ECONOMIC ANALYSIS OF COMMUNITY BASED WATER SUPPLY IN THE KATHMANDU VALLEY

By

Peter Toth

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements for the degree of

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ABSTRACT

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Acute water shortage in the Kathmandu Valley is the aggregate effect of uncontrolled city development, in-migration, and overexploitation of shallow and deep aquifers, climate change, and low effectiveness of water supply from the utilities.

A private water market has emerged, offering trucked water and bottled water. The government has responded by initiating the much-awaited Melamchi project. The local communities responded by establishing water user associations and rehabilitating the traditional water supply system of stone spouts and public wells, supplemented with rainwater harvesting.

In spite of the fact that community water supply projects are successful in providing water to thousands of households, they do not address the issue of groundwater extraction rights and permits.

The paper examines the viability of an “ideal” project based on the elements of community water supply projects supplemented with a municipal level regulation of water rights pertaining to groundwater in the Lalitpur Metropolitan Area of the Kathmandu Valley with the methodology of economic analysis of water projects applied at the Asian Development Bank.

Summary

Water shortage and intermittent drinking water supply have been a part of everyday life in Lalitpur [1] for years. Droughts, more than 40% leakage (Annapurna Post, 2009) from the municipal pipeline, haphazard urban development, and unregulated subsurface water extraction and water rights contribute to the problem of rapid depletion of subsurface water sources and dry taps in households.

Out of 18 Asian water utilities examined, the one in Kathmandu ranks last in terms of water production/population with a value of 0.11 m3/day/capita. Moreover, even though statistics show that 83% of the population of the Kathmandu Valley has access to water, “none of them enjoy 24-hour supply” (ADB, 2004).

At the same time as water-user associations and successful community initiatives bring water to hundreds of households, a mega-project, titled the “Melamchi Project” once abandoned by the World Bank and now funded by the Asian Development Bank has been promising to supply abundant and safe water to the Kathmandu Valley for years.

The thesis aims to examine the political and economic viability of community based initiatives to water supply, as well as their potential integration into the large infrastructure and water supply framework. This paper also includes a detailed economic analysis of an alternative water supply project based on a high level of community participation, regulation of water rights, technical interventions for water supply and shallow aquifer conservation, as well as a management

[1] Lalitpur is one of the three major cities located in the Kathmandu Valley, Nepal,. The other two cities are Kathmandu and Bhaktapur.

structure involving the key stakeholders in the process. A set of economic indicators in the with/without regulation of water rights alternatives is used to demonstrate the usefulness of an effective regulatory framework.

The thesis concludes that the involvement of stakeholders as well as the introduction of regulations on water rights and extraction is essential for the success of an alternative water supply project. In addition, the water rights regulations constitute a project component that produces superior results as compared with a conventional community-based water supply project. The paper also emphasises that in spite of positive economic indicators, a project can fail due to lack of political will and institutions not conducive to project implementation.

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CHAPTER 1: INTRODUCTION

1.1 Summary of Problem

The water shortage in the Kathmandu Valley has been intensifying in recent years due to population pressures. The population of the Valley increased from 1.1 million (1991) to 1.65 million (2001) and has been estimated to increase at a rate of 4.06%/year (ICIMOD, 2007.). In spite of the fact that 80% of the urban population of the Valley is connected to the water supply network, the supply is only available intermittently (as low as every fifth day in some districts). According to a statement issued in 2009 by Kathmandu Upatyaka Khanepani Limited (KUKL, the current operator of water supply services) the Valley`s drinking water distribution system suffers from 50`% leakages and an inadequacy of supplied quantity, with 230 million litres per day (mld) of demand and only 100 mld supply.

The Melamchi water supply project is planned to be completed by 2013. Due to this time lag and the scarcity of water, the urban population of the Kathmandu Valley has increasingly turned to the private sector (trucked water, bottled water), household solutions (rower pumps, shallow wells), and the traditional water supply network of the Valley [2] to satisfy water demand (ADB,2004). The gravity of the situation is underlined by the fact that in the summary of various water related statistics for 18 Asian Cities prepared by the Asian Development Bank (2004), Kathmandu has the worst ranking in terms of water production/population with a value of 0.11 m3/day/capita.

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[2] A network of canals, ponds, waterspouts and wells that in some areas has been operational for more than a millennium.

Moreover, even though statistics show that 83% of the population of the Kathmandu Valley has access to water, “none of them enjoy 24-hour supply”. In fact, Nepal is regressing in terms of urban water supply coverage, according to the Asia Water Watch 2015 (ADB-UNDP-UNESCAP-WHO (2006). This is likely to persist until the completion of works on the Melamchi supply system.

Rapid and unplanned urban growth and industrial water use of aquifers has disrupted natural groundwater flows and made a number of the waterspouts dry up, further contributing to water shortage for the population. In other areas, waterspouts continue to supply water to the communities and a number of community-based initiatives for the conservation of shallow aquifers and traditional supply have sprung up in the Valley as a response to the unreliable water supply from the piped network and the uncertainties related to the Melamchi project. After recognizing the importance and role of water spouts in providing water to the public (at least until the completion of the Melamchi project) the Government of Nepal has made their conservation a priority.

These alternative means of water supply utilise the shallow aquifers of the Valley. Over-extraction of groundwater due to lack of regulation on water rights and extraction and the competition for water resulted in the drying up of traditional wells and stone waterspouts, while intense urbanisation and lack of wastewater treatment pollutes shallow aquifers and surface water sources as well.

1.2 Purpose

This paper aims to prove that an alternative, community based water supply project supplemented with effective regulations on water rights and groundwater extraction is economically superior to a community-based water supply project without regulatory changes. To test this hypothesis, this paper provides an economic analyses of two competing water supply projects in the Lalitpur city area.

The thesis contains the analysis of economic feasibility of an alternative water supply project based on community operation and the utilisation of the traditional supply network[3] as applied in a number of neighbourhoods in the Lalitpur Metropolitan Area. The purpose of the analysis is to compare the proposed project with the economic viability of the alternative water utilisation of the traditional supply network as applied in a number of neighbourhoods in the Lalitpur Metropolitan Area, using the cost-benefit analysis approach according to the guidelines of the Asian Development Bank (ADB, 1998).

More specifically, this thesis seeks to answer the following questions: What is the economic viability of an alternative WSP in Lalitpur, taking into account of the ADB-funded Melamchi project? What political and institutional risks exist that may jeopardise project sustainability? Can an alternative water supply project specifically benefit the poor?

In the course of the analysis a number of key issues will be examined. These include the definitions relating to the target group of the project, the rationale of the project, the feasibility and viability of institutional arrangements, and whether the project is justifiable based on the

[3] To be referred to as „alternative water supply project" or alternative WSP.

analysis of economic costs and benefits.

Fundamental to the alternative WSP project is a robust coordinative and cooperation effort involving the local authorities, traditional communities, NGOs, as well as various water users. Technical interventions are as important as putting into place the institutional and regulatory components that ensure effective management of water use and the conservation/protection of the traditional network elements as monuments of historical as well as ecological importance. The former components carry a considerable element of risk that needs to be addressed if such a project is to be successful.

1.3 Significance

The thesis applies the method of economic analysis to an alternative WSP. Due to the fact that such community-based projects are generally moderate in scope and scale and they are also limited in terms of expertise and funding available for the preparation of background studies, this paper may be a useful input for non-governmental organizations and local communities intending to apply for small-scale funding (e.g. embassy funds or bilateral funds).

1.4 Rationale, scope, and limitations

> ”...to ensure safe drinking water and sanitation for urban poor, Kathmandu Upatyaka Khanepani Limited (KUKL) has sought help of stakeholders so as to manage community tap stands and other community managed water points in the Valley.... officials of KUKL informed that beneficiary communities will manage the alternative modes of water services, which could be bottled water distribution and isolated water supply from shallow wells, stone spouts, etc, on a pilot project.” (The Kathmandu Post, June 30, 2008)

The above news excerpt demonstrates the rationale for the project in terms of the need for community involvement in the management of water supply at the local level. It also emphasises the magnitude of the water scarcity in the Kathmandu belong to the institutional and legal realm. It is important to note that the problem areas are not separable in reality; their separation here is only for the convenience of description.

