Scope of Payment for Ecosystem Services Mechanism for better water and watershed management in Bhaktapur

A Dissertation

Submitted For Partial Fulfillment of the Requirement for the

Degree of Master of Science in

Environmental Science

Submitted By

Medinee Prajapati

Khwopa College

Submitted To

Department of Environmental Science

Khwopa College

(Affiliated to Tribhuvan University)

Kathmandu, Nepal

March, 2012

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CONFIRMATION LETTER

Ms. Medinee Prajapati of Khwopa College completed her research and prepared a thesis entitled "**Scope of Payment for Ecosystem Services Mechanism for Better Water and Watershed Management in Bhaktapur**" under my supervision. This thesis is in Partial fulfillment for her degree of Master in Environmental Science (M.Sc) on Mountain Environment. She successfully defended her thesis at Khwopa College on 30th March 2012.

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LETTER OF ACCEPTANCE

The thesis attached hereto, entitled "**Scope of Payment for Ecosystem Services Mechanism for Better Water and Watershed Management in Bhaktapur**" prepared and submitted by Medinee Prajapati in the partial fulfillment of the requirement for the degree of Master of Science in Environment Science is hereby accepted.

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LETTER OF DECLARATION

I, Medinee Prajapati, hereby declare that this study entitled "**Scope of Payment for Ecosystem Services Mechanism for better water and watershed management including in Bhaktapur**" is based on my original research work. Related works on the topic, by other researchers, have been duly acknowledged. This work has not been published or submitted elsewhere for any academic award.

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LETTER OF APPROVAL

This dissertation entitled "**Scope of Payment for Ecosystem Services Mechanism for Better Water and Watershed Management in Bhaktapur**"submitted by **Ms. Medinee Prajapati** has been carried out under our supervision. The entire work is based on the results of her research work and has not been submitted for any other degree and organization to the best of our knowledge. We recommend this dissertation work to be accepted for the partial fulfillment of Master of Science degree in Environmental Science.

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Abstract

Bhaktapur district in Kathmandu valley has a dense human population and an acute shortage of water. The two rivers Mahadev Khola and Manohara Khola are the primary source of surface water. The company KUKL manages water collection, treatment and distribution. The town people blame the upstream communities for haphazard water withdrawal and insufficient water supply.

This research aimed to assess better understand the factors causing water scarcity problem both at upstream and downstream levels, and to seek potential solutions. Direct observation was made, Focus Group Discussion was conducted, and Key informants from upstream, town people, officials from KUKL and DFO were interviewed. Data on water supply in the town were collected from secondary sources. The study indicates on significantly decrease in water supply in recent years. The perception of decreasing water availability is because of increasing demand by increasing population, urbanization, water leakage from distribution pipes in town, and diversion of water in the upstream area.

Pine trees (*Pinus roxburghii),* planted on the hill slopes of Nagarkot forest are reported to decrease the water holding capacity of the catchment. Native "water storing trees" are believed to be better than Pine trees to retain water in the soil and to purify. Intensive agriculture (mainly for cash crops) requires much water and application of agrochemicals may affect both quality and quantity of river water. The study concludes that better management of water sources in the catchment area land and in the distribution system in town can alleviate water scarcity problem. Providing incentives to upstream communities for their role in protecting upstream forest land and water-conserving activities through a PES (Payment for Ecosystem Services) scheme will also help reduce water scarcity problem in Bhaktapur. In a PES scheme the water consumers in town can provide payment to upstream communities as incentives for conserving water (not wasting) for household use, maintaining good forest cover in catchment area , planting water holding tree species and reducing application of agrochemicals (fertilizers and pesticides) on agriculture crops.

Key words: Water, Urbanization, Ecosystem Services, PES, Participatory Rural Appraisal.

List of Abbreviations and Acronyms

CBS	Central Bureau of Statistic
CCPL	Cemeca Consultant Private Limited
CF	Community Forestry
CFUGs	Community Forest User Groups
CV	Contingent Valuation
DFO	District Forest Office
DIIS	Danish Institute for International Studies
ECA	Economics Commission of Africa
ES	Ecosystem Services
FAO	Food Agriculture Organization
FECOFUN	Federation of Community Forest Users, Nepal
FGD	Focus Group Discussion
GIS	Geography Information System
KUKL	Kathamandu Upatyaka Khanepani Limited
IAEA	International Atomic Energy Agency
ICIMOD	International Centre for Integrated Mountain Development
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
MEA	Millennium Ecosystem Assessment
MKW	Mahadev Khola Watershed
NGO	Non-Governmental Organization
PRA	Participatory Rural Appraisal
PEDRR	Partnership for Environment and Disaster Risk Reduction
PES	Payment for Ecosystem Services (or Payment for Environmental Services)
SEN	Small Earth Nepal
THD	Tongaat Hulett Developments
TU	Tribhuvan University
VDC	Village Development Committee
WTP	Willingness to Pay
WWF	World Wildlife Fund

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CHAPTER 1

1 INTRODUCTION

1.1 Background:

Fresh water is becoming a scarce resource. In fact, the scarcity of clean and fresh water is one of the world's most pressing environmental problems (Arms, 2008). With an increasing population, the welfare and changes in food consumption and lifestyle pattern have considerably increased water use. Slightly more than one-half of available fresh water supplies are currently used for human use. The world water demand doubles every 20 years (USAID, 2003). Water resources are increasingly over-exploited, influencing river discharge and groundwater level.

Water is critical to social and economic development. Over-exploitation of water resources directly affects human society, and threatens the sustainability of the natural resources base. Since 1950, world population has doubled while water use has tripled (ECA, 2006). By 2025, more than 2.8 billion people or- 35% of the world's projected population- will live in 48 countries facing water stress or water scarcity (USAID, 2003). According to the UN Water Assessment Program, by 2050, 7 billion people in 60 countries may have to cope with water scarcity (Chenoweth, 2008; Abaje *et al*, 2009). Water scarcity is emerging as one of the most pressing problems of the 21st century (ECA, 2006).

Watersheds are a source of economic goods that are vital to livelihoods and economies, and provide spaces for recreation and cultural heritage (PEDRR, 2011). The total available water in a watershed mainly depends on precipitation and internal renewable resources which are replenished by rainfall. In many places, human activities are causing watersheds to deteriorate thereby affecting water supply and its quality.

Ecosystems provide multiple direct and tangible benefits to humankind as well as intrinsic ecosystem services. Many of these ecosystem services are being degraded or used unsustainably. Over the past 50 years, watersheds namely supply of fresh water and water purification, and to a lesser extent water-regulation services, have degraded significantly (MEA 2005; Porras *et al*. 2008). The Millennium Ecosystem Assessment (M.A., 2005) states“ ecosystems control the character of renewable freshwater resources for human well-being by regulating how precipitation is partitioned into evaporative, recharge, and runoff processes”.

Among the major processes influencing water quantity and quality at the watershed scale are changes in land use intensity and land cover change. Land use changes affect evapotranspiration, infiltration rates and runoff quantity and timing. That is the reason why Payment for Watershed Ecosystem Services (PWES) -are oriented to maintain or change land uses that increase or maintain the capacity of the watershed to provide the ecosystem services desired (Escobar *et al*. 2009).

Incentives to the communities for good management of watershed areas fall within the domain of Payment for Ecosystem Services (PES). PES is a generic term for a variety of arrangements where local communities, farmers and other water and land managers are paid, rewarded or compensated for conservation activities that enhance ecosystem services. The four main ecosystem services that have been addressed by PES schemes are watershed services, carbon sequestration, landscape beauty, and biodiversity conservation (WWF, 2006).

1.2 Rationale of the Study:

Water is the most essential element for all living beings. Water catchments provide numerous essential ecosystem services including water for both urban and rural population. The increasing scarcity of fresh water is major pressing problem throughout the world. Kathmandu valley is no exception with its rapidly increasing human population and demand for fresh water. The Bhaktapur district is one of the three districts inside the valley, now has a human population of 303,027 (CBS, 2011). The district is one of the most densely populated districts in the country. There is acute and chronic supply of water in the district.

The valley water company Kathmandu Upatyaka Khanepani Limited (KUKL) manages water collection, treatment and distribution in Bhaktapur town, as in other urban areas of Kathmandu valley. For distribution in Bhaktapur, KUKL extracts surface water from two rivers Mahadev Khola and Manohara Khola and ground water form Jagati and Bode area. Water from Mahadev Khola (MK) is distributed to Ward 1 to 10 and some parts of Ward 11 and 14. Similarly MK is also a main source of water for Bageswori, Nagarkot and Sudal VDCs. The town people complain that the water supply is not sufficient and the water in the rivers is decreasing. They put the blame largely upon people living in the water catchment area for haphazard water withdrawal.

The watershed of Mahadev Khola is recharged by 7 Community Forests (CF) in 3 VDCs of Bhaktapur and Kavre Palanchowk district. The population in the 3 VDC is 15,617 in 2011 while in there are 64,810 people living in Ward no 1 to 10, parts of 11 and 14).

The water from the rivers is also used for irrigation and numerous industries near the river. The demand of water is increasing with growing population in the Municipality. The climatic condition is also affecting the hydrological cycle which is simultaneously affecting the source of the MKW, and its natural water storage potential.

The water scarcity problem in Bhaktapur town is due to the wide gap between demand and supply. The severity of water scarcity peaks during the dry season when water supply is significantly reduces due to reduced water in the rivers. A number of factors may be involved- land cover change, population increase, water usage, water extraction and climate change amongst others. It is important to understand the root reasons for the increasing water scarcity before solutions can be sought. This study focused on the key factors that have a bearing on water availability, reduces water supply, potential solutions to water scarcity problem and perceptions of upstream and town communities and relevant institutions.

The following research questions were developed prior to the commencement of research:

Research Question

1. What is the real problem (leading to water scarcity)
2. Who are the factors causing the problem?
3. What are possible solutions?
4. Can PES mechanisms be part of the solution?

1.3 Objectives of Study:

The overall objective of the study is:

to assess the water scarcity problem in Bhaktapur Municipality and to develop recommendation on how to address this.

Specific Objectives:

1. To understand the perceptions of upstream and downstream community about the water services of Mahadev Khola Watershed.
2. To assess the water status of Mahadev Khola.
3. To analyze the problem related to the water supply in Bhaktapur Municipality from Mahadev Khola.
4. To assess the potential of PES scheme to improve water services.
5. If PES appears feasible to develop, to develop recommendations for an appropriate PES scheme.

1.4 Limitations:

The study was carried out in the watershed area of the Mahadev Khola comprising of three Village Development Committees (VDCs) and in four wards of Bhaktapur Municipality that receive water from Mahadev Khola. The field work conducted from March 2011 to August 2011 covers only water services. Lack of time series data on river flow and water distribution was a limitation and 1- year (2009-2010) data of river discharge from could be used. Quality of primary data, mostly qualitative, depends on the reliability and accuracy of respondents.

The terms used in this paper: upstream used in this thesis refers to area Bageswori, Sudal and Nagarkot VDCs in the community forest. Likewise downstream refers to Bhaktapur Municipality wards (1 to 10, parts of 11 and 14).

CHAPTER 2

2 LITERATURE REVIEW

2.1 Water Scarcity

Scarcity of fresh water is emerging as one of the most pressing problems of 21st century. Slightly more than one- half of available freshwater supplies are currently used for human purposes. The world water demand doubles every 20 years (USAID, 2003). Since 1950, world population has doubled and water use has tripled (ECA, 2006). The number of people relying on the earths' fresh water reserves is increasing. The scarcity of clean, fresh water is pressing major environmental problem (Arms, 2008). Economic growth, increases in human population and water use are increasing demand for fresh water, while increasing pressure on natural ecosystems (Porras *et.al*. 2008).

2.1.1 Natural Factor

Water supply regulation is influenced mainly by rainfall, rainfall pattern, geology, land cover and, vegetation. Climate change may rainfall distribution and this can ultimately affect water runoff to rivers and lakes. Local warming with a corresponding decrease in runoff could have adverse consequences on the water demand side (Jose *et al.* 1999).

The Angat Reservoir and Lake Lanao of Philippines, which are already exposed to extreme rainfall variability and its adverse consequences, face more threats of increased climatic variability as suggested by results of general circulation model (Jose *et al*. 1999). In the Angat reservoir, runoff is likely to decrease in the future and be insufficient to meet future demands for water. Lake Lanao is also expected to see decreased runoff in the future. With the expected vulnerability of the country's water resources to global warming, possible measures to cope with future problems facing the country's water resources are identified by Jose et al. (1999).

China has been facing increasingly severe water scarcity, especially in the northern part of the country. Its water scarcity is characterized by insufficient quantities of water because of uneven spatial distribution of water resources that has dramatic effects on society and the environment (Jiang, 2009). Natural condition of water resources represents the physical limit to which China needs to adopt in its development. Hence, improving water resource management seems to be a cost effective (Jiang, 2009).

