			6745	7284	7750	8347	9449

Appendix 6: Calculation of NPV, BCR and payback period of the schemes

Salyan MUS

Amount in US $	
Project Cost	8,635
O/M Cost	67
Agricultural Cost	15,958
Total project cost	24,659
total annual Income	32,344
Payback period in years	0.76
Payback period in mon	9.15

Agricultural cost

	hours	Days	In NRs	In US $
Labor cost	1080	135	13500	
Seed	10 gm	150 per gn	4500	
Fertilizer co	30 doka pe	750	2250	
Pesticides	500 ml per	300	300	
		1 ropani	20550	274

Name of the scheme	Year of construction	Unit	1	2	3	4	5	6	7	8	9	10	Total
Salyan MUS	2006												
Total cost (in US $)		US $	24,659	16,025	16,025	16,025	16,025	16,025	16,025	16,025	16,025	16,025	168882.2
Total benefit (in US $)		US $	32,344	32,344	32,344	32,344	32,344	32,344	32,344	32,344	32,344	32,344	323435.2
Discount rate	$(1+r_t)^t$	US $	1.1	1.21	1.331	1.4641	1.61051	1.771561	1.948717	2.143589	2.357948	2.593742	17.53117
Discounted total cost	$\sum_{t=1}^{10} \frac{C_t}{(1+r_t)^t}$	US $	22418	13244	12040	10945	9950	9046	8223	7476	6796	6178	106315
Dicounted total benefit	$\sum_{t=1}^{10} \frac{B_t}{(1+r_t)^t}$	US $	29403	26730	24300	22091	20083	18257	16597	15088	13717	12470	198737
NPV of the project		**US $**											**92422**
Net BCR		**%**											**87**
Discounted BCR													**1.87**

Armala MUS

Amount in US $	
Project Cost	11,004
O/M Cost	67
Agricultural Cost	16,332
Total project cost	27,403
Total annual Income	30,223
Payback period in years	0.907
Payback period in mon	10.88

Agricultural cost

	hours	Days		In US $
Labor cost	1080	135	13500	
Seed	10 gm	150 per gm	4500	
Fertilizer co	30 doka pe	750	2250	
Pesticides	500 ml per	300	300	
		1 ropani	20550	274

Name of the scheme	**Year of construction**	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Armala MUS	2006												
Total cost (in US $)		US $	27,403	16,399	16,399	16,399	16,399	16,399	16,399	16,399	16,399	16,399	174991.5
Total benefit (in US $)		US $	30,223	30,223	30,223	30,223	30,223	30,223	30,223	30,223	30,223	30,223	302225.3
Discount rate	$(1+r_t)^t$	US $	1.1	1.21	1.331	1.4641	1.61051	1.771561	1.948717	2.143589	2.357948	2.593742	17.53117
Discounted total cost	$\sum_{t=1}^{10} \frac{C_t}{(1+r_t)^t}$	US $	24911	13553	12321	11201	10182	9257	8415	7650	6955	6322	110767
Dicounted total benefit	$\sum_{t=1}^{10} \frac{B_t}{(1+r_t)^t}$	US $	27475	24977	22707	20642	18766	17060	15509	14099	12817	11652	185704
NPV of the project		**US $**	**74938**										**74938**
Net BCR		**%**	**68**										**68**
Discounted BCR			**1.68**										**1.68**

Dharapani MUS

Amount in US $	
Project Cost	3,961
O/M Cost	67
Agricultural Cost	9,350
Total project cost	13,378
total annual Income	13,993
Payback period in years	0.96
Payback period in mon	11.47

Agricultural cost

	hours	Days	In NRs	In US $
Labor cost	1080	135	13500	
Seed	10 gm	150 per gn	4500	
Fertilizer co	30 doka pe	750	2250	
Pesticides	500 ml per	300	300	
		1 ropani	20550	274