There is an acute water scarcity in Lalitpur (Kathmandu Valley) represented by a deficiency of supply of 21 million litres per day due to the low level of water infrastructure development, outdated water network and high leakage ratio, as well as climate change. This causes losses of economic activity, diseases, and hinders normal daily life. At the same time, the ADB-funded Melamchi Water Project is not to be completed until 2014, which raises the need for intermediate, relatively low-cost solutions for water supply in Lalitpur. Valley. For the description of project rationale, the Asian Development Bank requires a project identification table (Annex 2.) as part of an economic analysis. The main points described in the table are summarised below.

The goal is to provide safe water to the residents of Lalitpur through an integrated project that includes required technical interventions as well as sustainable legal and institutional arrangements for the operation of the infrastructure and the protection of subsurface water sources. Residents and visitors to Lalitpur will benefit from the protection of aquifers, the conservation of cultural heritage, water quality improvement at source, and the creation of jobs.

Community based and managed water supply projects that utilise the traditional supply network of water spouts represented a local response to the inadequacy and delay of central government policy responses to the water scarcity[4]. However, these projects do not address the problem of

[4] The Historical Stone Spouts and Source Conservation Association (HSSCA) was established on 20 May 2006 based on the local initiatives and the awareness raising campaigns of the NGO Forum for Urban

aquifer and groundwater protection as they do not provide for the complete mapping of these water resources. Furthermore, community based projects cannot provide a regulatory response to the competition for water. This legal instrument is the second, equally important element of the project analysed in this paper.

The institutional and legal problems can be summarised as the lack of municipal regulations that consider the relationship between intense building activity, in-migration, and exploitation of subsurface water resources. This is further aggravated by the limited ability of the current institutional framework to control the unsustainable extraction of groundwater. In the year 2000, 58.6 million litres per day (mld) was extracted as opposed to the sustainable yield of 26.3 mld) (ICIMOD, 2007).

Water rights for subsurface water extraction need to be regulated and the importance of subsurface aquifer protection must be reflected in local building codes. This can be supported by setting up institutions based on traditional community water management and encouraging the involvement of local authority and other stakeholders. As an additional measure a municipal fee system for aquifer use needs to be introduced.

The above measures contribute to social capital and institution building with community participation, awareness raising, and the generation of fee revenues for maintenance. A serious challenge is that the introduction of a fee for aquifer use raises the need to resolve conflicts related to water rights with current extractors of subsurface water, namely the unauthorised users.

It is also important to consider ensuring the continuity of the new institutional framework by

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Water and Sanitation. HSSCA works together with Lalitpur Sub-metropolitan City to replicate successful conservation initiatives. (UN-HABITAT, 2007) utilising it with a limited role after Melamchi Water Project is completed in 2014. The operational agreements for the Melamchi water supply project envisage a role for the local communities and municipal institutions as well. This role can relate to the collection of fees, maintenance of the network and water supply, as well as traditional network maintenance.

The following sections describe the scale and scope of the project analyzed in terms of geographical area, objectives, beneficiaries, stakeholders, and components. The analysis is limited to the alternative WSP to be implemented in the Lalitpur metropolitan area of the Kathmandu Valley. The project has the potential to benefit 30,000 people.

Geographical area

The wider project area, the Kathmandu Valley, is comprised of the three districts of Kathmandu, Lalitpur, and Bhaktapur. The total area of the Valley is more than 600 km2, and it encloses 50% of Lalitpur district, and the major part of Kathmandu and Bhaktapur districts.

There are four distinct seasons in the Valley’s subtropical climate: spring, summer, autumn, winter. Most of the average annual rainfall (approximately 1600 mm) falls during the summer monsoon. It is during the dry season that water scarcity is the most severe.

In the Pliocene times there was a lake at the area of the Valley, where sediments were deposited in varying thickness. Since the receding of the lake, these sediments have stored groundwater in the Valley. Deep aquifer recharge rates can be as low as between 1095 and 3285 m3/day, which is one-twentieth of the current water extraction rate (Warner et al., 2007).

In contrast to deep aquifers, the shallow aquifers are recharged from direct infiltration and monsoon rains. While these sources make shallow aquifers more vulnerable to pollution, they also ensure a faster recharge rate than that of deep aquifers. Based on this, and their continued utilisation, it is important to improve the state of shallow aquifers to ensure short- and medium-term supply of the population.

The Lalitpur district has a population of 337 785 (2001), an annual growth rate of 2.73%, and a population density of 877 p/km2.

Objectives

One of the key conclusions of the problem analysis is that a growing number of communities in the Kathmandu Valley are forced to use alternative means of water supply due to the current water shortage. The traditional hiti and well system is particularly important due to linkages with shallow aquifers and the need to protect them as a resource. Based on these conclusions, three objectives have been identified for the project:

- to provide an alternative supply of water to local communities by the revitalisation of the traditional water supply system,
- to protect the shallow aquifers that supply water to the traditional hitis (water spouts) in Lalitpur,
- to set up sustainable management structures based on local stakeholders participating in the operation of alternative water supply.

The stone spouts, traditionally built to supply water to a small population in a localised area, are increasing in importance given the present water supply deficiencies in the Kathmandu Valley. Some studies (e.g. Brown and Watkins, 1994 as cited in Warner et al, 2007) estimated that 20% of the population of Greater Kathmandu rely on stone spout systems for their water supply. According to the United Nations (UNEP, 1998), stone spouts benefit between 150 and 250 persons per spout (3-4% of the population) in Kathmandu, and between 300 and 400 persons per spout in Patan (4-6% of the population).

Based on the average total daily flow of stone spouts in Patan, the volume supplied could (in case of system restoration) supply more than 30 000 people. In the dry season, the spouts supply more people as water is filled into tankers and distributed to other localities as well. Effective management of the resource can increase the number of households supplied from an improved water source (ADB, 2008), consequently reducing water scarcity.

Beneficiaries

Direct beneficiaries of the project are the local communities in the supply area of the hitis revitalised in the frame of the project a) with regard to reducing the water shortage in their community, b) as well as conserving a valuable part of cultural heritage in the locality. The number of households (direct beneficiaries) benefiting from the project is estimated at 5000-7000 (depending on hiti discharge and dry/rainy season).

The project indirectly benefits other stakeholders (local NGOs, local authority, and the local service providers of utility services (e.g. Lalitpur Sub-Municipality Corporation) by building up social capital through cooperation in the project. In addition to the above, the project – due to its nature as a demonstration project – can benefit other communities in the Kathmandu Valley that consider similar alternative responses to the current water shortage problem.

Institutional framework, stakeholders, potential partners

There are a number of institutions whose contribution and/or cooperation is of key importance for the success of an integrated effort to protect the shallow aquifers of Lalitpur and to ensure the revitalization/conservation of the traditional supply system:

- users, the community groups, local businesses,
- municipality (Lalitpur Metropolitan Area municipality and mayor),
- Government agencies at district level,
- non-governmental organizations (ICIMOD, NGO Forum for Urban Water and Sanitation, Historical Stone Spouts and Source Conservation Association, etc.), including researchers
- donors (UNDAF, UN-Habitat, UNESCO, UNICEF, bilateral development agencies, e.g. SIDA, CIDA, DFID, etc.), international NGOs, expert consultant, etc.

The role of users and community groups is vital for the planning, implementation and sustainability of interventions. Particularly important is their support in the management and maintenance of the traditional system. The municipality is an important co-ordinating partner, provider of resources (information, expertise, limited funding) as well as a key player in the conservation of aquifers due to its local building control role. Donor agencies can provide important financial contribution and professional expertise for the project.

1.5 Structure

This chapter is followed in Chapter 2 by a description of the research methodology and the sources of data and other information used as inputs to the analysis in Chapter 4

Chapter 3 provides an overview of the international development scene in terms of community-based initiatives in and outside Nepal and identifies the factors that led to their success or failure. A historical perspective to the local problem will be introduced, followed by the problems and issues with the traditional practice of water supply and the need for considering alternative and sustainable water supply schemes.

Chapter 4 describes the project alternatives to be analysed and provides the analysis of the political and economic viability of the alternative project. The main indicators and risk factors are also identified, with special emphasis on the assessment of the impact of the Melamchi project on the policy and institutional environment.

The final chapter assesses the results of the analysis and draws conclusions relevant to the local setting as well as to alternative water supply projects (WSPs) in general.