The quantity of urban water supply is decreasing and the quality of available water is degrading in Nepal. The situation is further exacerbated by climate change. Climate change that degrades water quality and quantity is an emerging challenge to urban water management. Pumping of water and boiling ultimately adds carbon dioxide emission. Hence ensuring continuous supply of safe water by applying Water Safety Plan is necessary. National water quality database should be made and used rationally by making reference laboratory (TU and SEN, 2011).

2.1.2 Human Factor and Landuse Change

All living beings required water to survive. Humans need about 115 liters per person per day. The actual amount used may greater depending on the ease and convenience of supply (Ayoade and Oyebande. 1983; Abaje *et al*. 2009). The international consumption figures released by the 4th World Water Forum (March, 2006), indicate that a person living in an urban area, uses an average of 250 liters/ day; but individual consumption varies widely around the globe (THD, 2007; Abaje *et al*. 2009). Moreover, even as the world's human population grows, the limited easily accessible fresh water resources in river, lakes and shallow ground water aquifers are dwindling as a result of over exploitation and water quality degradation (IAEA, 2004 ; Abaje *et al*. 2009). Some examples of problem of water management and possibilities for integrate management in the urban areas are:

The city of Dar es Salaam in Tanzania, an East African country along the coast of the India Ocean, has an estimated population of about 1.5 million people. The increasing population has stretched to the limit provision of utilities. There are frequent interruptions in water supply in city. There is a lot of wastage of water in the city's distribution system due to faulty valves, broken pipes, and lack of metering facilities. Water management of urban areas was vested in municipal councils. There is a need for integrated master plan and funding for the rehabilitation of water system in urban areas (Gondwe, 1990).

The northern part of China is facing water scarcity. Supplied water is insufficient and of poor water quality with serious effects on society and the environment (Jiang, 2009). Rapid economic development combined with population growth and urbanization triggers the potential conflict between water supply and demand. Effective water resource management is a promising approach that can help alleviate China's vulnerability especially when water scarcity is more severe in the future. Water right institutions, market based approaches, and capacity building should be the government’s top priorities to address the water scarcity issue (Jiang, 2009).

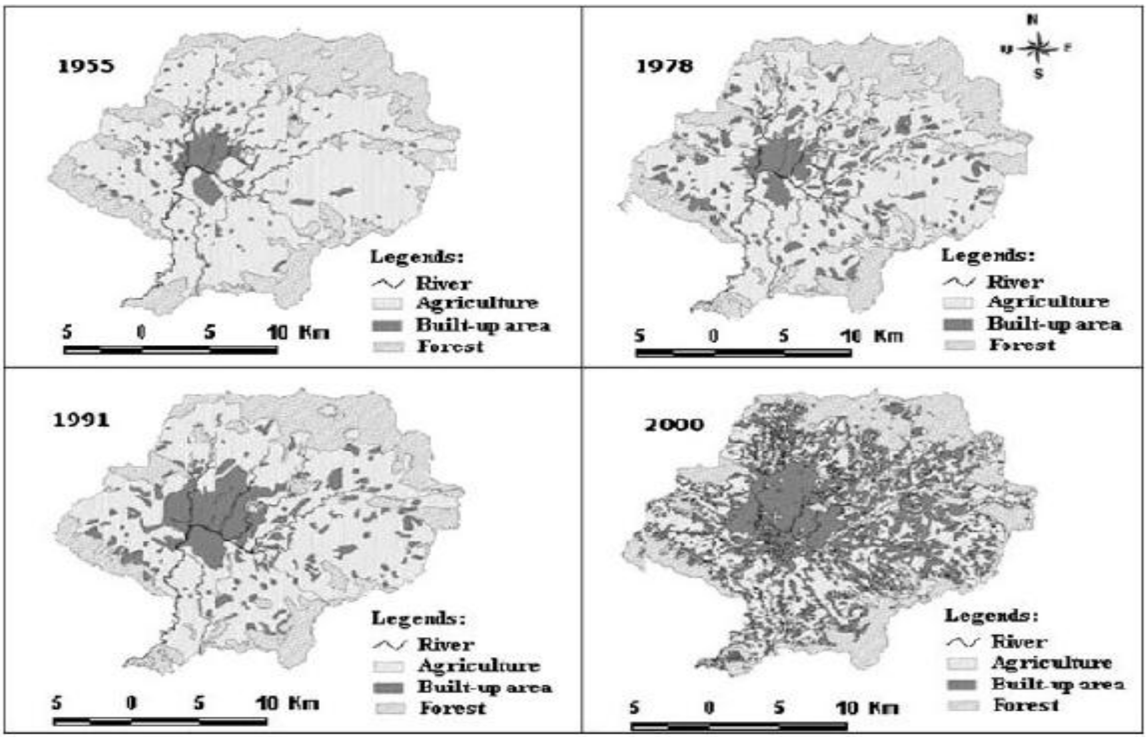
The role of water in modern society such as the urban centers of Nigeria cannot be over-emphasized. In Jema’a Local Government Area of Kaduna State of Nigeria, it is not possible to meet the water demand because of its increasing population, standard of living, and inadequate power supply, poor state of equipment, and reckless over-consumption and misuse of water (Abaje *et al*. 2009). Most of the people who have piped water supply in their houses are not satisfied with less than 2 hours of supply a day making it necessary to seek alternative sources of water. The poor water supply situation also responsible for prevalence of water borne diseases in the area. The situation may improve with a deliberate policy on water and sanitation particularly a policy on acceptable safety levels (Abaje *et al.* 2009).

Disposal of solid and liquid waste, encroachment upon river waterways and water extraction are major causes of river degradation in urban areas. The major causes of river degradation in Bhaktapur include upstream water extraction, disposal of untreated urban sewerage and solid waste directly into the river, development of urban infrastructure and services without consideration of the river environment. There is a lack of recognition of river conservation and restoration in urban development planning (Sada, 2010).

The quantity of urban water supply is decreasing and the quality of available water is degrading in Nepal. There is 40% leakage in municipal water supply system due to ill-distribution systems due to poor distribution system and maintenance. The leakage is a big challenge to water distribution system. Unplanned settlements, river banks as open toilets, haphazard disposal of solid waste, and diversion of water from upstream regions, sand mining and river bank encroachment exacerbate the problem. For sustainable urban water management, a better option is the use of public private partnership at a larger scale. Safe water and sanitation to all citizens can be ensured by making these a fundamental right in the new constitution of Nepal with good implementation mechanism (TU and SEN, 2011).

Change in Landuse Pattern

Kathmandu valley has witnessed dramatic changes in the landuse pattern over the last few decades which have been largely due to the rapid growth of urban population. Pradhan and Perera (2005) reported that the build-up area in the valley expanded fivefold from 3,330 ha in 1955 to 16,472 ha in 2000. Similarly, Haack and Rafter (2006) reported that the increase in the urban area between 1978 and 2000 has been over 450 percent. A pattern of urban growth in Kathmandu valley from 1955 to 2000 is shown in Figure 2.1 which clearly reflects that much of the changes in the rate of urbanization have occurred between 1991 and 2000 (Sada, 2010).



(Source: Pradhan and Perera, 2005)

Map 2.1: Land use change in the Kathmandu Valley from 1955 to 2000.

The contribution of landuse changes to water pollution links through the changes in the local hydrology. Conversion of open land and areas under vegetation cover to buildup areas is known to increase the rates of overland flow and reduce the soil infiltration and groundwater recharge, resulting to decline in the groundwater level. According to Metcalf and Eddy (2000), the groundwater level has dropped from 9 meters to as low as 68 m in the valley over a few years (Sada, 2010).

2.2 PES Theory

A watershed is the area of land that feeds water into a river, through the process of precipitation draining through the landscape, into tributaries and into the main river channel. Watersheds are also called ‘catchments’, ‘drainage basins’ or ‘river basins’. The various components that make up the landscape within a watershed, for example forests, grasslands, cultivated areas, riparian areas and wetlands form groups of ecosystems. These are defined as the benefits obtained from the ecosystems within a watershed that support downstream water users, including ecosystems (Smith *et al*., 2006).

Watersheds provide a wide range of goods and services to both urban and rural population and play an important role in supporting urban life and development. Watersheds are also a source of economic goods that are vital to livelihoods and economies, and provide spaces for recreation and cultural heritage (PEDRR, 2011).

Table 2.1: Key water-related services in a typical watershed

1.Provisioning services Services focused on directly supplying food and non-food products from water flows	• Freshwater supply
	• Crop and fruit production
	• Livestock production
	• Fish production
	• Timber and building materials supply
	• Medicines
	• Hydroelectric power
2.Supporting services Services provided to support habitats and ecosystem functioning	• Wildlife habitat
	• Flow regime required to maintain downstream
3.Cultural and amenity services Services related to recreation and human inspiration	• Aquatic recreation
	• Landscape aesthetics
	•Cultural heritage and identity
	•Artistic and spiritual inspiration
4.Regulating services Services related to regulating flows or reducing hazards related to water flows	• Regulation of hydrological flows (buffer runoff, soil water infiltration, groundwater recharge, maintenance of base flows)
	• Natural hazard mitigation (e.g. flood prevention)
	(Source: Smith *et al*. 2006)

Payment for Ecosystem Services or PES is a novel mechanism in which 'providers' (or sellers)of environmental services are rewarded (paid) by consumers or beneficiaries of these environmental services. There is increasing interest in PES and incentive-based mechanisms with growing demand of food drinking water and energy combined with pressure on natural resources in most parts of the world. The PES terminology is applied to a wide range of very diverse situations and there is no single definition of PES. In an attempt to formally define PES and clarify the concept, Wunder (2005) proposed a set of five basic principles:

A PES scheme is:

1. A voluntary transaction where
2. A well-defined environmental service (or a land use likely to secure that service)
3. Is being "bought" by at least one buyer
4. From a (minimum of one) environmental service provider
5. If, and only if, the environmental service provider secures environmental service provision (conditionality)

For a payment scheme to succeed and endure, the actions and change brought by upstream land and water managers should result in identifiable benefits for downstream water users. Therefore, clear cause-and-effect relationships between upstream land and water use practices and the provision of watershed services for downstream users needs to be identified. The degree to which this is possible varies considerably from case to case. Negotiations among buyers and sellers of watershed services can take many years. To complete these negotiations successfully, facilitators and stakeholders have to develop a shared understanding of the diverse interests, assets, capacities and power of the players. The aim should be the formation of an agreement that specifies the design and rules for operating a payment scheme that is effective, efficient, enforceable, transparent, equitable and sustainable (Smith *et al*. 2006).

Noordwijk et al. (2007) proposed four criteria for an effective PES mechanism(Table 2.2) under two broad components- efficiency and equity.

Table 2.2: Four dimensions and 12 sub- criteria for compensation and reward mechanism for ecosystem services.

	Stage	Criteria	Sub-criteria
A. Effectiveness, Efficiency and Sustainability			
a. Realistic	Scoping	Effectively mitigates, reduces or avoids threats to ES for all parties involved	1. A broadly shared perception of ***cause–effect*** relation links ***threats*** to ES, to potential ***activities to reduce or avoid*** these threats by identifiable actors at a relevant temporal and spatial scale
			2. The ***value*** to ES-beneficiaries of reduction or avoidance of the

			threats, relative to alternative ways to meet their needs, is ***substantive*** (within the context of the key actors)
			3. There are ***opportunity costs*** and/or ***resource access constraints*** for the potential 'ES providers' that can be off-set or overcome without major negative 'external effects'(leakage)
			4. The threat to the ES and its reduction (or avoidance) by ES providers can be ***assessed*** and ***monitored*** in a transparent way, as a basis for conditional incentives
b. Voluntary	Stake-holder analysis	Engagement involves choice rather than being the object of regulation	5. Legitimacy at individual level: representation is subject to checks and balances
			6. Effective voice of all stakeholders is heard; ***free and prior informed consent*** principle apply
			7. ***Adaptiveness*** of the mechanism includes a time frame for review and exit strategy
c. Conditional	Negotiation and implement-tation	Service and rewards or compensa-tion are dynamically linked	8. ES-reward agreements strike a balance between outcome-based rewards, targets for agro-ecosystem conditions, activity-centered incentives, support for community-scale resource management and establishment of trust
			9. Sanctions exist to deal with non-compliance by contract partners, within the human and legal righs of both side (linked to exit strategy in 7)
			10. ES reward agreements acknowledge the potential of ***environmental variability*** and change, 'third-party roles' (incl. climate change) to affect the ecosystem and its ES provision
B. Equity			
d. Pro- poor	All stages	Mechanisms selected are	11. ES reward mechanisms support 'sustainable development'

		positively biased towards disadvant-aged stakeholders	pathways out of poverty for achieving Millennium Development Goals, by addressing the priorities (and criteria….) of ' poor' stakeholders
			12. ES reward mechanisms reduce asset insecurity (including access to land)
(*Source:* Noordwijk *et al*. 2007)			

2.2.1 PES examples

A PES programme was developed and implemented by Vittel (Nestlé Waters), a mineral water company in north-eastern France, in order to address the risk of nitrate contamination caused by agricultural intensification in the aquifer. The world leader in the mineral water bottling business is financing farmers in the catchment to change their farming practices and technology. Main conclusion is that establishing PES may need to be complemented with other approaches to address urban based non-point source pollution (sourcea; Perrot-Maître, 2006).