Name of the scheme	**Year of construction**	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Dharapani MUS	2006												
Total cost (in US $)		US $	13,378	9,417	9,417	9,417	9,417	9,417	9,417	9,417	9,417	9,417	98133.65
Total benefit (in US $)		US $	13,993	13,993	13,993	13,993	13,993	13,993	13,993	13,993	13,993	13,993	139931.5
Discount rate	$(1+r_t)^t$	US $	1.1	1.21	1.331	1.4641	1.61051	1.771561	1.948717	2.143589	2.357948	2.593742	17.53117
Discounted total cost	$\sum_{t=1}^{10} \frac{C_t}{(1+r_t)^t}$	US $	12162	7783	7075	6432	5847	5316	4833	4393	3994	3631	61466
Dicounted total benefit	$\sum_{t=1}^{10} \frac{B_t}{(1+r_t)^t}$	US $	12721	11565	10513	9558	8689	7899	7181	6528	5934	5395	85982
NPV of the project		**US $**	**24516**										**24516**
Net BCR		**%**	**40**										**40**
Discounted BCR			**1.40**										**1.40**

Malewabasne MUS

Amount in US $	
Project Cost	3,080
O/M Cost	67
Agricultural Cost	10,971
Total project cost	14,118
total annual Income	16,557
Payback period in years	0.85
Payback period in mon	10.23

Agricultural cost

	hours	Days	In NRs	In US $
Labor cost	1080	135	13500	
Seed	10 gm	150 per gn	4500	
Fertilizer co	30 doka pe	750	2250	
Pesticides	500 ml per	300	300	
		1 ropani	20550	274

Name of the scheme	**Year of construction**	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Malewabasne MUS	2006												
Total cost (in US $)		US $	14,118	11,038	11,038	11,038	11,038	11,038	11,038	11,038	11,038	11,038	113459.3
Total benefit (in US $)		US $	16,557	16,557	16,557	16,557	16,557	16,557	16,557	16,557	16,557	16,557	165570
Discount rate	$(1+r_t)^t$	US $	1.1	1.21	1.331	1.4641	1.61051	1.771561	1.948717	2.143589	2.357948	2.593742	17.53117
Discounted total cost	$\sum_{t=1}^{10} \frac{C_t}{(1+r_t)^t}$	US $	12834	9122	8293	7539	6854	6231	5664	5149	4681	4256	70623
Dicounted total benefit	$\sum_{t=1}^{10} \frac{B_t}{(1+r_t)^t}$	US $	15052	13683	12440	11309	10281	9346	8496	7724	7022	6383	101736
NPV of the project		**US $**	**31112**										**31112**
BCR		**%**	**44**										**44**
Discounted BCR			**1.44**										**1.44**

Saurabhanjyan MUS

Amount in US $	
Project Cost	6,824
O/M Cost	67
Agricultural Cost	4,987
Total project cost	11,878
total annual Income	6,745
Payback period in years	1.76
Payback period in mon	21.13

Agricultural cost

	hours	Days	In NRs	In US $
Labor cost	1080	135	13500	
Seed	10 gm	150 per gm	4500	
Fertilizer co	30 doka pe	750	2250	
Pesticides	500 ml per	300	300	
		1 ropani	20550	274

Name of the scheme	**Year of construction**	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Saurabhanjyan MUS	2006												
Total cost (in US $)		US $	11,878	5,054	5,054	5,054	5,054	5,054	5,054	5,054	5,054	5,054	57361.93
Total benefit (in US $)		US $	6,745	6,745	6,745	6,745	6,745	6,745	6,745	6,745	6,745	6,745	67445.14
Discount rate	$(1+r_t)^t$	US $	1.1	1.21	1.331	1.4641	1.61051	1.771561	1.948717	2.143589	2.357948	2.593742	17.53117
Discounted total cost	$\sum_{t=1}^{10} \frac{C_t}{(1+r_t)^t}$	US $	10798	4177	3797	3452	3138	2853	2593	2358	2143	1948	37257
Dicounted total benefit	$\sum_{t=1}^{10} \frac{B_t}{(1+r_t)^t}$	US $	6131	5574	5067	4607	4188	3807	3461	3146	2860	2600	41442
NPV of the project		**US $**	**4185**										**4185**
BCR		**%**	**11**										**11**
Discounted BCR			**1.11**										**1.11**

Appendix 7: Calculation details of Internal Rate of Return (IRR)