CHAPTER 2: METHODOLOGY AND LITERATURE REVIEW

2.1 Methodology

The aim of the research into the secondary sources has been twofold. First of all, to understand the global as well as the local scene in relation to alternative water supply initiatives in the frame of water scarcity. A wide range of studies and news media reports have been reviewed. This qualitative research of international literature has been helpful in identifying the key elements of similar projects implemented or supported by bilateral development institutions or international NGOs. The sources for this component of the thesis included The Kathmandu Post, the Nepalnews website, ScienceDirect, and factsheets and reports from WaterAid and ELDIS. A selection of research papers on the effects of urbanisation on groundwater as well as research on the role of communities in groundwater management have also added to this study. The understanding of various technological and institutional aspects of the topic was greatly enhanced by relevant publications of the United Nations Environmental Program and the UN Human Settlements Program.

In this analysis of the local context, the UN Habitat publication on community initiatives in Patan has been particularly useful as it covered a wide range of topics and provided a good overview of the context. Thapa (2008) provided invaluable information on Kathmandu. The data for the analysis has been “mined” from various publications of the Asian Development Bank and the Nepal Rastra Bank.

For the project background, case studies of earlier initiatives have proved instrumental in understanding the mechanisms and causes underlying community initiatives that addressed the challenge of alternative water supply by utilising the traditional supply system in Patan. Newspaper articles (Kathmandu Post courtesy of NGO Forum, Nepal) and project reports have been the main source for these case studies.

Secondly, the economic analysis of the alternative water supply project has required extensive research into quantitative data with regard to a number of factors including water demand, the size and income of households, wage rates, and indicators describing the quantity and quality of water available in the project area, as well as related trends of change. The main sources for this data package are official publications, technical notes, and project reports of the Asian Development Bank, and the Household Survey carried out by Nepal Rastra Bank.

To ensure reliability and replicability of the methods and results, the economic analysis provided in this thesis follows the recommendations and methodology published in the Handbook for the Economic Analysis of Water Supply Projects (ADB 1998).

With regard to providing a common basis for the data originating in various years due tothe utilisation of various sources (ranging from 1998 to 2007 in terms of official publications), the trends in official surveys and programming documents used by the international financing and development institutions have been used to arrive at the values actually used in the analysis. In this regard, it has been assumed that the trends, data, and analysis provided by the UN, ADB, and Nepal Rastra Bank experts are valid (UN-HABITAT, 2007. UNEP-ICIMOD-MiEST, 2007; Nepal Rastra Bank, 2007).

In case of discrepancies, an effort has been made to calculate a solid basis for the analysis. The method for this in calculating the willingness-to-pay aspect of the analysis will be described in the relevant section. With regard to the costs of water from alternative sources to households not connected to piped water a number of research papers and case studies analyzing projects implemented in developing countries in Asia (e.g. Pattanayak et al., 2005) have been reviewed for relevant data.

The main sections of the economic analysis of the project follow the guidelines set by the Asian Development Bank (ADB, 1997). These are only briefly listed within this section, with detailed methodological steps described in the economic analysis section and the relevant annexes. The most essential element is defining the project rationale and the examination of the macroeconomic and sectoral context with special regard to the project`s relation to sector strategies and the regulatory framework. After establishing the project rationale and putting the project into context, various alternatives can be drawn up and the best of these selected for the actual analysis.

The analyst needs to describe the method of selecting the best alternative. The following steps are more technical in nature and form the core of the economic analysis. These are: demand analysis, identification of costs and benefits, establishing and using shadow prices for the subsequent calculations of net present value and internal rate of return. After the economic analysis is completed, the impact of various factors on the net present value and internal rate of return are examined in the framework of a sensitivity analysis. The scope of this thesis does not allow for a detailed risk analysis; however, it is possible to identify risks related to the institutional and policy environment, as well as counter-measures proposed. To complete the analysis, a brief section will assess the issues of sustainability and distribution of project impacts.

2.2 Literature Review

In the course of the research, a wide range of secondary sources have been reviewed. The sources can be categorised into three groups.

The first includes those papers that lay the general theoretical groundwork for approaches to water supply in an age of water scarcity in urban environments in developing countries. The second group of papers contribute to the debate on water as commodity or public good, and research examining the relationship between project effectiveness and community participation. Finally, the sources on the application of economic analysis have also been consulted for more detailed instructions related to the methodology of the analysis.

Starting from the global level and a focus on the description of the situation, the publications of the United Nations (UNEP, 2007; UNDP, 2006; UN Habitat, 2007; WHO, (2005, 2007)) have provided useful insight into the general trends and summary of analysis of policies. These documents also contributed to a deeper understanding of the global policy context and some underlying developing country specific issues related to water supply, especially with regard to the realisation of the Millennium Development Goals.

For a deeper analysis of the "how?" of water supply in cities in developing countries, this paper has reviewed a number of studies ranging from the purely technical to the philosophical (in terms of topics) and the theoretical models to the practical (case study analysis). Gleick (1998) advocates for considering access to water as a human right and adds some important dimensions as to the impact of such a view. This has a number of implications regarding the design and implementation of water supply projects, as demonstrated by the emphasis on participation, the introduction of demand management, sustainability considerations, and a focus on the institutional context rather than the ownership of the water utility. Prokopy (2005) used statistical methods to examine the impact of participation on rural water supply project outcomes, while Bakker et al. (2007) applied a new conceptual framework (governance failure) to a case study on the water supply in Jakarta, Indonesia and its effects on the urban poor. Vairavamoorthy et al. (2008) turns our attention to a more technical analysis of climate change and water scarcity, while Gumbo et al. (2005) argue for more relevance for water demand management and stakeholder training as complementary methods to supply-side interventions. In his paper, Niemczynowicz (1999) outlined the key challenges in the field of urban water management and argued that the specific urban context requires a special application, urban hydrology.

2.2.1 Water scarcity in the global scene

According to the Human Development Report 2006 (UNDP, 2006) water scarcity on the global scene is not due to an absolute lack of water resources or the depletion thereof, but rather the result of the ineffectiveness of the institutions and policies to ensure an equitable and sustainable utilisation of water. According to the WHO Resource Sheet for the International Decade for Action (WHO, 2007) 1.1 billion people do not have access to safe water. According to the same paper, global population growth (especially in developing countries) slows down the pace of improvement in providing access for an increasing number of people. Another key factor is climate change, which in general increases rainfall in the Northern hemisphere, while in the global South[5] periods of drought are becoming longer, causing seasonal scarcity of water and disruption of agricultural production.

The difference in the volume of water used is striking: an average consumer in Europe uses

[5] In development terminology, “the North” generally means the group of developed countries, while the global “South” represents the group of developing countries.

about 200 litres per day for domestic purposes, while the average water use per capita per day in Nepal was estimated at 12 litres in 2000 (Gleick, 1998). The UN suggests that each person needs 20-50 litres of safe freshwater a day to ensure their basic needs for drinking, cooking, and cleaning. The World Health Organization has calculated that by achieving the Millennium Development Goals related to water and sanitation the value of time savings can reach USD 64 billion globally, while the annual global value of working days gained (due to less illness) amount to an estimated USD 750 million (WHO, 2005). These figures and the fact that more than 400 million school days are lost annually due to water-related diseases (UNDP, 2006) reflect the enormous losses to the world economy due to limited access to safe water and sanitation.

Increased investment in water related infrastructure is clearly required to achieve the Millennium Development Goals. It is important to distinguish between water scarcity in rural and urban contexts. One reason for this is the different geographical, spatial, settlement and institutional characteristics, including the existence or lack of a "market" for water. The Human Development Report 2006 acknowledges the existence of informal and formal markets for water in the urban context in developing countries and argues for governments` extending regulations to make the informal markets more accessible to poor people to ensure more equitable access. The second reason is that the above mentioned differences call for and enable different approaches in designing and implementing water supply interventions. The migration of rural population to urban centres has contributed to urban poverty and uncontrolled expansion of cities in developing countries. A study published by WHO and UNICEF has estimated that the urban population without access to improved water sources rose from 5% to 6% of the total global urban population (Hinrichse et al.,2002 as cited in Vairavamoorthy, 2008). According to

Vairavamoorthy et al the number of cities with more than 1 million residents will exceed 600 by 2025, which represents an increase of more than nine times since 1950. This statistic has considerable implications for the theme of urban water scarcity in developing countries as it represents serious challenges for supplying good quality water in adequate quantities.