A PES scheme was implemented in Houay Xon watershed of Luang Prabang province of Laos PDR to improve the quality and flow of a small mountain. However, at the whole catchment scale, major obstacle to the immediate implementation of a PES scheme were i) a lack of clear relationship between environmental services, users and providers, ii) insufficient willingness to pay (WTP) among water users (approx. USD 0.3/month/household) to maintain water quality along the stream through waste management and iii) absence of a critical mass of buyers. A precondition of successful implementation of PES in the area is to the awareness of environmental issues in the concerned communities (Mousquès *et al.* 2007).

The area of the Cidanau Watershed in Indonesia is facing water problem. The encroachment of forest area which has degraded the function of catchment area and application of fertilizers and pesticides in farms pollute water. PES implementation has produced some benefits to the environment and the income of farmers involved in the project. Following PES, there is a reduction in illegal logging, increase in tree cover and better application of conservation farming and higher household income (Budhi *et al.* 2008).

Bungo district, Jambi province in Indonesia, is surrounded by three national parks. From late 1980s, the district has been severely deforested and forest have been replaced by rubber and oil palm plantations, as well as other agricultural land uses. Some farmers plant rubber seedlings in the gaps cause by death of rubber and non-rubber trees, it is less labour intensive and does not require much capital investment and continuous income generating. In 2004, ICRAF initiated a PES pilot project in Bungo district in order to conserve the rich biodiversity inside the complex rubber agroforests. RUPES project carried out rapid biodiversity assessment in the district and found that the biodiversity inside such area is normally very high, comparable to surrounding forest. The incentives local peoples included support to establish micro- hydro power plants, setting up of rubber nurseries and demonstration plots of improved rubber agroforests, and clonal plants of high yielding rubber trees for intensively managed rubber gardens elsewhere (Joshi, 2008)

A pilot study was conducted in Yunan province of China, that aimed to identify the main ecological and environmental services, and the most appropriate payment schemes to provide incentives to landholders for continued ecosystem services (Sgobbi *et al*. 2008). The downstream waters of the Lashihai wetland, Lijiang city play an important landscape function and improved agricultural practices around the lake can thus benefit the city through improved water quality bird' biodiversity. The study noted that a PES solution to the problem is more likely to be cost effective and politically acceptable than an engineering solution involving water diversion to Lashihai Lake. The general lessons can be drawn from this study: first of all, whenever possible, it is advisable to use existing institutions and payment vehicles; secondly awareness campaigns are a necessary strategy to ensure acceptance of, and compliance with, the scheme; thirdly, a clearly defined monitoring strategy needs to be in place, and the participation conditions must be transparent and adhered to; finally – and given the experience elsewhere in China – it is of the utmost importance to exploit fully one of the most attractiveness characteristics of PES schemes, that is, their potential financial sustainability. (Sgobbi *et al*. 2008).

A majority of East African nations rely heavily on hydropower for their energy needs. Climate change experts predict significant changes to total precipitation and seasonal weather patterns in this area. Feasibility of PES schemes in a major Rwanda watershed as both a tool for community vulnerability reduction and for energy sector resilience to climate change impacts has been investigated. Primarily, it gives physical value to specific resource improvements. Secondly, PES reorganizes funding streams towards particular environmental objectives using positive incentives. In effect, it can develop a sustainable, locally-driven, conservation funding mechanism. Successful implementation of watershed PES in Rwanda will depend on careful scheme design and persistent trust-building in order to harmonize wetland inhabitant and electric utility needs (Willetts, 2008). Findings show that Rwandan decision-makers will need more hydrologic data to make ecologically informed and efficient decisions and to set targets. With several necessary conditions in place, watershed PES in Rugezi may be a feasible tool for climate change adaptation and energy sector resilience (Willetts, 2008).

For protecting and managing the lower basin of the Reventazón watershed in eastern Costa Rica, an empirical research was done on the demand and financial sustainability of local PES programmes as an incentive-based policy instrument. Using a dichotomous choice Contingent Valuation survey, it was noted that the local demand is not an obstacle for developing PES schemes for protecting watershed and associated ecological services. Further studies and analyses may help to determine the extent to which local and national institutional settings contribute to the potential demand for local scale PES programmes (Ortega-Pacheco *et al*. 2009)

2.2.2 PES in Nepal:

Piped water supply is the most common source of drinking water in Kathmandu valley in Nepal. The water collection, treatment and distribution is managed, by Kathmandu Upatayaka Khanepani Limited (KUKL), a state managed company. Water scarcity has become a serious problem for the people in the valley both in terms of quantity and quality, because of the rapid growth of population and urbanization. The research, repoeted by Kandel (2007), dealt with the willingness to pay (WTP) for improvements in the drinking water quality. To estimate the residents‟ WTP, the study employed the Contingent Valuation (CV) method. The mean monthly expenditure incurred by the households for the water buying and treating found out to be Rs 388.08 (1USD= 82NR). And the maximum WTP for the improved water quality found out to be Rs 518.6. The statistical mean ratio of WTP to monthly water expenditure turned out to be Rs 1.85. The research estimated that the people are willing to pay almost two times current water expenditure to get the improved quality water in their tap (Kandel, 2007).

The Churia hills in Nepal are under severe threat from human interference and natural factors. A study to estimate the economic value of selected goods and services, and to assess the possibility of PES mechanism for a local self sustaining conservation financing watersheds across the length of the Churia. Non Timber Forest Products were valued using opportunity costs as well as market values, while the water used in agriculture was valued using residual imputation method. Though hydrological relations could not be established scientifically, there are other positive signs indicating the possibility to PES-like innovating financial mechanism (Karn, 2008).

Kathmandu valley population receives 40% of its drinking water from Shivapuri National Park, which provides numerous ecosystem services among which drinking water supply and water purification occupy the highest value and that is US $112/ha/yr, which is significantly higher than global estimates. Valuations methods applied to calculate the value was by using current water price and avoided cost methods. A survey carried out among Kathmandu people showed that people give more importance to water services, feels responsible to protect and conserve these water sources and are willing to pay 1% of their average monthly income (US $300/month). The study indicate ample investment opportunities for watershed protection that lie within the national park and its surrounding areas through PES (Maskey, 2008).

Sundarijal Watershed in Shivapuri National Park provides watershed services to Kathmandu Valley in terms of both Hydropower generation and drinking. An MSc research (Niraula, 2008) focused on the valuation of these services. The study concludes that there are significant, benefits from hydropower generation and drinking water sevices as there good potential to implement PES schemes to promote livelihood supporting incentives to upstream villagers, to engage local communities for conservation activities (Niraula, 2008).

After decades of destruction and deforestation since the nationalization of all forests in 1957, the forests of Kulekhani watershed in Makwanpur district now managed by local communities as community forests. The Kulekhani watershed is the source of water to hydropower plants and downstream fields. Earlier hydropower plant, suffered from a rapid loss in capacity of the reservoir because of siltation. A PES scheme was developed in which part of the royalty paid by the hydropower plant is used to reward the community forestry user groups for maintaining a good forest cover in the catchment that reduce the siltation problem (Joshi, 2009).

There are numerous indigenous PES- like mechanisms in the hillsof Nepal mostly for the protection of water sources in upstream forests to ensure consistent supply of good quality water used by downstream consumers. Examples of such PES mechanisms include water collection and distribution systems in:- Dhulikhel, Dolakha and Gorkha (Pers. _Comm._ Dr. Laxman Joshi, ICIMOD).

CHAPTER 3

3 STUDY AREA

3.1 Bhaktapur District

Bhaktapur is located in the easterm rim of Kathmandu Valley; it is 13 km east of Kathmandu capital of Nepal, and also known as Bhadgaon or ‘ the city of devotees’. It lies between 85^o 21’ to 85^{o}32’ E longitude and 27^{o}36’ to 27^{o}44’ N latitude on Nepal, has an area of 119 km. The topography of Bhaktapur is with high hills in east and low land in west respectively so the origin of rivers is east hills. The district is surrounded by Kavrepalanchowk in east, Kathmandu in west and north and Lalitpur in south (CBS, 2001).

3.1.1 Administrative Division

Bhaktapur District covers an area of 119 sq. km and comprises of two municipalities viz. Bhaktapur Municipality (6.88 sq. km) and Madhyapur Thimi Municipality (11.47 sq. km) and 16 Village Development Committees. Bhaktapur Municipality has 17 Wards out of which Ward 4 is the largest and Ward 9 is the smallest. On the basis of the nature of land, it has been divided into two district geophysical zones viz. hills and valley floor. The population of the district is 3, 03,027 in 2011(CBS, 2011). In 2001 the population was 2, 25,461 (CBS, 2001), with an urban population of 1, 20,294. In the last 10 years, the district population has grown by about 34%.

3.1.2 Climate

The climatic condition varies to a greater extent in view of several geographical factors. The district falls under the subtropical climatic region where the climate is fairly pleasant, generally rainy season starts in June and ends in September, average precipitation is 1400 mm. The general climatic condition is cold in winter and hot in summer with average minimum temperature of -2^{o}C and average maximum temperature is 35^{o}C (CBS, 2001).

3.1.3 Land use

Eighty percent of land of the district is suitable for agriculture; irrigated paddy production is dominant, in terraces up the slopes. The natural vegetation is dictated by the climatic conditions and vegetation zone of Kathmandu valley fall under the Deciduous Monsoon Forest Zone. The dominant species under this zone comprises of oak, elm, beech, maple and so forth with coniferous trees at higher elevation (CBS, 2001).

3.1.4 Water source and scarcity

Numerous rivers in Kathmandu valley flow through Bhaktapur district. Among them, Hanumante and Manahora are the major rivers. Besides rivers, district is rich in ponds and *dhunge dhara* (stone spouts). There are 87 stone spouts, 220 wells and 7207 piped lines (185 taps) (Diwakar *et al*, 2007) in district. Bhaktapur is dependent upon the wells, stone spouts, tube wells and taps water to fulfill their daily water needs. The water supply schemes generally use river water and some tube wells for drinking purpose in the municipality. Water in town is supplied from Manohara and Mahadev Khola as surface water sources, and Manohara, Bode, Mahadev Khola and Jagati are mainas ground water sources (KUKL, 2011).

Generally, drinking water supply facility is also available to all settlements of upstream area namely Bageshwori, Sudal and Nagarkot VDCs. The water supply schemes generally use spring sources located at higher altitudes. The water is conveyed through pipes from the sources to public taps using gravity flow. These taps are located in common places to serve the surrounding households. There are also private taps distributed in the project area in the settlements like Jitpur, Dwaretol, Kalihopi and so on. Irrigation facility is not available in most settlements. Irrigation is possible only during rainy season in the project area (CCPL, 2010).

The storage capacity of the Bansbari water treatment plant is 4.9 ML/d (KUKL). Mahadev Khola supplies about 4.5 ML/d of water in wet season and 1.5 ML/d in dry season. The total water demand for municipality is 8 ML/d (KUKL, 2011) indicating a clear deficit of water. Therefore, there is conflict for water that is likely to increase in future due to population and changing lifestyles.

3.1.5 Mahadev Khola Watershed

Mahadev Khola Watershed (MKW) is located in the eastern region of the Bhaktapur District. Mahadev Khola is a spring fed mid hill (Mahabharat hill) stream, originating from Mahadev Pokhari, located at Nagarkot. Mahadev Khola flows between Nagarkot and Bageswori Hill to the west until it reaches Sudal and then flows in south westerly direction. The river is about 10 km long; the area of catchment is 11 km^2 and annual water yield is 19 million cubic meters (Sada, 2010). Its elevation ranges from 2152 meters above sea level at the Nagarkot hill to 1387 meters above the sea level. The river then flows as the Hanumante River to unite with Bagmati River at Imadol in Lalitpur.

Mahadev Khola is recharged by community forests of Bageswori VDC, Nagarkot VDC, Sudal VDC and part of Kavrepalanchok district.

The stream has been dammed by weir in Bageshwori VDC for Mann Pokhari (pond) that is used for supplying drinking water inside Bhaktapur Municipality. Since many years the water treatment plant in Bansbari treats water from Mahadev Khola to supply water in the town. The design capacity is 4,900 m^3/day, but this plant is not provided with a chemical feeding facility. Raw water flows directly into the sedimentation basin without addition of coagulant. Especially when the turbidity of water is high during the rainy season, the sediments also flows directly into the filter basins. There are 3 filter basins but due to the lack of washing equipment, washing to filter materials is manually performed by removing them from the basins. For disinfection, bleaching powder is added to the reservoir. The residual chlorine was found to be about 0.1ppm in the dry season, but less than o.1 ppm in the rainy season (JICA, 1990).

3.1.6 Geology

The shape of the watershed is leaf shaped. The district falls in the lesser Himalaya Sediments zone that comprises rocks such as quartzite and schist. In general, soil type along the alignment can be classified as alluvial, colluvial and residual (CCPL, 2010).