Salyan MUS

NPV at 10%					
Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	32,344	1.10	29,403		
2	32,344	1.21	26,730		
3	32,344	1.33	24,300		
4	32,344	1.46	22,091		
5	32,344	1.61	20,083		
6	32,344	1.77	18,257		
7	32,344	1.95	16,597		
8	32,344	2.14	15,088		
9	32,344	2.36	13,717		
10	32,344	2.59	12,470		
		NPV of benefit	198,737	40,684	158,053

Here difference is positive so will go for higher discount rate

NPV at 80%					
Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	32,344	1.80	17,969		
2	32,344	3.24	9,983		
3	32,344	5.83	5,546		
4	32,344	10.50	3,081		
5	32,344	18.90	1,712		
6	32,344	34.01	951		
7	32,344	61.22	528		
8	32,344	110.20	293		
9	32,344	198.36	163		
10	32,344	357.05	91		
		NPV of benefit	40,316	40,684	-368

NPV at 70%					
Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	32,344	1.70	19,026		
2	32,344	2.89	11,192		
3	32,344	4.91	6,583		
4	32,344	8.35	3,873		
5	32,344	14.20	2,278		
6	32,344	24.14	1,340		
7	32,344	41.03	788		
8	32,344	69.76	464		
9	32,344	118.59	273		
10	32,344	201.60	160		
		NPV of benefit	45,976	40,684	5,292

Calculation of IRR

a	lower discount rate in %	70.00	1
b	NPV difference at lower level	5291.74	5,292
c	Differences of the difference NPV	5659.67	5,660
d	Difference of discount rate in %	10.00	0.10
	Internal rate of return	a +(b*d)/c	0.79
	IRR in %	79	

Armala MUS					
NPV at 10%					
Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	30,223	1.10	27,475		
2	30,223	1.21	24,977		
3	30,223	1.33	22,707		
4	30,223	1.46	20,642		
5	30,223	1.61	18,766		
6	30,223	1.77	17,060		
7	30,223	1.95	15,509		
8	30,223	2.14	14,099		
9	30,223	2.36	12,817		
10	30,223	2.59	11,652		
		NPV of benefit	185,704	43801.3	141,903

Here difference is positive so will go for higher discount rate

NPV at 80%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	32,344	1.80	17,969		
2	32,344	3.24	9,983		
3	32,344	5.83	5,546		
4	32,344	10.50	3,081		
5	32,344	18.90	1,712		
6	32,344	34.01	951		
7	32,344	61.22	528		
8	32,344	110.20	293		
9	32,344	198.36	163		
10	32,344	357.05	91		
		NPV of benefit	40,316	43801.3	-3,485

NPV at 70%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	32,344	1.70	19,026		
2	32,344	2.89	11,192		
3	32,344	4.91	6,583		
4	32,344	8.35	3,873		
5	32,344	14.20	2,278		
6	32,344	24.14	1,340		
7	32,344	41.03	788		
8	32,344	69.76	464		
9	32,344	118.59	273		
10	32,344	201.60	160		
		NPV of benefit	45,976	43801.3	2,175

Calculation of IRR for Armala

a	lower discount rate in %	70.00	1
b	NPV difference at lower level	2174.54	2,175
c	Differences of the difference NPV	5659.67	5,660
d	Difference of discount rate in %	10.00	0.10
	Internal rate of return	a +b*d/c	0.74
	IRR in %	74	

Dharapani MUS

NPV at 10%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	9,988	1.10	9,080		
2	9,988	1.21	8,255		
3	9,988	1.33	7,504		
4	9,988	1.46	6,822		
5	9,988	1.61	6,202		
6	9,988	1.77	5,638		
7	9,988	1.95	5,126		
8	9,988	2.14	4,660		
9	9,988	2.36	4,236		
10	9,988	2.59	3,851		
		NPV of benefit	61,373	22795.6	38,578

Here difference is positive so will go for higher discount rate

NPV at 50%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	9,988	1.50	6,659		
2	9,988	2.25	4,439		
3	9,988	3.38	2,959		
4	9,988	5.06	1,973		
5	9,988	7.59	1,315		
6	9,988	11.39	877		
7	9,988	17.09	585		
8	9,988	25.63	390		
9	9,988	38.44	260		
10	9,988	57.67	173	22795.6	
			19,630		-3,166