2.2.2 Water as a commodity and other considerations

The methods and even the perception of water (commodity versus human right or economic versus social good) have been contested. This makes water supply projects in developing countries a contentious issue.

The view that access to water is a basic human right has gained popularity with the rise of social movements and community opposition (Wateraid, 2003 as cited in Bakker, 2007) to private investment and operation of water supply services in developing countries. According to Gleick (1998), acknowledging a basic human right to water would guide investment and management decisions towards providing a basic level of water supply for all.

However, the perception of water as a commodity or a basic human right does not change the fact that the poor in developing countries already buy their water from markets that "skew prices against them." (UNDP, 2006). The Human Development Report identifies the "market distance between the water user and the utility" as the main reason for the disproportionately high prices that the poor have to pay for water. Moreover, in South Asia access to water does not mean a water tap in one's household, but rather the availability of water from a public tap or standpipe. The large number of intermediaries and the use of varying sources of water results in prices 10-20 times higher than that of water provided through a utility (Bakker et al., 2007). In spite of this disadvantage, poor households choose not to (or are not able to) connect to the water supply network due to the high connection costs, perceptions of water quality, housing status (no tenure no property rights), and instability of supply (Bakker et al., 2007).

Based on the recognition that the existence of markets for water can neither be denied nor can these markets be eliminated, attention has been focused on design, pricing, and management tools as well as the participation of local communities. In fact, with substantial local participation, solutions to water scarcity can even contribute to the empowerment of local communities through private sector engagement (Akbar et al., 2007). The paper proposes a "Community Mixed Water Supply" model (p.29.) that integrates the community and various other actors` actions related to the local resource. This model was applied successfully in Dhaka, Bangladesh. It is adapted to the reality of poor households using a variety of water sources and provides a solution by international donors, NGOs, and increasingly the private sector investing in water points that ensure continuous supply of potable water to the urban poor.

Other authors have joined the debate over public versus private sector provision by examining performance, ownership, and institutions. A substantial part of the research literature seems to demonstrate that public or private ownership is not a predictor of the efficiency of water supply provision (Bayliss, 2003; Braadbart, 2002; Kirkpatrick, Parker & Zhang, 2006, and others as cited in Bakker, 2007). On the other hand, Bakker emphasises the importance of institutions in water utility performance and follows this argument to its logical conclusion that it is neither market nor government, but rather a governance failure[6] that causes the poor to not connect to water supply networks.   Due to governance failure the poor households' capability to connect to

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[6] Governance failure in the context of the referenced paper means the failure of coordination between various stakeholders (government, private sector, population served, non-governmental organizations) resulting in disincentives and obstacles for connecting the urban poor to water supply networks.

the piped water supply system is undermined by a range of economic and non-economic factors. These factors can include the spatial distribution of water mains, the business model applied by the water supply company, high connection fees and transaction costs due to intermittent supply.[7]

Further aspects include operational irregularities of the service provider resulting in inequitable access to water supply[8], land use planning policies of local municipalities, and local decision-making mechanisms that do not consider the interests of poor households.

To add another element to the 'big picture', Nienczynowicz (1999) argues that ecological and hydrological considerations are also essential, as shown by the negative impacts of land subsidence and increased flood risk due to overexploitation of groundwater resources in many large cities, such as Bangkok, Jakarta, Mexico City, and Beijing.

Another paper (Foster, 2007) on the linkages between groundwater and urbanisation states that

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7 The spatial distribution of mains can be affected by past decisions (e.g. in Jakarta mains were constructed to supply the districts settled by "Europeans" or in Kathmandu the original network was constructed to supply the Rana rulers and their clientele. The business model applied may contain disincentives to connect the "loss-making poor", and the high connection costs and the lack of an option to pay it in installments may be prohibitive to the poor.

8 "Why to pay tariff when the tap has been dry for the past 25 years?" asked Gopal Kachyapati, proprietor of Kantipur Hotel, Durbar Marg which is in the defaulters' list of KUKL for not clearing water tariff, adding, "We do not care if the company cuts off the connection that do not supply water anyway." He accused the company of making public the due amount without proper calculation." (Retrieved from: http://www.irinnews.org/report.aspx?Reportid=86273 (IRIN, humanitarian news and analysis, a project of the UN Office for the Coordination of Humanitarian Affairs)

"...local residents in Kaldhara found out that KUKL staff had organised an unscheduled water delivery one day at midnight while only informing their relatives about it. Kaldhara residents get water only once every 5 days. ...Third, former project staff and other government officials, including Former Prime Minister Girija Prasad Koirala, have been accused of unauthorised use of eleven expensive vehicles belonging to the Melamchi Water Supply Project. In some cases government registration plates have been replaced by private ones. Meanwhile the project is spending Rs. 0.3 million a month on hired vehicles for its consultants." (Retrieved from: http://washasia.wordpress.com/2009/07/30/nepal-kathmandu-water-utility-kukl-under-scrutiny-amid-continuing-water-shortages, Source: The Kathmandu Post, June 5, 2009) when groundwater exploitation results in depletion of aquifers, a cycle of well deepening ensues, which is inefficient in terms of economic and natural sustainability. The same paper proposes that the objectives related to groundwater resources should be the improvement of sustainability of resource exploitation as well as enabling a more efficient resource utilisation.

For this latter goal, an important instrument can be a regulatory framework, possibly in the form of "local decree within municipal limits through a local aquifer management committee" (Foster, 2007).

Finally, it has been proven that projects cannot be sustainable in design and implementation without participation of local stakeholders. A number of studies related to the South Asian region (Sri Lanka, India, and Indonesia) found that decision-making by the communities affected regarding the design of interventions is highly correlated with satisfaction with project services during the operation (Isham and Kahkonen, 1999, 2002 as cited in Prokopy, 2005). The same study argues that the poor's participation in raising the funds to start up a water supply project contributes to a sense of ownership, higher, more effective levels of participation, as well as project sustainability.

CHAPTER 3: BACKGROUND

Based on the above, it is necessary to consider all of the sustainability aspects (technical, financial, economical, ecological, legal, and social) of the project. The personal experience of having lived in Patan for almost a year and sharing the queues with other patient Nepalese at the wells has contributed to my ability to integrate and conceptualize these considerations and led to a heightened interest in finding a solution for the period until the Melamchi project is completed. This paper aims to carry out this task by proposing an integrated water supply project for the Lalitpur city area and test its economic and political viability.

For an adequate analysis of urban water supply in the South, it is then necessary to consider technical, financial, economic, and political aspects of water management.

3.1 Water supply in Lalitpur – a historical perspective

The traditional system of water utilities in the Kathmandu Valley included public wells (tun), stone spouts (hiti), canals that fed the spouts (rajkulo), artificial ponds (pukhu) to recharge the shallow aquifers, and drainage and irrigation canals. There are three major aquifers in Patan: Naricha, Nayekhyo, Khwyebahi. In total, 400 traditional stone spouts were recorded in the Kathmandu Valley. There are 58 stone spouts, 220 traditional public wells and 39 pukhus in Patan (UN-HABITAT, 2007). The oldest hiti found in Patan (Mangā Hiti) was built in the 6th century AD.

Manga hiti, Patan

The hiti is constructed in a pit for convenient spouting of sub-surface water that arrives at the spout via natural flow or through artificial channels. The man-made channels were normally made from burnt clay or wood. Some hitis have sand, gravel, or charcoal filtration systems as well, installed before the water reaches the spout.

The base of the hiti is paved and has side drains, while the outlet drain is channelled to lead to ponds or agricultural fields outside the settlement where the water was and in some cases is still used for irrigation, washing agricultural products, or duck farming.

There are more than 1000 public wells (tun) in the Kathmandu Valley, with a depth varying between 4-6 metres (UN HABITAT, 2007). The wells are of circular shape and usually have a brick wall. Depending on water quality, the water from these wells can be used either for the primary purposes of consumption and cooking, or for secondary purposes e.g. washing and cleaning. The *tun* is not part of the *pukhu-rajkulo-hiti*-drainage network. Traditionally, neighbourhood associations (guthi) were responsible for the maintenance of hiti in their locality.