3.1.7 Community Forestry

The Forest Act 1961 that was first amended in 1978 signaled a major change in forest policy from government management to community to community ownership. In 1982, the community forestry legislation and decentralization act was passed and plans were made to increase local forestry rights. Nepal gained democracy in 1990, and the popularly elected government acted in 1993 to hand over forest management rights to forest user groups (FUGs) (SANDEE, 2004). District forest office of Bhaktapur was established in 2042 for the conservation of ecosystem services provided by the forest and its management. This forest office includes 4 range posts,

1. Telkot range post
2. Nagarkot range post
3. Suryabinayak range post
4. Dadhikot range post

   The watershed lies in Nagarkot Range posts, it contains 19 CF, 2 PF and 4 VDCs. Bageswori, Sudal, Nagarkot, Chitapol and Tathali.

Table 3.1: CF recharges MKW

S.N	Name of CF	Address/ Ward no.
1.	Bahal CF	Bageswori-3,4,5
2.	Bahal CF	Bageswori-5,6
3.	Bahal CF	Sudal -7
4.	Mahamanjushree CF	Sudal -6
5.	Aindada CF	Nagarkot- 1,2,3,6
6.	Lakhane CF	Nagarkot -7,8
7.	Dhunge Pakha and Nala Tukucha CF	Bhaktapur -8 and Kaver -5
Source: District Forest Office Bhaktapur 2011		

According to the report of Bhaktapur District Forest Office 2011, most of the forests of Bhaktapur were handed over to Community in 1990s.

The vegetation and wildlife found in the watershed are as follows:

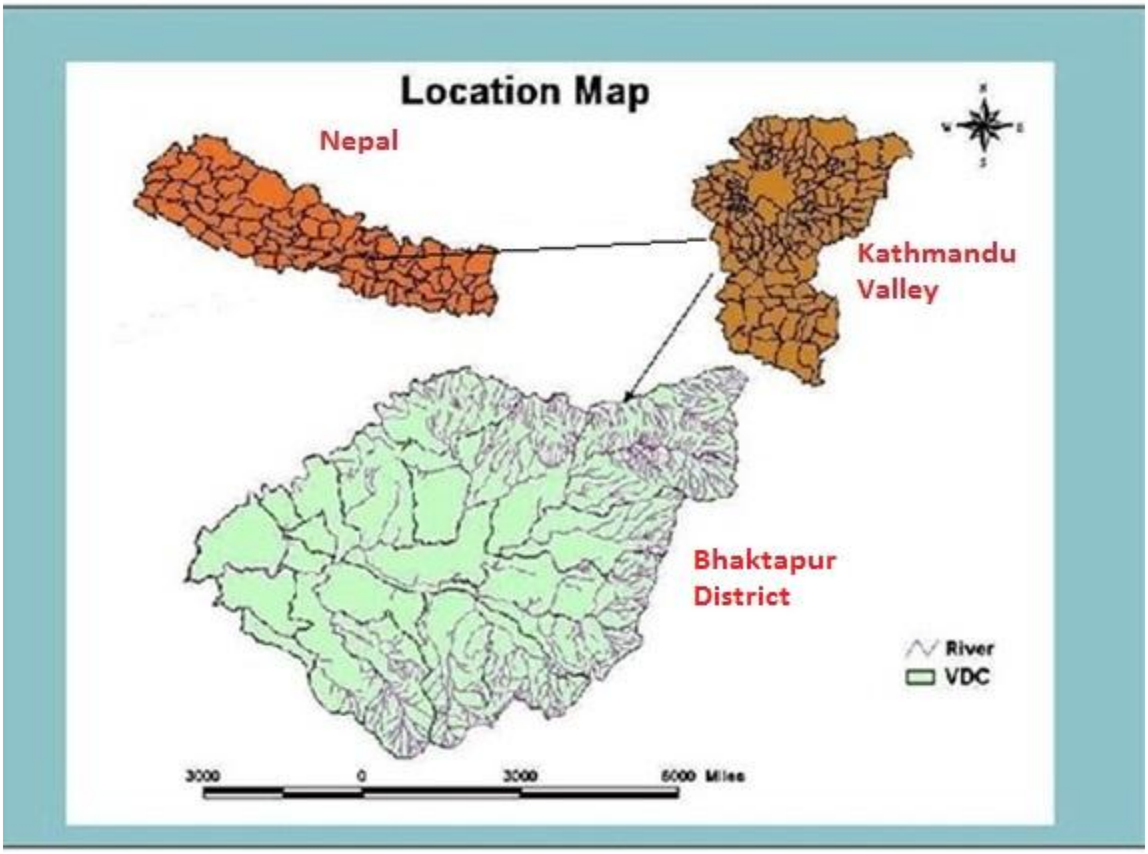
I. Vegetation

The dominant forest and fodder species reported are *Alnus nepalensis* (Uttis), *Schima wallichii* (Chilaune), *Pinus roxburghii* (Khote Salla), and *Castanopsis indica* (Katus). Other plant species found are *Buddleja asiatica* (Bhimsen pati), *Litsea monopelata* (Kutmiro), *Ficus semicordata* (Kanyu), *Lindera neesiana* (Siltimur), *Fraxinus floribunda* (Lankuri), *Prunus cerasoides* (Painyu), *Ficus religiosa* (Pipal), *Choerospondias axillaris* (Lapsi), *Bahunia purpurea* (Tanki), *Bahunia variegate* (Koiralo), *Albizia labbeck* (Sirish), *Bassia latifolia* (Mauwa), *Pisidium guyava* (Amba), *Saurauia nepaulensis* (Gogan), *Drepanostachyum intermedium* (Nigalo), *Dendrocalamus strictus* (Bans), *Maesa chisia* (Bilaune), *Urtica dioca* (Sisnoo), *Vitex negudo* (Simali), *Lyonia ovaliforiya* (Angeri), *Woodfodia fruticosa* (Dhangeri). The main NTFP species found are *Lindera neesiana* (Siltimur), *Asparagus racemosus* (Kurilo), *Azadirachta indica* (Neem), *Gaultheria fragrantissima* (Dhasingare), *Solanum surattense* (Kantakari), and *Rubia manjith* (Majitho) (CCPL, 2010).

II. Wildlife

Muntiacus muntijak (Barking deer), *Hystix indica* (Porcupine), *Canis aureus* (Jackal), *Macaca mulatta* (Monkey), *Sus scrofa* (Bandel), *Felis chaus* (Jungle Cat), *Macacca mulatta* (Bandar), *Rattus rattus* (Musa), *Martes flavigula* (Malsanpro), *Ratufa* spp.(Lokharke), *Herpestes edwardsi* (Nyauri Musa), *Vulpes montana* (Fyauro) are the wild animals reported in the forests of proposed road area. Similarly birds are *Lophura lencomelana* (Kalij pheasant), *Columba livia* (Pigeon), *Corvus splendens* (Kag), *Passer domesticus* (Bhangero), *Streptopelia* spp. (Dhukur), *Gallus gallus* (Jungle fowl), and

Psittacula kramen (Suga). However, none of these wild lives are endangered species (CCPL, 2010).



Map 3.1: Location of Study Area in Nepal

(*Source*: Sada, 2010)

Map 3.2: Study area in Bhaktapur district

(*Source*: Google Earth Image, July15, 2011)

Map 3.3: Hanumante Basin in Bhaktapur district and Mahadev Khola Watershed

(*Source:* Sada, 2010)

CHAPTER 4

4 MATERIALS AND METHODS

4.1 Methodological Framework

The methodological framework adopted in the course of the study is illustrated in Figure 4.1. The methodology involved extensive review of secondary sources of information and consultation with stakeholders that led to identifying the research questions, setting out the study objectives and identifying the appropriate sets of tools of inquiries. A number of methodological tools were then used in collecting primary and secondary information relevant to the objectives of the study.

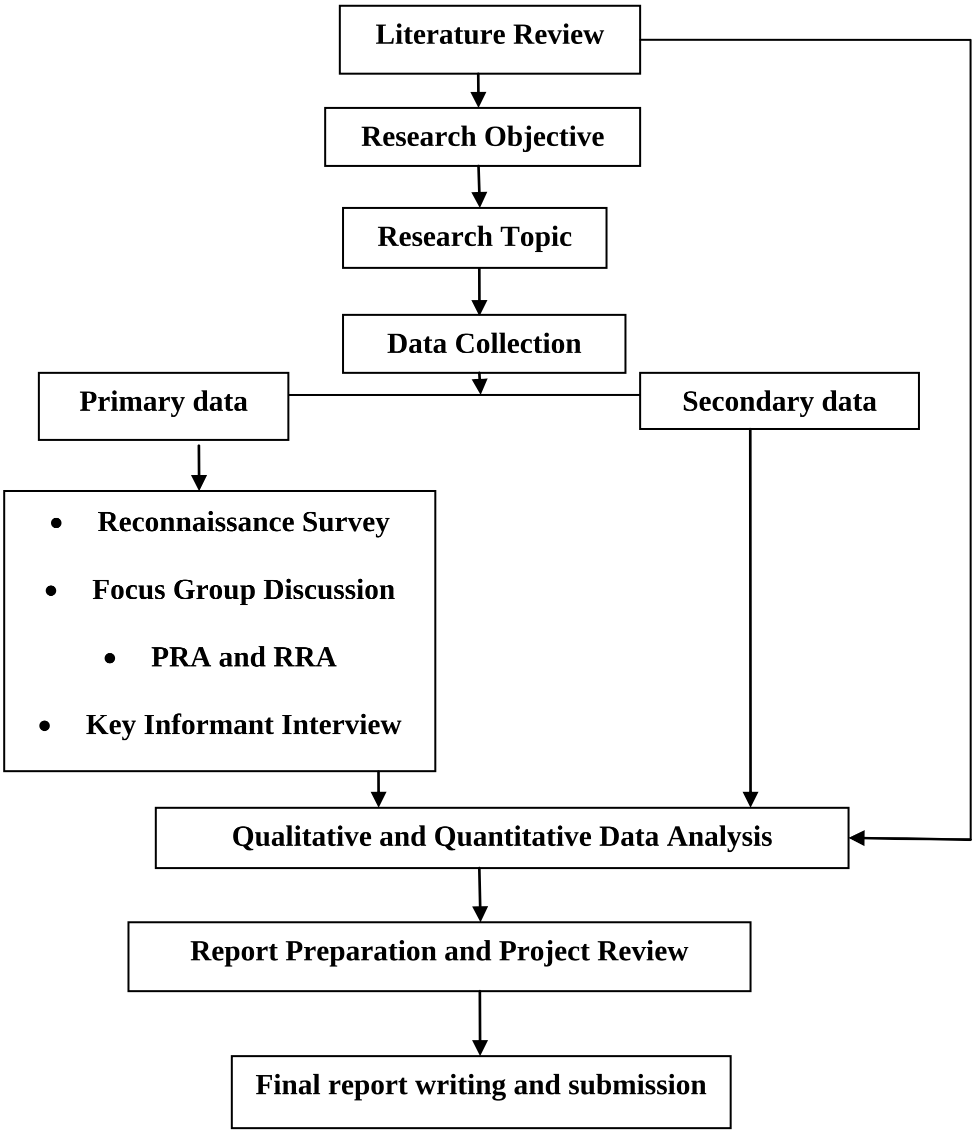


Figure 4.1: Methodological Framework of the study

The methodological tools adopted in the course of exploring specific set of information leading to achieving the study objectives are illustrated in Table- 4.1. These tools were identified based on a rigorous analysis of their strength in capturing specific set of information needed to achieve the study objectives. In selecting the specific tools, the limitations of the resources available for the study were also taken into account.

Table 4.1 Objectives and respective Methodological Tools

Objectives	Research Tools
1. To understand the perceptions of upstream and downstream community about the water services for Mahadev Khola watershed.	• Field Visits • Focus Group Discussions • Key informant surveys
2. To assess the water availability for use in Bhaktapur Municipality.	• FGDs • Key informant surveys • Secondary Data
3. To analyse the problem related to the water supply in Bhaktapur Municipality from Mahadev Khola.	• FGDs • Key informant surveys • Secondary Data
4. To assess the potential of PES scheme to improve water services.	• FGDs • Secondary Data • Literature Reviews
5. To develop recommendation for developing the appropriate PES scheme.	• Literature Reviews

4.2 Data Collection for Research

The research strategy used for collection and analysis of both primary and secondary data:

A. Primary Data

Primary data were received from direct observation, key informant interview (11) and Focus Group Discussion (FGD) and other Participatory Rural Appraisal (PRA) techniques

- Nagarkot Yandada Samudaik Ban Upobhokta Samitee,
- Bal Samudaik Ban Upobhokta Samitee,
- Bal Samudaik Ban Upobhokta Samitee,
- Canteen workers of Khwopa College (Byashi and Lalachhe),
- Kamal Binayak Pokhari tatha Mandir Parisar Sudhar Samiti (Kamal Binayak) and
- Liwali Awas Chhetra Bikash Samiti (Liwali).