NVP at 40%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	9,988	1.40	7,134		
2	9,988	1.96	5,096		
3	9,988	2.74	3,640		
4	9,988	3.84	2,600		
5	9,988	5.38	1,857		
6	9,988	7.53	1,327		
7	9,988	10.54	948		
8	9,988	14.76	677		
9	9,988	20.66	483		
10	9,988	28.93	345	22795.6	
			24,107		1,312

Calculation of IRR for Dharapani			
a	lower discount rate in %	40.00	0
b	NPV difference at lower level	1311.62	1,312
c	Differences of the difference NPV	4477.26	4,477
d	Difference of discount rate in %	10.00	0.10
	Internal rate of return	a +b*d/c	0.43
	IRR in %	42.93	

Malewabasne MUS

NPV at 10%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	16,557	1.10	15,052		
2	16,557	1.21	13,683		
3	16,557	1.33	12,440		
4	16,557	1.46	11,309		
5	16,557	1.61	10,281		
6	16,557	1.77	9,346		
7	16,557	1.95	8,496		
8	16,557	2.14	7,724		
9	16,557	2.36	7,022		
10	16,557	2.59	6,383		
		NPV of benefit	101,736	25155.6	76,580

Here difference is positive so will go for higher discount rate

NPV at 70%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	16,557	1.70	9,739		
2	16,557	2.89	5,729		
3	16,557	4.91	3,370		
4	16,557	8.35	1,982		
5	16,557	14.20	1,166		
6	16,557	24.14	686		
7	16,557	41.03	403		
8	16,557	69.76	237		
9	16,557	118.59	140		
10	16,557	201.60	82	25155.6	
			23,536		-1,620

NVP at 60%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	16,557	1.60	10,348		
2	16,557	2.56	6,468		
3	16,557	4.10	4,042		
4	16,557	6.55	2,526		
5	16,557	10.49	1,579		
6	16,557	16.78	987		
7	16,557	26.84	617		
8	16,557	42.95	385		
9	16,557	68.72	241		
10	16,557	109.95	151	25155.6	
			27,344		2,188

Calculation of IRR for Malewabasne			
a	lower discount rate in %	60.00	1
b	NPV difference at lower level	2188.40	2,188
c	Differences of the difference NPV	3808.49	3,808
d	Difference of discount rate in %	10.00	0.10
	Internal rate of return	a +b*d/c	0.66
	IRR in %	66	

Saurabhanjyan MUS

NPV at 10%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	6,745	1.10	6,131		
2	6,745	1.21	5,574		
3	6,745	1.33	5,067		
4	6,745	1.46	4,607		
5	6,745	1.61	4,188		
6	6,745	1.77	3,807		
7	6,745	1.95	3,461		
8	6,745	2.14	3,146		
9	6,745	2.36	2,860		
10	6,745	2.59	2,600		
		NPV of benefit	41,442	16931.5	24,511

Here difference is positive so will go for higher discount rate

NPV at 20%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	6,745	1.20	5,620		
2	6,745	1.44	4,684		
3	6,745	1.73	3,903		
4	6,745	2.07	3,253		
5	6,745	2.49	2,710		
6	6,745	2.99	2,259		
7	6,745	3.58	1,882		
8	6,745	4.30	1,569		
9	6,745	5.16	1,307		
10	6,745	6.19	1,089		
		NPV of benefit	28,276	16931.5	11,345

NPV at 30%

Year	Cash Flow	Discount Rate	Present Value	Total Initial project Cost	Difference between NPV and initial project cost
1	6,745	1.70	3,967		
2	6,745	2.89	2,334		
3	6,745	4.91	1,373		
4	6,745	8.35	808		
5	6,745	14.20	475		
6	6,745	24.14	279		
7	6,745	41.03	164		
8	6,745	69.76	97		
9	6,745	118.59	57		
10	6,745	201.60	33	16931.5	
			9,587		-7,344

Calculation of IRR for Saurabhanjyan

a	lower discount rate in %	20.00	0
b	NPV difference at lower level	11344.65	11,345
c	Differences of the difference NPV	18688.96	18,689
d	Difference of discount rate in %		0.10
	Internal rate of return	a +b*d/c	0.26
	IRR in %	26	