The driest day of June (Sithinakha) was the national day of waterworks maintenance in the traditional Newar culture of the Valley. The city level infrastructure was maintained by city level institutions. In Patan, the Rato Matsyendranath Jatra (a special festival in honour of the God of water, Rato Matsyendranath) is linked to water management.

Before the festival all of the bigger ponds in Patan were to be filled with water before the chariot of the god was completed. People from different neighbourhoods and different castes had their specific responsibilities in the festival, most of the activities being related to the maintenance of water works. In addition to the festival, mending and maintaining the *rajkulo* with the involvement of various neighbourhoods was traditional practice.

3.1.1 Recent developments

The main water supply for the urban areas of the Valley utilizes surface water sources of the Bagmati River, its tributaries, and a number of lakes and springs from the hills around the Valley and subsurface water from 37 deep wells. A secondary source of domestic and industrial water is the shallow aquifers in the Valley. About two thirds of the total supply is from surface water. Access to tapped drinking water is on average provided to 81% of the households in the Kathmandu Valley, with Lalitpur having 83% coverage. However, the unstable supply of electricity and the high percentage of leakage (up to 50%) (Annapurna Post, 2009)[9] means that drinking water supply is not continuous and the quantity supplied is far below the demand. According to the Asian Development Bank, the nonrevenue water[10] constitutes 37% of water produced.

In order to meet the gap in domestic water supply the people in the Valley use public taps,

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[9] According to Kathmandu Upatyaka Khanepani Limited, the current operator of the water supply system, the age of the pipelines (27-70 years old) contributes to the high level of leakage from the system.

[10] Nonrevenue water is the quantity of water unaccounted for the company either due to technological loss or because consumers water use cannot be measured and charged for by the water supply company. Consequently, nonrevenue water represents a form of financial loss.

traditional stone spouts, community public wells, rower pumps, or tube wells.

The above forms of water extraction compete for the shallow aquifers and, along with the private, unlicensed wells, often hamper supply from the community sources that are used by low-income, disadvantaged groups of the society.

The quality of drinking water from the dug wells, public wells, tube wells, as well as stone spouts does not fulfil WHO standards. The treatment of drinking water in the piped system is not satisfactory either, as shown by samples having chlorine levels lower than the WHO standard. The subsurface and surface water sources are heavily polluted due to the low sewerage rate (only 22% of Valley population is connected to the network (ADB, 2004) and the insufficient capacity of existing wastewater treatment plants. The majority of the population uses septic tanks or their wastewater is discharged directly into surface water sources. A market for water has emerged including suppliers offering trucked water, bottled water, or bottled mineral water. According to the Asian Development Bank, the private scale providers serve about 4.7% of the total households in Kathmandu Valley.

The government has embarked on a long-term program to increase the water supply in Kathmandu Valley towns through inter-basin transfer from the Melamchi, the Yarke, and the Langri rivers, new water treatment plants, extension of the bulk distribution network, and additional storage capacity. The project is part of the Millennium Development Goals of Nepal and its three stages aim to provide a total of 510 mld of water to the Kathmandu Valley. The first stage is planned for completion by 2013. The implementation of the project has been delayed for years. Moreover, the project was abandoned by the World Bank previously (The Answer is No.

Nepali Times (2002))[11], due to a number of political and managerial difficulties.

Community managed water supply projects are not feasible without a regulatory environment conducive to them. The Nepali legislation (based on WaterAid, 2005) includes a number of regulations and Acts that serve the basis for the project proposed. The Act also introduces the term “beneficial use” which represents reasonable and equitable utilisation without causing any negative effects on the water rights of others. The Water Resource Act of 1992 (2049 BS) establishes that the first priority of water utilisation is for drinking and domestic use. The Local Self Governance Act of 1999 (2005 BS) authorizes local bodies to make policies and implement programs in relation to drinking water, as well as to raise revenues via local tax and other means. Regarding the Water User Associations, their legal entitlements and related procedures are set out in the Drinking Water Regulation 1998 (2055 BS). The regulation states that groups of people who wish to benefit collectively from developing and operating their own project may

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11 “*What about Melamchi? Why aren't you involved?*

Well, those are exactly the questions we have been asking ourselves. I know this is not necessarily a popular position in Kathmandu, where many people view Melamchi as the solution to all their water problems. We believe that important options have not been explored to utilise the water resources available within the valley. First order of business is to fix the distribution system, and start charging prices to reflect the scarcity of water. Only then, one can find out how serious the alleged water shortage is. It may turn out that a shortage does not exist, at least for many years. Besides, without fixing the distribution system, Melamchi water will have no place to go but into the Bagmati River. Now you may ask why the World Bank is reluctant to fund rehabilitation of the system. You need only to look at the history of the four projects we did try to support over the last two decades to realise that it was money down the Bagmati. The question that begs to be asked before spending about 10 percent of GDP on this project, which benefits arguably the richest 5 percent of the population, is about its necessity and priority relative to the vast needs of the poor who live outside the valley. Some have argued that higher water charges will pay for Melamchi and hence this project does not affect HMG's ability to implement more poverty focused projects. I question that assertion. This project costs over $400 (Rs 31,000) per valley resident. Do you really think people are ready for that kind of investment? Also, in 2002-03 budget, inclusion of Melamchi as P1 did displace Rs 1.8 billion worth of other priority projects.”

Ken Ohashi, World Bank representative to Nepal on World Bank withdrawal from the MelamchiProject, Nepali Times 2002.

form a Drinking Water User Association.

Finally, an important aspect in relation to projects funded by international financial institutions (IFIs), as opposed to bottom-up, community based projects with participation from non-governmental organizations, is described by Younger(2007). In his paper, he mentions that the “uncritical export of northern attitudes and hardware to the South does violence to both the value systems and realities in many Southern countries.” The Asia Water Watch 2015 publication (ADB-UNDP-UNESCAP-WHO, 2006) emphasises the need to “establish a supportive environment for the further development of private sector, civil society, and community level organizations.”.

This paper does not attempt to analyse the strengths and weaknesses of IFI funded high-technology content projects as opposed to community-based, more traditional projects. Rather, it proposes to support the application of a community-based solution as a catalyst for institutional change and sustainable utilisation of the shallow aquifers. It is with this view that community based projects in Lalitpur are described in the following section.

3.1.2 Community based projects

The following case studies have been presented in the UN-Habitat publication on water movements in Patan (UN Habitat, 2007). The projects described below represented the local communities` response to the water scarcity. However, they lack the regulatory element proposed in the project analysed, which is an important factor of sustainability.

The Nag Bahal hiti was restored with support from the US Embassy Fund. The Fund provided approximately 85,000 USD to the Patan Tourism Development Organization in 2008 for the Nag Bahal Hiti Rehabilitation Project of Lalitpur. Mapping of related structure, detailed documentation of water supply channels, cleaning, and repairing the inlet water channel were part of the project, in addition to the construction of maintenance wells and the restoration of the sunken water spout. The restored traditional water spout can now supply water to more than 100 households in the courtyard and the surrounding areas.

As part of the Urban Development through Local Effort (UDLE) program (GTZ, 2006) with assistance from the German Agency of Technical Co-operation (GTZ), the Patan Conservation and Development Project was initiated in 1992. The project had a number of highly successful elements, but due to various constraints the restoration of traditional water supply systems and "Building Control, Action Plans and Projects, and Strategy Planning" were only partially completed. Based on the initiative, Lalitpur Sub-Municipal Corporation intends to implement the Rajkulo[12] Rehabilitation Project (a part of the traditional water supply systems of Patan) with support from other donors.

The UN-HABITAT publication "Water movement in Patan" (UN-Habitat, 2007) describes the restoration and management of Alkwo Hiti as a best practice project. The hiti was established in 1415 AD and has supplied water continuously ever since. The challenge faced by the community was to adapt to the changing needs of a new, renter population and to prevent pollution of the aquifer by agriculture, a bone mill, and uncontrolled building in the area. The User's Committee initiated and successfully completed the project, and water distribution to the doorsteps of households began in 2004. A regular monthly user fee is charged for the service. Alkwo Hiti is

[12] Rajkulo: water channel connecting the surface water sources and ponds or reservoirs.

capable of supplying water to 900 households in wet season (300 in dry season). The hiti complex was renovated in 2005. The historical stone spout conservation committee was initiated based on the Alkwo Hiti movement.