B. Secondary data

Secondary data were collected from student thesis, journal articles, reports, books and from different government and non- governmental organizations such as: Kathmandu Upatyaka Khanepani Ltd. (KUKL), Federation of Community Forest Users Nepal (FECOFUN), and District Forest Office (DFO), Cemeca Consultant Limited. Japan International Cooperation Agency (JICA), International Union for Conservation of Nature (IUCN), International Centre for Integrated Mountain Development (ICIMOD), Danish Institute for International Studies (DIIS), World Agroforestry Centre, World Wide Fund (WWF) , Tribhuvan University (TU) and Small Earth Nepal (SEN).

4.2.1 Data analysis

Analysis of data involved the verification of problems, logical organization of data and presentation of data.

The data analysis procedure included:

- Analysis of land use change in the MKW with the help of Arc GIS 9.3 and from data available from different report.
- Analysis of data available from KUKL and information obtained from direct observations, focus group discussion, key informant survey with different stakeholders and different journal and reports. Overall findings obtained were analyzed from the different level and MS Excel was used to analyse the data.

4.3 Methods of Data Preparation

Direct Observation

Direct observations from the field were taken for the purpose to perceive the natural condition of the watershed.

Focus Group Discussion

The group discussions with upstream and downstream were conducted by consulting residential people and the organization related with development. For discussion groups were formed in 3 VDCs of upstream area, water available area and water scarce area in downstream with the help of residential people. Following are the dates, wards, number of participants and concern organizations for discussion in upstream and downstream respectively: (Annex 6)

Table 4.1: FGDs in Upstream area

Upstream				
S N	Date	Ward No.	No. of participants	Concern organization
1	26/07/2011	7	7	Nagarkot Aaindada Samudaik Ban Upobhokata Samitee
2	30/07/2011	7	24	Bal Samudaik Ban Upobhokata Samitee
3	3/08/2011	6	21	Bal Samudaik Ban Upobhokata Samitee

Table 4.2: FGDs in Downstream area

Down stream				
S N	Date	Ward No.	No. of participants	Concern organization
1	02/06/2011	5 and 10	7	Canteen workers of Khwopa College (Byashi and Lalachhe)
2	12/06/2011	4	10	Kamal Binayak Pokhari tatha Mandir Parisar Sudhar Samiti (Kamal Binayak)
3	30/06/2011	2	18	Liwali Awas Chhetra Bikash Samiti (Liwali)

Key informant interview

The officers of KUKL of Bhaktapur and Kathmandu, DFO of Bhaktapur and Kathmandu, Forest guard of Bhal Ban ward number1, 2, 3, and resident people of Municipality helped for the information. Altogether 11 key informants were interviewed from the different organization and local people (Annex 6).

CHAPTER 5

5 RESULTS

5.1 Ecosystem services

Table 5.1 : Important Ecosystem Services

SN	Upstream	Downstream	DFO
1	Fresh Water	Fresh Water	Timber and log
2	Fresh Air	Fresh Air	Fodder, Litter and grass
3	Timber	Wildlife	
4	Fodder, leaf, litter and grass		
5	Wildlife		
6	Biodiversity		

The table shows that upstream people listed more ecosystem services of relevance than downstream people. According to the need and use of the participants (n=52) of upstream and participants (n=35) downstream of the ES are listed and fresh water is in top on the priority list. From the DFO Bhaktapur all community forests are taking benefit of timber, log, fodder and litter.

5.2 Forest cover and land use change

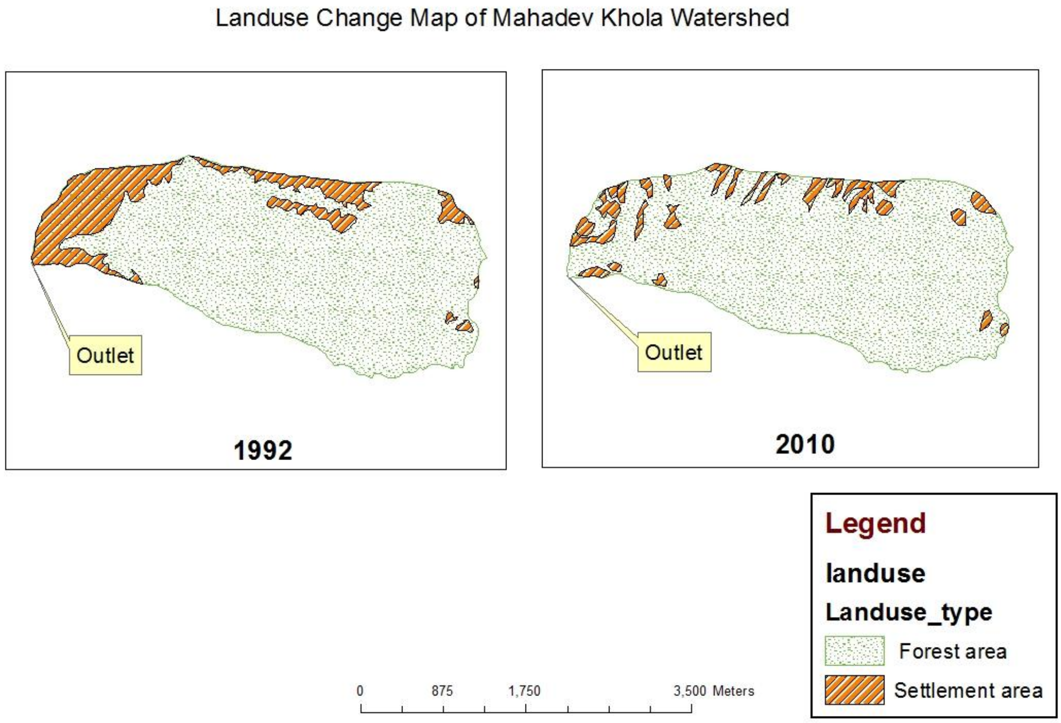
5.2.1 Forest Cover

Table 5.2: Total area of Community forest of MKW.

S.N	Name of CF	Address/ Ward no.	Area of CF past (ha)	Area of CF present (ha)
1.	Bahal CF	Bageswori-3,4,5	52.1	No Change
2.	Bahal CF	Bageswori-5,6	63.5	No Change
3.	Bahal CF	Sudal -7	69.03	No Change
4.	Mahamanjushree CF	Sudal -6	38.76	No Change
5.	Aaindada CF	Nagarkot- 1,2,3,6	25.5	34
6.	Lakhane CF	Nagarkot -7,8	3.69	No Change
7.	Dhunge Pakha and Nala Tukucha CF	Bhaktapur -8 and Kaver -5	103	No Change
				Source: DFO Bhaktapur, 2011

According to DFO Bhaktapur, the addition of Ward 6 (8.5 hectares) in Nagarkot Aaindada on 2064/11/20 (2008/3/3); increase the forest area. Before addition of Ward 6, the Nagarkot Aaindada consisted of Wards 1, 2, 3 (25.5 hectares). Total area of all the community forest that lies in the Mahadev Khola Watershed is 364 hectare. Communities are aware about forest and watershed and their benefits. Whereas upstream people listed more ES than downstream that may be because upstream are residing near the forest thus, upstream are taking direct benefits and downstream are indirectly benefited from the watershed. Awareness and training to the communities' people will benefit the livelihood and the conservation.

5.2.2 Land use change



Map 5.1: Landuse Change Map of Mahadev Khola Watershed.

The Topographic Map of year 1992 and Google Earth Map of year 2010 were used to compare the changes in the land use pattern of MKW. Using Arc GIS 9.3 software, the landuse change of Mahadev Khola Watershed was analyzed. The total area of the MKW is 6.98 km^2. The landuse data for forests and settlement areas is provided in Table 5.3:

Table 5.3: Landuse cover in Mahadev Khola Watershed area in 1992 and 2010

SN	Landuse Type	1992	2010
1	Forest area	5.85 km^2	6.41 km^2
2	Settlement area	1.14 km^2	0.57 km^2

The time series land cover data show a reforestation trend from non-forest land to forest in MKW. The total area of watershed in 1992 was 6.98 km^2 with 5.85 km^2 of forest. By 2010, the forest area has increased to 6.41 km^2. The increase in forest land is mainly due to the reforestation of parts (about 0.56 km^2) of the settlement area that decreased from 1.14 km^2 in 1992 to 0.57 km^2 in 2010.

Perception

Active participation of CFUGs and DFO Bhaktapur helped to improve the forest. Participants of both upstream and downstream area have similar positive opinion about the improved of forest cover. After the Australian project in 1990s, the plantation program of pine trees (*Pinus roxburghii*) increased forest cover. However, pine trees are believed to not to be good for water holding and water treating potential. NGOs launched awareness program about consequences of pine trees and facilitated to replace it through broad leaf tree species. .

5.3 Water Services

Besides drinking purpose, water of Mahadev Khola is also used for agriculture and industrial purpose.

Perception of upstream people

Water is a vital resource to the living being to sustain their life. The availability of water is adequate as the forest is dense and new springs are erupting but the increasing population in the upstream area may cause water scarcity in future.

Perception of downstream people

Urbanization, increasing population and haphazard extraction of water are the major causes of water scarcity in the municipality. As the human pressure is likely to grow with time, watershed services in future are likely to be affected and conflict over water can start.

From the perception of upstream and downstream communities the pathway of cause and effect on water services of MKW are formed, this clears the effect of each variable in causing water conflict which is shown in Figure 5.3.

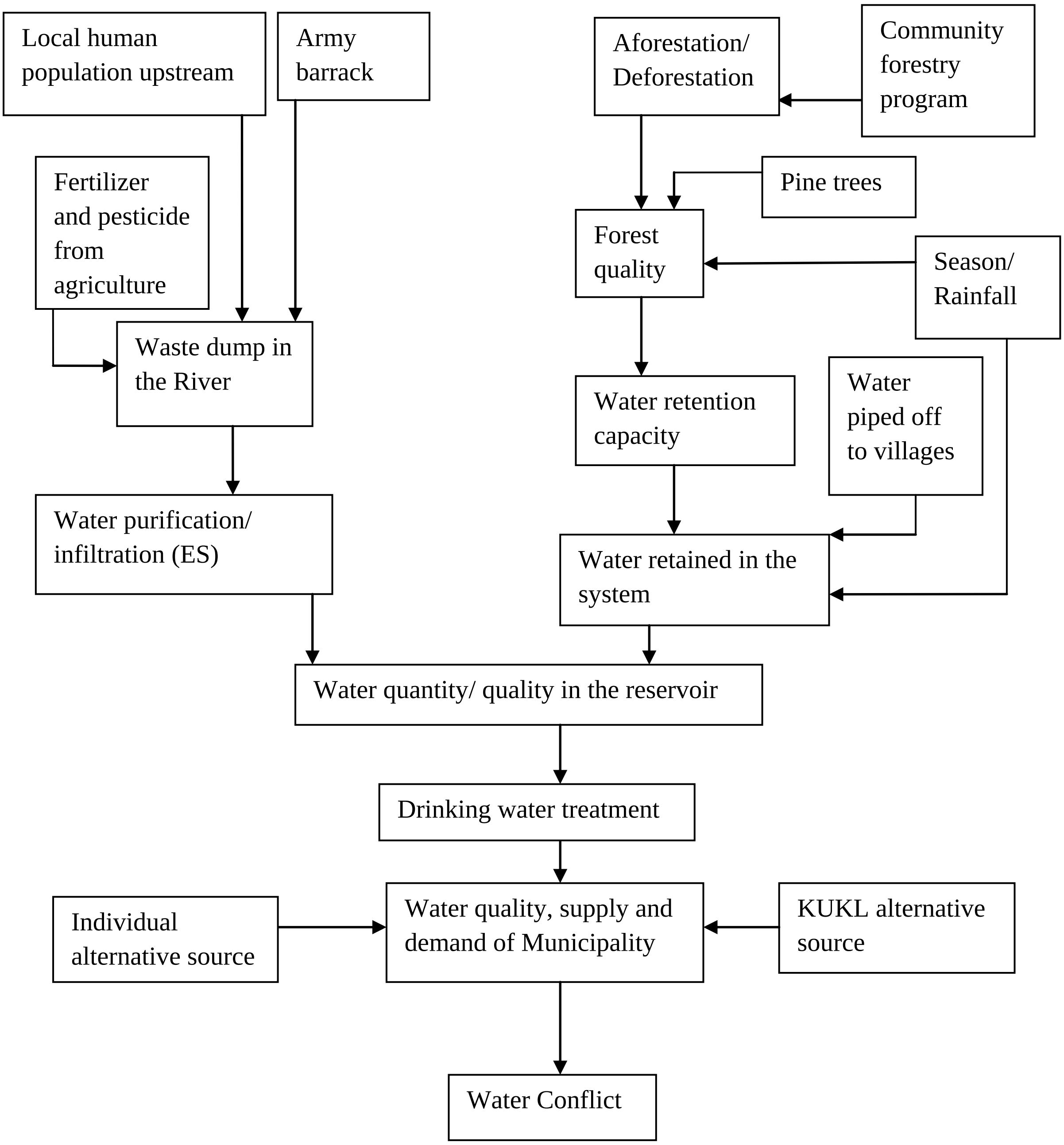


Figure5.3: Cause and effect pathway in Mahadev Khola Watershed

(Based on local interview)

It appears the use of water in upstream area, including army barrack and their activities are the primary reasons affecting both water quality and quantity in the reservoir. Like KUKL households in town are also looking for alternative sources of waters. Increasing urban population will intensify water scarcity problem without alternative sources. In the mean time, conflict for water in the municipality will increase.

5.4 Water status

Water status in the watershed is determined by the following aspects: Waters sources and availability, water demand and supply system and water quality.

5.4.1 Water Source

Perception of upstream people

Generally, drinking water supply facility is available to all settlements in upstream area. The water supply schemes generally use spring sources located at higher altitudes. The water is conveyed through pipes from source to public taps (stone spout) through gravity flow. In recent years, many private taps have been installed with much water diverted from the springs.

Perception of downstream people

The water supply system generally uses river water some deep bore water. Due to insufficient water, some downstream households buy water in tankers and collect rain water during water deficit seasons.

5.4.2 Availability of Water

Water availability is specific to surface water yields of major source in the watershed, i.e. Mahadev Khola. KUKL, Bhaktapur do not keep any records of water flow in the river. The monthly data of the fiscal year 2009/10 and 2010/11 and the information from the KUKL officer is used for the estimation of the water withdrawal in the watershed.

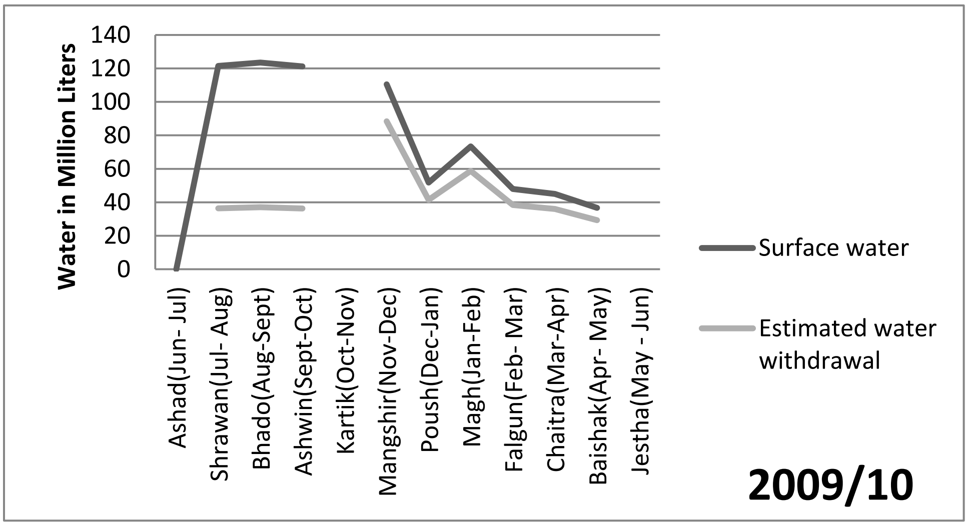


Figure 5.4.2.1: Surface water flow and estimated water withdrawal in fiscal year 2009/10

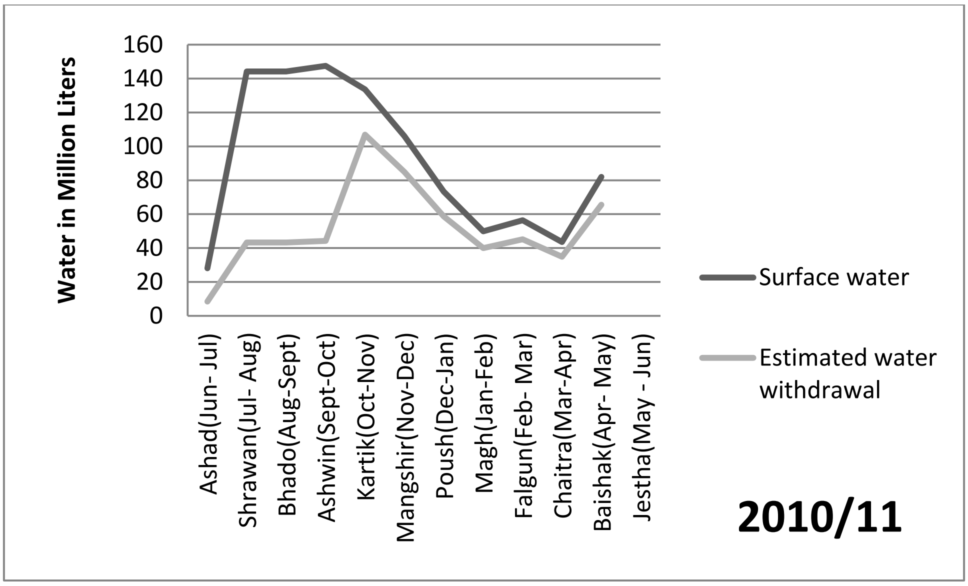


Figure 5.4.2.2: Surface water flow and estimated water withdrawal in fiscal year 2010/11

Monsoon in Nepal starts in May-June (Jestha) and ends in August-September (Aswin). The period from end of May to September is referred to as the wet season and remaining months as dry season. According to KUKL officials, about 30% of annual water withdrawn from Mahadev Khola is withdrawn in wet season and 80% in dry season. In the fiscal year 2009/10 the total discharge in Mahadev Khola was estimated to be 731 ML and about 402 ML was withdrawn for distribution in the municipality. In 2010/11 the river discharge was estimated to be 1009 ML and estimated 575 ML was withdrawn. A slight peaking of increased river discharge and withdrawal in the months of Poush (December-January) to Falgun (January-February) is normally due to a small amount of winter rain.

5.4.3 Water Demand

According to KUKL officials, the demand for water in the municipality stands at 8 ML/d.

Perception of upstream people

Despite of eruption of new springs, drinking water is still the problem in the upstream. Topography and climate also play an important role in availability of water. Daily water need of a household is approximately 20 gagris (240 liters or 0.00024 ML per day).

Perception of downstream people

The water supplied by KUKL is not sufficient for downstream users. Water supply is adequate only in Ward 4 (Kamal Binayak Mandir Parisar Sudhar Samiti); whereas there is serious water scarcity problem in Ward 10 and 5 (Canteen workers of Khwopa College) and Ward 2 (Livali Awas Chetra Bikash Samiti). To cope up with this insufficiency, the people of Bhaktapur Municipality buy water in tankers. Demand of water for a household is approximately 700 liters per day.

Population and water consumed in upstream and downstream areas in 2001 and 2011

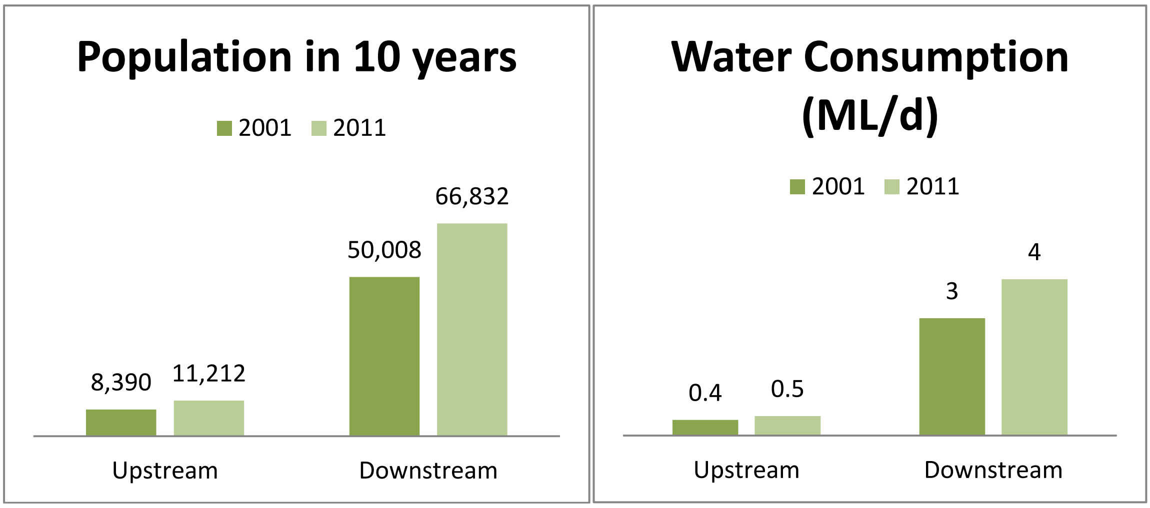


Figure 5.4.3: Population and water consumption in 2001 and 2011 in upstream and downstream areas

In 2001 the population of upstream was 8,390 and consumption of water was 0.4 ML/d. In 2011, this population has reached, 11,212 and water consumption is 0.5 ML/d in 2011. Similarly, the downstream population was 50,008 in 2001 with the consumption of 3 ML/d. The population in 2011 is 66,832 and the water consumed is 4 ML/d. In an interval of 10 years, the consumption of water has increased with population and this is likely to increase further in future. The increase in water demand is not only due to increased population, but also due to changing lifestyles, mainly in the urban areas. People following modern lifestyle consume more water than those in the past.

5.4.4 Water supply

The daily water supply in municipality from Mahadev Khola is 4.5 ML/d in wet season and 1.5 ML/d in dry season and the capacity of treating water the Bansbari water treatment plant is 4.9 ML/d (KUKL)

Perception of upstream people

Climatic condition and topography are the major factors that influence water. New springs are indicators of good management of forests; this is why the water availability has improved in recent years.

Perception of downstream people

Water is not sufficient in the downstream, Water supply is adequate in Ward 4 (Kamal Binayak Mandir Parisar Sudhar Samitee) whereas in ward 10 and 5 (Canteen workers of Khwopa College) and ward No. 2 (Livali Aawas Chetra Bikash Samitee), there is scarcity of water. In the rainy season (about 3 months) water supply is adequate but water is heavily polluted with fine sediments. In remaining 9 months water is supplied for 1 hour in an interval of 2 days and this is grossly inadequate for most households. Many households have to buy water in tankers during the dry season. Households pay about Rs 1000 for one tanker of water (about 5000 liters) and this is sufficient fro only a week.

5.4.5 Water quality

Perception of upstream people

As upstream community consume water directly from source and new erupted springs, the water is pure for drinking and they don't use any purification method.

Perception of downstream people

The water distributed is generally turbid and low quality. Sediments in the water is maily due to climatic condition and breakage of the pipe. In the rainy season, the river carries lot of fine sediments and damaged pipes allow solid or unwanted substances that decrease water quality. Boiling and filtering are the main water treatment methods used by the downstream people.

Aluminium sulphate (Al_3SO_4) commonly called 'alum', bleaching powder, caustic soda, and lime are used for the water treatment, and FRC (Free Residual Chlorine) test is regularly done for water quality. (KUKL, 2011)

5.5 Problems related to the water scarcity in Bhaktapur Municipality

Leakage and breakage of pipes for drinking and irrigation purpose by downstream people and haphazard water extraction by upstream people and unmanaged water uses are the main causes of water scarcity and disturbance in water supply system. The pipe lines were installed 40-50 years ago but they have not been replaced. Crack and breakage in the pipers are a major problem leading both to reduced water supply and reduced water quality. KUKL could do much more for proper management.

Table 5.5: Leakage identification and repaired in the Bhaktapur

S.N	Month	2008/9 (2066)		2009/10 (2067)	
		Leakage identification	Leakage Repaired	Leakage identification	Leakage Repaired
1	Baishak(Apr-May)	38	38	39	35
2	Jestha (May-Jun)	34	34	38	28
3	Ashar (Jun-Jul)	35	35	28	28
4	Sharwan(Jul-Aug)	32	32	36	36
5	Bhado(Aug-Sept)	33	33	35	35
6	Aswin(Sept-Oct)	22	22	40	40
7	Kartik(Oct-Nov)	36	36	36	36
8	Mangshir(Nov-Dec)	42	42	58	45
9	Poush(Dec-Jan)	36	36	45	45
10	Magh(Jan-Feb)	35	35	48	48
11	Falgun(Feb-Mar)	37	37	25	25
12	Chaitra(Mar-Apr)	42	42	40	40

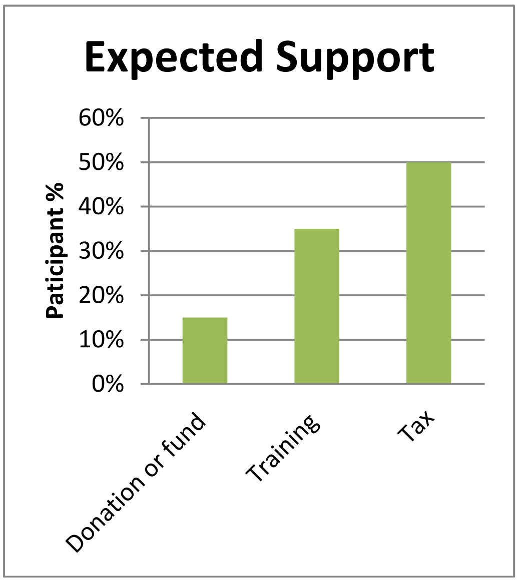
Source: KUKL

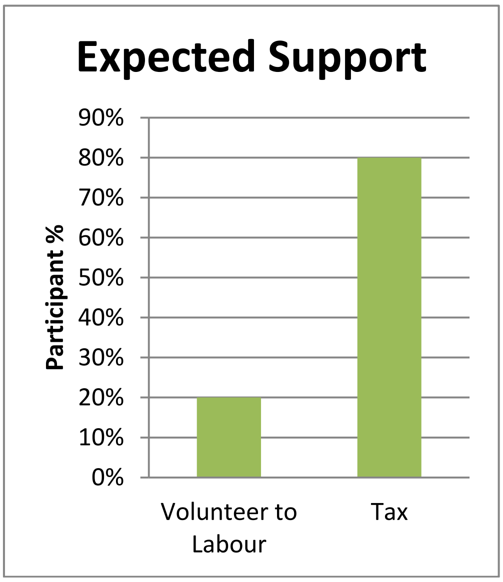
Table 5.5 shows that leakage is a severe problem in Bhaktapur water supply system. The records indicate that KUKL is repairing the leakages but the leakage problem is severe according to local downstream people and KUKL officials admit this. Lack of sufficient budget with KUKL for repair and pipe replacement is a major challenge. KUKL is searching for new funding sources increase water supply in Bhaktapur. The project of boring and digging wells in Kamal Binayak and Dekocha failed for with huge loss. There is a plan for boring Katunje.