The Alkwo Hiti project is a model project in many respects, considering its innovative house delivery system, local regulations on protecting the aquifer, management by a local community, and the ability to raise funds for maintenance and expanding the system.[13]

3.2 Sources of drinking water in Lalitpur

Out of the total 68, 921 households in Lalitpur more than 57,000 (83%) rely on tap water for their water supply, 6,745 (9.8%) use wells, 3,099 (4.5%) use water spouts, and 825 use tube wells (Kathmandu Valley Environmental Outlook, ICIMOD (2007)). However, as a result of the limited availability/supply of tap water, a growing number of households rely on multiple sources of water featuring the ones listed above, as well as harvesting rainwater as part of their water strategies. However, the various techniques of acquiring water applied by different sections of the society constitute competing uses of water and may be a source of water conflict.

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13 "The municipality helped them with two PVC water tanks. After herculean efforts of three months, on 1st of Baisakh, 2061 BS, they inaugurated their community based water management system. At the beginning the system was serving 150 houses, which was later extended to 180 houses. They have established their own rules and regulations, regular meetings and continuous support from the community. With this effort each house is getting 250 to 300 litres of water every day. The best part of the system is the serving of water at their door step, which otherwise would not serve the present changed lifestyle of the urban community. In Patan, there are several traditional by NWSC in 1985 and UDLE in 1993. They established Alkwo Hiti Conservation and Water Supply Users' Committee (AHCWSUC) and came up with harvesting of water of the hiti and distribute door to door. A 7-membered committee was formed under the leadership of Mr. Sushil Shrestha, and started working in the project from late 2003. When their effort of bringing external support could not be successful, they initiated with their local fund with the commitment of more than 50% of the community to participate. It was not easy at the beginning as adequate fund contribution could not be collected. They even thought of dropping the project. Later, as the water tower started rising, the confidence started building. For more than three months locals contributed their labour every evening. ...They pump the water from well and convey through flexible pipes to the surrounding houses or store in an overhead tank to distribute later." (UN-Habitat, 2007)

The modern system of piped water was introduced by the Rana rulers in the late 1800s, and its expansion continued in the 1950s. However, the arrival of modern systems brought about the neglect of the traditional water and resource management systems.

The introduction of the system started with the diversion of traditional flows of water for the palaces and public taps. By 2001, 83% of the population of the Kathmandu Valley was connected to the water supply network, but 24-hour water availability was non-existent (ADB, 2004). The sewerage system construction in Patan started in 1978. During the construction, the traditional burnt clay channels that fed a number of hities were broken. These events represented a shift from a traditional system based on ecological principles designed for a low-population density settlement towards a system with little or no regard to natural groundwater flow patterns and more emphasis on serving a growing population.

3.2.1 Quantity supplied

In spite of the 83% service coverage in Lalitpur, in terms of actual supply only about 30% of households get water (UN Habitat, 2007). Municipal water supply is only available every fifth day. The *hiti* and the private or public wells remain the only option for a growing number of people.

In the Lalitpur branch, the total water requirement (including unaccounted for water) is 43.2 mld, while the water production in this branch is only 27 mld during the wet season and 17 mld during the dry season. The deficiency for the present population is 16 mld (wet season) / 25 mld (dry season (UN-Habitat, 2007). In the city core, most of the areas are supplied for two hours on every fifth day. The households that can afford high capacity pumps and large water tanks extract water from the municipal pumps and store it, while low income households and people in the outskirts of the town rely heavily on communal water sources, including the stone spouts.

Consequently, the traditional system will continue to play an important role in water supply until the large scale water supply infrastructure development in the Kathmandu Valley is completed.

3.2.2 Water quality

"Ensuring water quality is also a major challenge in Nepal….even piped drinking water is unsafe in many areas almost throughout the year. Nationally, 30 percent of the households reported incidences of diarrhoea, dysentery, jaundice, and typhoid or cholera. Among children under five years of age, the prevalence of diarrhoea was 20.4 (MoH/New ERA ORC MACRO 2002). …Improving the management and treatment of drinking water at the household level is an appropriate option for the country." (WHO, Country Health System Profile, Nepal)"

According to the Millennium Development Goals Report on Nepal (HMG Nepal/UN, 2005) 5% of the population have access to high-quality water supply, while 75% of the population survive on a level of basic services. In Nepal, the quality of drinking water is categorised as shown below.

Water Supply Standards in Nepal (Table 7.1, HMG NEPAL/UN, 2005)

Service level	Quantity (person per day)	Quality (months per years)	Accessibility	Reliability (hours per day)	Sustainability
High	According to WHO	According to WHO standard	According to WHO standard	24	12
Good	According to WHO/national standard	According to WHO/national standard	Installed inside the house compound	24	12
Basic	20-45 litres	Processed, generally not injurious to health	Available up to a distance of 20 minutes	4	12

The report states that a major source of pollution of surface and groundwater resources in the

Kathmandu Valley is that “Four out of the five treatment plants in the valley are out of operation.” (p.71.). The Baghmati and Bishnumati rivers flowing through the Valley are essentially open sewers during the dry season. The key polluting sources include broken sewage pipes, septic tanks, and open pit toilets, as well as polluted surface water infiltrating into the ground.

Sewage contamination is indicated by bacterial, pH, iron, and ammonia contamination in the water.

As the municipal supply of water is inadequate, people use a number of groundwater sources (public wells, tube wells, stone spouts). It is important to note that stone spouts are water sources of religious significance and are generally preferred by low- and low-medium income people to other sources. This is in spite of the fact that they often “spend up to 45 min walking to the nearest *dunge dhara*[14] where they can wait in line for more than 6h to fill their 15-L containers.*”*(Warner et al.,2007). For the same study, 115 various water sources have been tested. The result was that the stone spouts and public wells had the two highest median *E.coli*[15] concentrations. Nitrate and other inorganic pollutant levels were also higher in these water sources than the WHO or national guidelines.

A number of reports and research papers contain detailed water quality indicators and data (ICIMOD, 2007; Warner et al., 2007; HMG/UN 2005). For the purposes of this study, it is sufficient to state that the consumption of unsafe water causes a serious health risk in the Kathmandu Valley underlined by the fact that 15% of all illness and 8% of total deaths are due to

14 Traditional stone spouts

15 A bacteria that can cause stomach cramps, diaorrhea, and vomiting if ingested with food.

typhoid, dysentery, and cholera (Warner et al., 2007).

Regarding the assessment of various water sources by the public, Pattanayak et al. (2005) surveyed the households' perception of water sources they had access to in Kathmandu.

It is apparent that stone spouts received a relatively good assessment (poor taste 6%, dirty 16%, irregular 8%), while private water connection (piped water) received an overall bad assessment (poor taste 53%, dirty 77%, irregular 60%). The table summarizing the result is shown below:

Table 2. Respondents' Perceptions of Water Quality from Available Sources[a]

Source/Quality	Poor Taste	Dirty/Very Dirty	Some/Serious Health Risks	Irregular/Unreliable
Private water connection (PWC)	53	77	82	60
Public taps	42	67	66	35
Public well	28	44	57	11
Neighbors that give water away	36	67	70	50
Private well[b]	40	50	75	7
Vendors/tank	16	33	70	52
Stone spouts	6	16	38	8
Other surface water sources (river/stream/lakes)	26	26	50	28
Rainwater	32	49	68	95
Bottle mineral water	...	...	9	...

[a]In percent.
[b]Private well is a broader category including tube wells and other wells that could be operated by hand/rower/electric pump.

In conclusion, the shallow aquifers will continue to be used until safe sources of drinking water replace them. This lends further emphasis to the importance of training, awareness-raising, and the introduction and promotion of low cost disinfection methods for the low income population of the Valley. Such methods can include SODIS (a cheap solar disinfection method) or PIYUSH (HMG/UN,2005).

3.3 Water scarcity in the Kathmandu Valley – an overview of causes and effects

The following factors contribute to the water shortage in the Kathmandu Valley.