5.5.1 Possible solutions to decrease water scarcity

Watershed services are often considered as a public good, meaning that, nobody can be refused to use them even if they do not contribute to its conservation. Thus watershed services are facing “tragedy of commons”. For the conservation of the watershed services good management practices are essential.

To implement good management practices in MKW, questions on expected support and choice of institutions for crucial enforcement were asked to both upstream and downstream communities.





a. Upstream (n=52) b. Downstream (n=35)

Figure 5.5.1.1: Upstream and Downstream choice of Expected Support

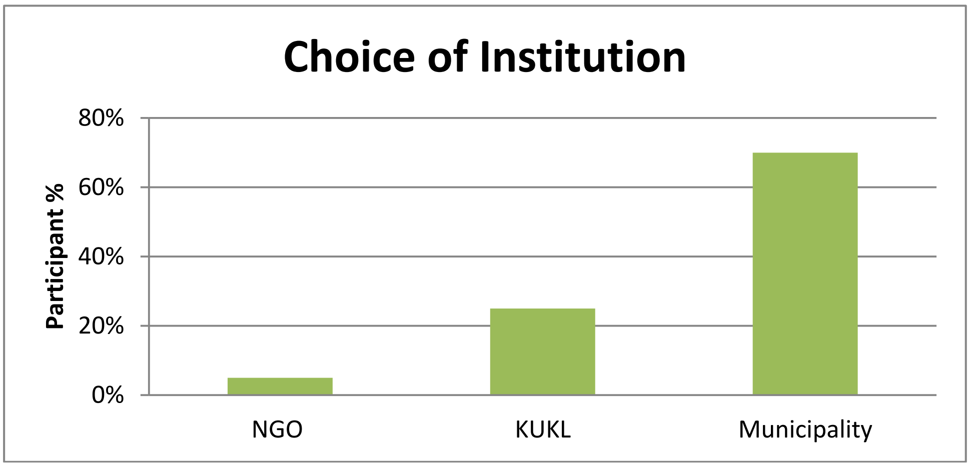


Figure 5.5.1.2: Choice of Institution the participant wants payment contribution

Respondents of upstream area (n=52) gave fore- most priority to the Tax payment (50%) followed by Training (35%) and then Donation or Fund (15%). Similarly, downstream (n=35) expressed their preference of payment through a "Tax" (80%) and volunteering for construction work (20%). For the choice of institution the participants (n=87) want payment or supporting through the involvement of Bhaktapur Municipality (70%), KUKL (25%) and NGO (5%).

5.6 Potential of PES scheme to improve the Water Services

The negotiation between both buyers (downstream) and sellers (upstream) and involvement of government for enforcement such as PES can be a possible way to address the water scarcity problem in Bhaktapur. The willingness to pay "tax" amongst downstream communities, willingness to pay "tax" payment amongst upstream communities and the preference for KUKL playing an intermediary role indicates a clear possibility of developing a PES scheme.

Effective, efficient, sustainable as well as equitable compensation and reward mechanism for environmental services could be a possible solution for water scarcity.

Table 5.6: Meeting the 4 criteria of PES in Bhaktapur water supply system

Principle of PES	Notes on how the criteria can be fulfilled
Realistic	• Continuing conservation activities. • Ecosystem hydrological services water quality. • Replacement of Pine trees into water storing trees.
Conditional	• Payment for forest enhancing activities. • Payment for increased of water supply. • Payment for replacement of Pine trees into water storing trees. • Payment planting trees on open land. • Payment for reduced water use in the upstream area. • Payment for reducing pollution.
Voluntary	• Upstream and downstream have the freedom to engage in payment scheme • KUKL is also a likely beneficiary of the scheme and could actively pursue diverse interests, including those of downstream beneficiaries.
Pro-poor	• Upstream are generally poorer than municipality people. PES scheme will ensure incentives and rewards to upstream people provided by downstream water consumers.

It is clear from the various discussions that both upstream and downstream communities are aware of the existing links between watershed conservation and hydrological benefits. Activities such as replacing pine trees with local broad-leaf species, improving forest cover are understood to be good for hydrological services of the catchment. The results of these activities are seen by both upstream and downstream communities to be “realistic”. Additionally, efficient use of water by upstream people can reduce water wastage in upstream, thus making this available for downstream users. There is clear willingness of the downstream water consumers to invest in conservation activities to ensure better watershed ecosystem, services.

Development of sustainable and equitable payment mechanism seems very possible. Payments to upstream communities can be made if forest enhancing and water conservation activities are conducted by the upstream communities. While PES concept advocates performance based system (e.g. evidence to show increase in dry season flow in the river), the conservation activities can be sufficient indicators for payment to upstream communities from downstream communities.

Negotiation between buyers (downstream) and sellers (upstream) will require facilitation and support of at least one intermediary. The study indicates the preference of buyers and sellers for the engagement of the Municipality. As KUKL also has a direct interest in the development and outcome any PES scheme, it can also take an active role as facilitator and ecosystem service monitoring agent in the PES scheme.

CHAPTER 6

6 DISCUSSION

The research is focused on watershed services of the MKW. Results indicate that PES scheme could be a possible solution to mitigate the problem of water scarcity in Bhaktapur Municipality. Proper management actions by KUKL and reward mechanism of PES for sustainable livelihood and conservation could improve the water supply in the Bhaktapur Municipality.

The increase in forest area shown by GIS data is also in line with the claim of the DFO of Bhaktapur of a substantial increase in forest area in Nagarkot over the last two decades. Though there is no empirical evidence of increased watershed ecosystem service, it can be confidently assumed that the forest ecosystem in the catchment area is improving with a positive impact on various ecosystem services, including the regulation and quality of water from the forest ecosystems. The role of the community forestry users and the local residents in the catchment has been instrumental in the forest rehabilitation and its proper management.

Water availability has decreased in the municipality and water conflict has intensified because of increasing population in both upstream and downstream area, haphazard extraction of water and river water polluting activities. The pine trees (*Pinus roxburghii*) planted in the watershed on a large plantation scale is believed to affect the water retention capacity, water purification and filtration capacity reducing both water quantity and quality in the ecosystem.

Incentives to recognize the service of the local upstream communities and to continue their participation in forest management for good forest cover and improved ecosystem services could be developed and implemented in order to provide them with additional encouragement.

6.1 Potential of PES schemes

Many countries around the globe are implementing different schemes for collecting payment to finance watershed protection. In Nepal, though few random efforts towards feasibility studies and setting up PES mechanism are made in recent years, it still remains fairly a new concept. There exists vast opportunity for Nepal to tap these interests, and facilitate with proper policy responses to benefit conservation as well as poverty alleviation issues (Paudel, 2010).

From the study, upstream and downstream are already convinced on the existing linkages between watershed conservation status i.e. replacement of pine trees by other water storing trees and downstream hydrological benefit, additionally efficient use of water by upstream could minimize the threat. And potential beneficiaries in the downstream are to invest, for the proposed management actions which will result in the delivery of hydrological services. A sustainable and equitable payment mechanism may be developed in which payments are made if forest conservation activities are conducted that lead to increase in water availability for downstream people. These activities may include, planting of open land with trees, replacement of pine trees into water storing trees, efficient use of water and reducing pollution.

From the study hydrological linkages, watershed conservation, replacement of pine trees by other water storing trees and efficient use of water are realistic solutions to mitigate the water scarcity problem. Negotiation between both buyers and sellers and involvement of KUKL for enforcement offer a practical solution to the water scarcity problem.

6.2 Water Management

Bhaktapur is an urbanizing area with common problem if urbanization as in Jema'a Local Government Area of Kaduna State, Nigeria where water demand cannot be met because of increasing population, changing life styles, and over use of water. The situation will improve only with a deliberate policy on water and sanitation particularly a policy on acceptable safety levels (Abaje *et al.*, 2009).

Piped water supply is the most common source of drinking water in Kathmandu. However, insufficient water in the supply system is a serious problem (Kandel, 2007). Similarly in Bhaktapur Municipality Mahadev Khola provides 4.5 ML/d in wet and 1.5 ML/d in dry season; while estimated demand stands at 8 ML/d.

Over extraction of water in the upstream area, disposal of untreated urban sewerage and solid waste directly into the river, development of urban infrastructure and services with complete disregard of the river environment and insensitivity of Bhaktapur municipality and other agencies and lack of recognition of river conservation and restoration are problematic in Bhaktapur urban planning (Sada, 2010). The downstream people receive polluted water because of exposure to the urban environment and open defaecation, particularly in the Ward 6 (Bal Samudaik Ban Upobhokata Samitee). The farming of boar by the army in the upstream catchment is also a major cause of cause river water pollution. Though the water is treated at the Bansbari, it is not sufficient and the broken pipes in the distribution system further aggravate the problem of both quality and quantity of water.

Sometimes climatic condition also plays a vital role for water scarcity as it is in Angat Reservoir and Lake Lanao of Philippines, which are already exposed to extreme rainfall variability and its adverse consequences, face more threats of increased climatic variability. In the Angat reservoir and Lake Lanao runoff is likely to decrease in the future and be insufficient to meet future demands for water (Jose *et al.* 1999). While climate has not been an important factor in MKW, the rising temperatures in the climate change context may lead to reduced or increased rainfall pattern that in turn will influence the availability of water to downstream communities in Bhaktapur.

Water management of urban areas is the responsibility of municipality and it should develop an integrated master plan and funding required for the rehabilitation of water system in urban areas and policy should be made to meet future demands for water.

6.3 General discussion

Bhaktapur is the smallest districts in Kathmandu Valley and its rate of urbanization and population growth is similar to other districts. The demand for water is increasing and the pressure on ecosystems for goods and services has increased over the last two decades. With increasing human population, the problem is likely to become worse in coming year. Human related and management problems (lack of timely maintenance of broken water pipes, river water pollution by household farming and the army) make the problem more serious. While the water scarcity in Bhaktapur is a common urban problem; it also provides an opportunity to develop and test a possible solution development of a PES scheme.

To summaries, the major causes of water scarcity in Bhaktapur Municipality are urbanization, population increase, leakage, haphazard extraction of water and water wastage in the upstream area, pollution activities near the river. The pine trees used in community forestry plantation program on the southern slopes of Nagarkot hill is believed by upstream communities to have reduced the catchment's capacity to store water, purify water, and regulate water flow. This can directly affect both quantity and quality of available water.

The human pressure on watershed services is likely to grow with time. The study concludes that while better management of water sources both in the catchment area as well as in the distribution system is likely to provide more water in town, implementing incentive based mechanism (also known as Payment for Ecosystem Services) can also help reduce water scarcity problem in Bhaktapur.

Experience of PES schemes elsewhere indicates sufficient potential for use in Bhaktapur water supply system. Therefore, harmonization of PES scheme and management of KUKL will be a good way forward.

CHAPTER 7

7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Mahadev Khola is major source of drinking water in Ward 1 to 10, parts of Ward 11 and 14 in Bhaktapur municipality. The people of Bageswori, Nagarkot and Sudal VDC, and Bhaktapur Municipality receive water for drinking, irrigation and industry from the MKW. It appears that MKW is capable of providing necessary volume of water if water collection and distribution systems are properly managed. There is also potential to increase the ecosystem services, including water regulation and quality improvement, through the development of an appropriate PES scheme. The study showed that the people of Bhaktapur Muncipality are facing chronic shortage of water in the dry season. Water supply in Bhaktapur Municipality from Mahadev Khola is 4.5 ML/d in the wet season and only 1.5 ML/d in the dry season whereas the current demand for water is 8 ML/d. To cope up with this problem the people resort to buying water tankers during the 9 dry months.