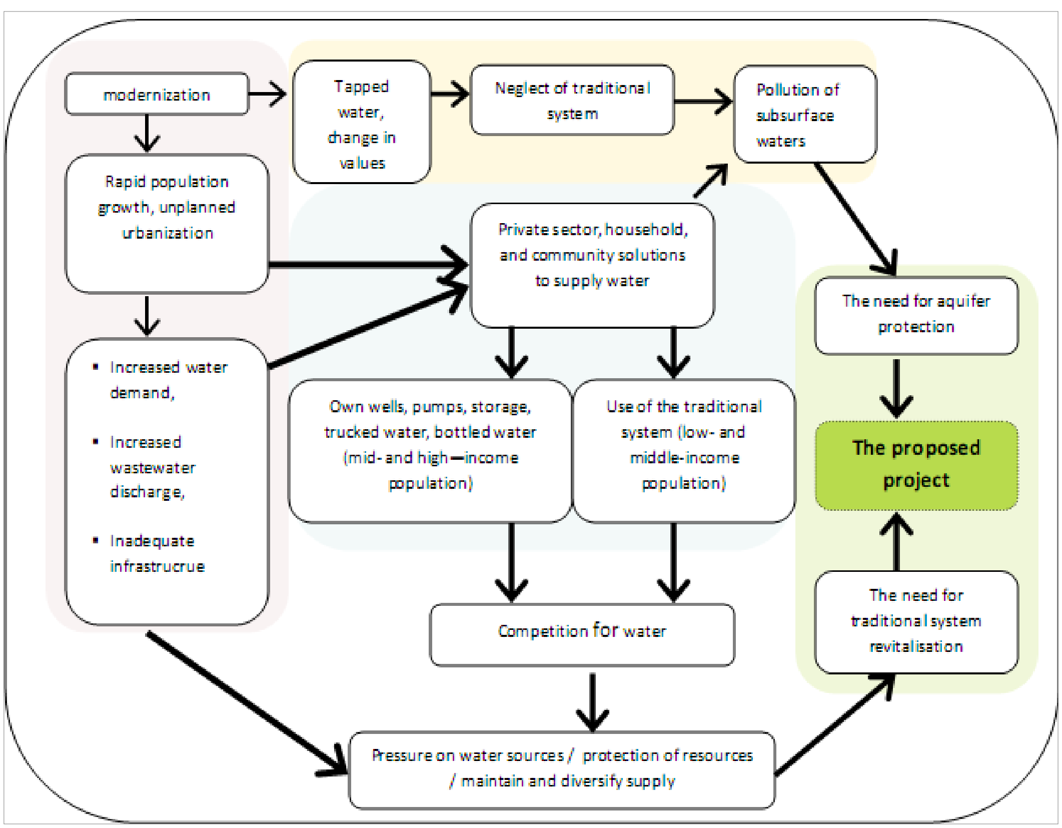
- Insufficient supply in terms of quantity due to rapid urbanization and population increase
- Load-shedding in the electricity supply system hinders the operation of the municipal

water supply,

- Outdated land-use plan (adopted in 1976), uncontrolled urbanization, building permits issued without concern for shallow aquifer protection, lack of by-laws on groundwater use,
- Community and other institutions encroachment on the area of traditional infrastructure,
- Inadequate level of sewerage treatment, effluent directly channelled into ponds or polluting groundwater,

- Lack of maintenance and eutrophication of ponds leading to loss of traditional function (aquifer recharge, irrigation, etc.),
- Exfiltration of sewage into the aquifer from broken/old sewers,
- Obstruction of natural groundwater flow due to large buildings/deep foundation/basement construction,
- The exact boundaries of aquifers not mapped/known.

The following diagram demonstrates the system of causes and effects leading to the current situation and the proposed project.



CHAPTER 4. THE ECONOMIC ANALYSIS

4.1 Introduction

The following analysis examines the components of a hypothetical project proposal. The goal of the project is to provide improved drinking water to the low- and medium income population of Lalitpur. The project is made up of technical interventions, awareness raising and training, as well as developing a management structure that connects local communities and the municipality. The final composition of the project is **based on the following assumptions**:

1. The linkages between the cultural, ecological, economic and social aspects in the project area are fully recognized and accepted by the main stakeholders,
2. Further to the above, stakeholders accept the need for a local regulatory regime controlling the use of subsurface water resources,
3. The project recognizes the interdependencies of the communities using the same groundwater resource,
4. It is crucial to acknowledge and consider the affordability constraints for the majority of the target group and the need for improved water sources until the completion of the Melamchi project,
5. The project puts a priority on recognition, consideration and effective utilization of existing cultural norms and practices in relation to the use of water,
6. The protection of underground water resources and related traditional infrastructure serves multiple purposes (water consumption, the prevention of subsidence, ecological balance, cultural values),
7. Donor funding can be made available from international NGOs, if the project is economically and institutionally viable.

In addition to the above basic prerequisites, there are some **limitations to the project design.** Being essentially community-based, the project aims to supply water only for domestic users.

In addition to this, the low technology input, the use of traditional means to increase access to **improved drinking water**[16] , and the budget constraint of users and the project requires the additional treatment/purification of water at the point of use. The project considers the use of some low cost methods to achieve this (SODIS, Piyush)[17].

Considering the time-frame of the project, the water supply component will operate until the start of piped water supply in the area from the Melamchi project (assumed to be in Year 5), while the conservation component can continue to function as long as the institutional (community, municipality, NGO) environment maintains and enforces the relevant regulation. For the cost-benefit calculations, it was assumed that the conservation component (with 50% of maintenance costs) will continue to operate until Year 10.

Based on the above, **the purpose of the project** is the following:

To ensure access to an improved water source to the population of Lalitpur sub-metropolitan area with the re-vitalisation of the traditional water supply and distribution system and the protection of shallow aquifers with regulatory measures.

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16 The ADB Discussion Paper on achieving water related Millennium Development Goals (ADB Discussion Paper,2008) quotes the Global Water Supply and Sanitation Assessment (UNICEF-WHO, 2000) for the description and definition of "improved water source". According to the Assessment, an improved source of water supply can be a house connection, a stand post/pipe, a borehole, a protected spring or well, collected rain water, or water disinfected at the point-of-use. Water supply service is not improved if it is unsafe to health or "unnecessarily costly, such as bottled water or water provided by truck". Unprotected wells and springs, vendor-provided water, bottled water, and water provided by tanker truck are considered unimproved water sources.

17 SODIS or solar disinfection is a method developed and publicized by the Swiss Federal Institute of Aquatic Science and Technology. The method makes use of non-colored PET bottles and the UV-A rays of the Sun to disinfect clear, filtered water. It has been introduced in a number of developing countries successfully. (http://www.sodis.ch/index_EN). Piyush is a water disinfection product, a chlorine solution that can be used in the households. One small bottle costs 17 NRs and is sufficient for disinfecting 400 liters of water (http://www.crs.org.np/piyush)

The **major project activities** needed to achieve this purpose are the following:

1. Fund raising
2. Underground flows/aquifer boundaries are mapped.
3. A plan for local legislation on aquifer protection and water use is prepared.
4. Local residents are trained in disinfection and water saving, and informed about the project,
5. New water user associations are set up (if needed) for the community management of the resource,
6. Existing and new water user associations are trained in demand management and point-of-use disinfection methods and on the importance of groundwater protection,
7. Local ordinance on protection/utilisation of shallow aquifer prepared with stakeholders,
8. Public wells are disinfected and resealed,
9. Water spouts and related systems are revitalised.
10. Machines and equipment are acquired and installed. Preparation is made for ongoing technological interventions, as well as the operation and maintenance of the system.

The project identification table for the project is presented in Annex 1. The logical framework for the project is presented in Annex 2.

4.2 Analysis

4.2.1 Description of the project

Based on the previous sections, the proposed project includes components on fund raising, training and awareness raising, water resource mapping, technical interventions, and introduction of the new regulation on water rights and water extraction.

The goal of the **fund raising** component is to establish the financial basis for the local water user associations as well as contacting donors with the project proposal. This also contains the fee that may be related to finalizing project documents. **Training and awareness-raising** are important for dissemination of knowledge among the local residents about a) the project, b) demand management methods, c) water disinfection methods at the point of consumption, and d) the importance of water rights regulation and water resource protection.

Mapping constitutes a somewhat separate component. It provides a valuable input to the aquifer protection component by enabling the drawing of exact boundaries for the relevant shallow aquifers in Lalitpur[18]. **Technical interventions** include the rehabilitation works, setting up water tanks with disinfection units, sealing and disinfection of selected wells, and the maintenance of the rehabilitated system.