Contrary to the norm of deforestation where forests are converted to other land uses, in MKW settlement areas have been reverted back to forests. The time series land cover data show a reversal trend from non-forest land to forest in MKW. The total area of watershed in 1992 was 6.98 km^2 with 5.85 km^2 of forest. By 2010, the forest area has increased to 6.41 km^2. The increase in forest land is mainly due to the reforestation of parts (about 0.56 km^2) of the settlement area that decreased from 1.14 km^2 in 1992 to 0.57 km^2 in 2010.

From the study, the causes of decrease in availability of water an increase in population, urbanization, pipe breakage and water leakage, haphazard extraction of water and water wastage by upstream people, river pollution. Additionally the pine trees (*Pinus roxburghii*) in the southern aspect of the Nagarkot forest are reducing the water retention capacity, water purification and filtration capacity that directly affect water quantity and quality. On-going agriculture intensification (cash crops) that required much irrigation and application of agrochemicals may affect both quality and quantity of water available for Bhaktapur town. As the human pressure is likely to grow in future it will influence forest ecosystems and its watershed ecosystem services.

Native water holding trees are better in terms of water retention in the soil and water purification. The study concludes that while better management of water sources both in the catchment area as well as in the distribution system is likely to provide more water in town, implementing incentive based PES mechanism will also help reduce water scarcity problem in Bhaktapur.

Incentive scheme may include payment by water users in Bhaktapur town to upstream communities for efficient use of water (not wasting) and proper management of their community forests by maintaining good forest cover, planting water storing species inside the forests, not degrading their forest resources and not haphazardly applying agrochemicals (fertilizers and pesticides) in the agriculture crops. Experience of PES schemes elsewhere indicates sufficient potential for use in Bhaktapur water supply system.

7.2 Recommendations

Based on the results, the following recommendations are made:

1. Government and KUKL should take necessary action promptly to minimize water leakage in the collection and distribution systems.
2. Bhaktapur Municipality should disseminate relevant information about water quality and water related health issues to both upstream and downstream communities.
3. KUKL should regularly monitor and maintain database water discharge from MKW.
4. A program to gradually replace *Pinus* spp in community forests with broadleaf species should be initiated.
5. An appropriate PES scheme should be developed and implemented for the benefits of both upstream and downstream people. A detailed planning exercise should be conducted with the involvement of all major stakeholders (upstream and downstream communities, Municipality, KUKL,and universities).
6. The PES scheme could be facilitated by Bhaktapur Municipality and supported by KUKL. University students should be able to carry out detailed research on bio-physical and socio-economic issues relevant to PES.

The following aspects will be relevant for a future PES scheme in Mahadev Khola Watershed.

1. Establish a Mahadev Khola Environment Fund to help fund conservation and poverty alleviation activities in the upstream areas.
2. Levy an "ecosystem service tax: to visitors (picnickers, hikers) MKW upstream area.
3. Include a "watershed service tax" in the water bill in the municipality. The rate could be a percentage (eg.10%) of total water bill.
4. Enhancing awareness about water holding trees and the consequences of Pine trees to upstream.
5. Introducing water quality maintaining plan for clean drinking water.
6. Launching program to minimize water wastage in upstream.
7. Giving alternative to chemical fertilizer and pesticide to minimize the water pollution.

8. Realizing importance of water by giving opportunity of managing water supply system to the locals of downstream.
9. The PES scheme should address the existing constraints in local livelihoods and take advantage of emerging opportunities in the area (e.g eco- tourism).
10. PES feasibility study could be conducted to develop essential elements (indicators of water quality and quantity for monitoring, conditions for payment and payment mode, willingness to pay amongst water users and institutional issues) for developing a fully fledged PES for better management of MKW.
11. MKW is rich and diverse in numerous ecosystem services; hence further research could be carried out to explore feasibility of bundling these services in a PES scheme.

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Annex -1

Photos

Photo 1: Mahadev Pokhari, Nagarkot

Photo 2: Mann Pokhari, Bageswori

Photo 3: Pipe line diverted for water supply

Photo 4: Bansbari Water Treatment Plant

Photo 5: FGD in Ward 7, Nagarkot

Photo 6: FGD in Ward 6, Bageswori

Photo 7: FGD in Ward 7, Sudal

Photo 8: FGD in Ward 4, Kamal Binayak

Photo 9: FGD in Ward 2, Liwali

Photo10: FGD in Ward 5, Lalachen and 10, Bayshi

Photo 11: Key Informant (KUKL Officers)

Annex -2
Checklist used for interviewing local people in the field

General information about watershed
a. Watershed name
b. Location
c. Source
d. Watershed characteristics
i. Climate
ii. Geology and physiographic
iii. Land use and cover condition
e. Watershed hydrology
i. Stream flow
• Quality
• Quantity
Water uses
a. Domestic
b. Irrigation
c. Industrial
d. Other
Water problem
a. Natural calamities
b. Water supply
c. Water demand
d. Change in landuse

Annex- 3

Questionnaire for Focus Group Discussion in Upstream Area

1. What are the benefits given by forest/ watershed?
2. How has the land use changed in the watershed area, say compared to 10 and 20 years ago? Is there any link between land use and water availability and water quality?
3. Is there any group who are conserving watershed? Any program conducted to conserve?
4. Is there sufficient drinking water supplied in your place? Has it changed over the years 5 years ago, 10 years ago and 20 years ago?
5. Are the present supplies adequate? Will present supplies meet the future demand?
6. The people of municipality are feeling lack of supply of drinking water. In your view what are the causes?
7. What could be the possible ways to increase the supply and how can you help to fulfill the demand? Is it possible to improve the land use system (forest and agriculture use)?
8. What should the people of municipality do to fulfill their demand?
9. What is your view for the current role of the KUKL? Are you satisfied?
10. If the people of municipality and KUKL are ready to help to increase the supply, by providing incentives for good land management in the upstream, what will you do and what you want?
11. Where the drinking water is taken for daily use?
12. Source of the water supply to your place?
13. How much liter of water does your family consume per day?
14. How many hours per day and how many days per week do you get drinking water from tap?
15. What is the maximum amount that you will to pay for a gagri of water?
16. Is water from your source drinkable? Yes or No

    If no, how do you treat drinking water?

Anne- 4
Questionnaire for Focus Group Discussion in Downstream Area

1. Do you know the source of your drinking water?
2. Are the present supplies adequate?
3. How will you fulfill your demand? How many liters you buy and how much it cost?
4. How much you have to pay to KUKL for drinking water? Will present supplies meet the future demand?
5. Why do you think the water scarcity problem is increasing?
6. Do you think people of upstream are responsible for decrease in water supply in municipality? If yes, what do you think they could do to increase the water supply? If no, who are responsible?
7. What could be the possible ways to increase the water supply and can you help for it? How?
8. If the people of upstream and KUKL are ready to work in watershed for increase in water supply. Would you like to help? How?
9. How could you minimize leakage and the scarcity in water supply?
10. Is there any group in ward who looks for the water supply and demand? Any program conducted?
11. What is your view of the current role of the KUKL? Are you satisfied?
12. Have you heard about rainwater harvesting? If yes, do you do it to fulfill the water demand?
13. Where the drinking water is taken for daily use?
14. Source of the water supply to your place?
15. How much liter of water does your family consume per day?
16. How many hours per day and how many days per week do you get drinking water from tap?
17. What is the maximum amount that you will to pay for a gagri of water?
18. Is water from your source drinkable? Yes or No

If no, how do you treat drinking water?

Annex -5
Questionnaire for KUKL officers (Key Informant)

1. What do you want to say about scarcity of drinking water in municipality? Why it is increasing?
2. Who do you think are responsible for the problem?
3. Do you think KUKL is doing their jobs properly?
4. What could be the possible way to fulfill the demand and how can you help?
5. What will you do if the upstream are ready to work and the downstream are ready to help?
6. Do you have any plan to increase the water supply?
7. How many people ask for water in any cost?

Annex -6

Participant in the Focus Group Discussions and individual interviews

Upstream			
SN	Nagarkot Aaindada Samudaik Ban Upobhokata Samitee Address: Nagarkot-7 Date: 26/07/2011	Bal Samudaik Ban Upobhokata Samitee Address: Sudal-7 Date: 30/07/2011	Bal Samudaik Ban Upobhokata Samitee Address: Bageswori-6 Date: 3/08/2011
1.	Shree Ram Khatri	Mani Ram Timilsina	Ram Krishna Timilsina
2.	Yage Bahadur Khatri	Rajendra Prasad Timilsina	Saradh Timilsina
3.	Kul Bahadur Khatri	Hari Prasad Timilsina	Puspa Timilsina
4.	Sahile Tamang	Keshab Timilsina	Meena Pariyar
5.	Naresh Tamang	Ram Prasad Timilsina	Sarita Timilsina
6.	Hari Sunwar	Santa Bahadhur Timilsina	Bhagwati Sunuwar
7.	Parash Tamang	Laxman Timilsina	Kamala Sunuwar
8.		Mann Hari Timilsina	Sunita Sunar
9.		Ujawal Timilsina	Kanchi Sunar
10.		Kalyan Timilsina	Hira Sunar
11.		Suman Sapkota	Sabitri Kadhaka
12.		Budha Pairyar	Sita Timilsina
13.		Sarita Timilsina	Radha Timilsina
14.		Deep Bharai	Asmita Timilsina
15.		Bhawan Timilsina	Sodita Khadka
16.		Goma Timilsina	Niru Pariyar
17.		Rita Timilsina	Sabitri Pariyar
18.		Deep Sapkota	Gyanu Pariyar
19.		Satyewoti Sapkota	Saraswoti Timilsina
20.		Surti Sapkota	Rabin Pariyar
21.		Rista Sapkota	Sabitri Sunar
22.		Rajan Bhatarai	
23.		Shanti Lamichane	
24.		Sumitra Timilsina	

Downstream			
SN	Canteen workers of Khwopa College Address: Byashi- 5 and Lalachhe- 10 Date: 02/06/2011	Kamal Binayak Pokhari tatha Mandir Parisar Sudhar Samiti Address: Kamal Binayak - 4 Date: 12/06/2011	Liwali Awas Chhetra Bikash Samiti Address: Liwali- 2 Date: 30/06/2011
1.	Purna Laxmi Lasiwa - 10	Tirtha Man Dumaru	Bal Krishna Prajapati
2.	Sir Laxmi Lasiwa – 10	Tulshi Ram Shrestha	Laxmi Prasad Prajapati
3.	Naresh Lasiwa - 10	Ram Sundar Rajchal	Budha Sagar Prajapati
4.	Sulochana Tyata-5	Kashi Nath Twanabashu	Bishnu Keshari Duwal

5.	Kabita Tyata- 5	Jeetendra Munnankarmi	Maya Hayanwa
6.	Padam Kulunju- 5	Sanu Kaji Shrestha	Krishna Laxmi Bainatyo
7.	Raj Kulunju - 5	Raju Jati	Tara Devi Manandhar
8.		Chiranjibi Dulal	Satay Laxmi Gaiju
9.		Gyanu Maskey	Purna Keshari Koju
10.		Punye Ram Dumaru	Purneswori Kusum
11.			Ram Kesari Chawaju
12.			Hari Maya Bhainatu
13.			Hari Thaku
14.			Krishna Laxmi Kusi
15.			Ram Maya Duwal
16.			Bal Ram Prajapati
17.			Krishna Prashad Khayemali
18.			Aachut Prajapati

Key Informant		
SN	Name	Name of Organisation
1.	Sudarsan Thapa	KUKL of Bhaktapur
2.	Sanu Shrestha	KUKL of Bhaktapur
3.	Bimala Bandhari	KUKL of Bhaktapur
4.	Suresh Adhikari	KUKL of Kathamandu
5.	Rameswor Bohora	FECOFUN of Bhaktapur
6.	Shanti Shrestha	DFO Officer of Kathamandu
7.	Satya Ram Prajapati	DFO Officer of Bhaktapur
8.	Tara Dhancha	Local
9.	Bal Ram Timilsina	Local
10.	Khdaka Bahadur Thapa	Local
11.	Laxman Giri	Forest Guard

Annex -7

Table 5.4.2: Monthly Flow Estimation of Mahadev Khola Watershed in ML (Million Liter) of 2009/10 and 2010/11.

SN	Month	Fiscal Year 2009/10			Fiscal Year 2010/11		
		Surface water (Ml)	Estimate water withdrawal		Surface water (ML)	Estimate water withdrawal	
			%	ML		%	ML
1	July		30		28.12	30	8.436
2	August	121.5	30	36.45	144.25	30	43.275
3	September	123.5	30	37.05	144.25	30	43.275
4	October	121.2	30	36.36	147.5	30	44.25
5	November		80	0	133.6	80	106.88
6	December	110.5	80	88.4	106.11	80	84.888
7	January	73.43	80	58.744	49.94	80	39.952
8	February	51.8	80	41.44	73.29	80	58.632
9	March	48	80	38.4	56.42	80	45.136
10	April	45	80	36	43.6	80	34.88
11	May	36.68	80	29.344	82.012	80	65.6096
12	June		30			30	
	Total	731		421	1009		575