Project lifetime

The water supply element of the project (as analyzed) is planned to operate for five years, when it is assumed that water users will turn to the Melamchi water to satisfy their demand. However, it is assumed that some water users will continue to use groundwater and pay the water rights tariff that will be used for maintenance and aquifer protection in the longer term (10 years).

4.2.2 With and without the project

It is assumed that ***without the project*** local initiatives would continue as communities try to find ways to reduce the negative impacts of the continuing water scarcity. Private water suppliers will continue to play an important role in water supply as the current water company (Kathmandu Upatyaka Khanepani Limited (KUKL)) is unable to provide adequate service to the population of the Valley. The use of relatively more expensive water sources (private tankers, KUKL tankers, purchasing water from neighbors) represents huge economic costs to the population of the Valley, and this situation shall remain, until the cheaper supplies displace them.

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[18] "Three major aquifers found in Patan are Naricha, Nayekhyo, and Khwyebahi. There are other smaller aquifers in Patan core area near Guita, Ikhachhen (Joshi,P. R. 1993) and Kiri Keba. These aquifers must be the outcome of the special geological formation where the northern slope of the topography helped to punch confinements and made possible to store water in the sand reservoir." (UN-HABITAT,2007)

Another important factor is that as shallow aquifers yield decreasing volumes of water, some wells and stone spouts dry up and the residents of neighboring poor households will have to travel further to fetch water for their daily consumption. This latter factor, coupled with the health problems associated with unimproved water sources, also represents a significant economic cost[19]. On the other hand, a major benefit of the project is that by rehabilitating the traditional system elements, water sources are brought nearer to the water users, consequently reducing the time required to provide sufficient water.

The project provides for the supply of improved water at the level of local communities, ensures the protection and more sustainable use of shallow aquifers by mapping and the introduction of the water right/extraction tariff as part of the planned regulation. Local water user associations with a stake in the resource further guarantee that the water resource is used in a sustainable way. An added benefit of the project is the coordination among water user associations (communities) based on the shallow aquifer boundaries.

In other words, the boundary of the project is not the local community`s boundary, but the boundary of the water resource. This enables local stakeholders to cooperate and coordinate the use of groundwater resources instead of competing over it.

First, each ***water user association*** manages the utilization of the groundwater resource within its boundaries. Second, the project includes a groundwater protection component by the introduction of a local regulation and related measures, such as monitoring of water quality,

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19 "Although the time the poor spend to access water for domestic use varies, approximately 1 hour is required each day. A number of domestic functions are undertaken at the water point to minimize the volume of water to be carried home. Women are the predominant carriers of water. Residents of low-income areas carry home only about 10 liters per person of water every day." (ADB TA report, 2006)

aquifer user charges, and users' registration.

The ***enforcement of the regulation*** should be the responsibility of the local municipality. It is important that this coordinating function is placed at the municipal authority level, in close cooperation with the relevant communities.

In addition to these factors, as a result of the water rights regulation, a certain proportion of the high income households that do not connect to the project (do not consume "project water"), but continue to use their own tube wells or other facilities will be required to pay ***the water user fee.*** A part of this fee will be used for the purposes of the project maintenance fund and the recharge of shallow aquifers, constituting a further benefit. Low and medium income households will have to pay a fee for using the "free" water sources. This fee will be utilized for the maintenance and operation of the system, as well as the personnel costs of the water user associations. The fee will reflect the hitherto "hidden" cost (value) of the groundwater from shallow aquifers.

The assumptions, figures, and calculations in the following sections are based on the "with water rights regulation" scenario. The assumptions and the related calculations for the option "without water rights regulation" are also presented. The conclusion will compare the two options based on the alternative project design.

The regulation determines the price of water for low and high-consuming households, sets the maximum ratio of price increases per year and the water rights fee payable for water extraction for households that opt out of the proposed system or for drilling new wells for corporate or private use. It also describes the guidelines related to management, coordination, transparency, and technical requirements related to the project and the use of subsurface water sources.

Without the regulation of water rights proposed in the project, competition over the water resource would continue almost certainly leading to its depletion to a level where its extraction becomes uneconomical.

Finally, the analysis will be carried out for the poor and the non-poor populations in the project separately, with the results summarized for the final assessment. This is necessary to ensure that the distribution analysis can be carried out after obtaining the final results for economic indicators.

4.2.3 Demand analysis

For the demand analysis, it is first necessary to consider the population trends, the actual consumption, the effective demand, the willingness to pay for water supplied, and the proposed tariff structure.

Population

For the supply and demand calculations, the basic limitation was the *constraint on sustainable water yield* from groundwater in the Lalitpur area, which limits the number of people supplied from wells and stone spouts to 30,000. Based on data of the 4^{th} Household Survey by Nepal Rastra Bank, an average household in the Kathmandu Valley consists of 5.21 persons.

For the calculations in this analysis, the 5 person/household value will be used (6000 households representing 30,000 residents). According to the population increase trends in Lalitpur, the annual increase of population is 2.73%.

However, this will be offset by the fact that the target number of residents to be connected to the system (30000)[20] is an ideal number that is used as a ***threshold value***, rather than designating the actual number of people supplied. It is assumed that a large proportion of medium- and high-income residents in the project area will continue to use their own wells or vended/trucked water for consumption, thus opting not to connect to the system.

The number of people actually supplied largely depends on the community and the awareness raising/publicity component of the project. Consequently, in this analysis, population increase represents **the number of people actually supplied from the system that remains within the actual 30000 threshold**. This also means, that the increase of population supplied each year is the combination of natural population increase, immigration, and extension of service coverage (existing residents joining the system), and is an assumed factor.

Affordability

Another important factor that influences water demand is affordability or household income. According to the "Key indicators for Asia and the Pacific" publication the proportion of urban

[20] "…Other stone spouts are connected to the municipal stormwater drainage system or directly discharged into rivers. Flows range from a minimum total daily discharge of about 1 575 m3/day during the dry season to a peak of about 4 596 m3/day during the rainy season. The average total daily flow is about 3 089 m3/day, a volume sufficient to theoretically supply some 31 000 people (assuming a per capita demand of 100 l per capita per day). While not all of this water is currently used for drinking (the volume of "useful water" is somewhat less than that of the average daily flow), the conservation and revitalization of the hitis could contribute to a reduction in the acute water shortage in Patan City." Source: Sourcebook of Alternative Technologies for Freshwater Augmentation in Some Countries in Asia. Retrieved from: http://www.unep.or.jp/ietc/Publications/techpublications/TechPub-8e/tradition.asp

population living in slum[21] areas in Nepal is 60.7% (Table 7.1, ADB, 2008). For the purposes of this analysis, 60% of the target population will be categorized as “poor”.

This is largely on account of lack of access to improved water supply and sanitation, rather than the other factors mentioned in the definition. According to the ADB Technical Assistance Report on preparing the Melamchi project (ADB TA Report, 2006) the WTP for the poor population is 0.43 USD/m3, while for the households with existing connections to the water network the WTP is 0.86 USD/m3.

For the demand calculations, 40% of the target population (2,400 households, 12,000 residents, the “poor” population) was considered with an actual consumption of less than or equal to 45 liters per capita per day (lpcd). For the rest of the population (3600 households, 18,000 residents, the “non-poor” population), the actual consumption calculated with was greater than 45 lpcd.

As for the poor, effective demand would remain below or reach, but not exceed 45 lpcd, while for the other part of the target population, it exceeds 45 lpcd and increases as the supply of water is improved. This is due to household income and affordability differences.

The demand analysis has been carried out separately for the “poor” and the “non-poor” households. For the purposes of this analysis, poor households have been defined based on the Nepal Living Standards Survey 2003/2004 (CBS, 2004). In a survey carried out by Pattanayak et al. (2005) for research on coping costs related to water supply 605[22] out of 1500 households

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21 Slum population is defined as urban population living in households with at least on e of these characteristics: (i) lack of access to improved water supply, (ii) lack of access to improved sanitation, (iii) overcrowding(3 or more persons per room), and (iv) dwellings made of nondurable material. (ADB,2008)

22 This sample shows that 40% of the surveyed households belonged to the lowest 40% of the income distribution.

surveyed were identified as poor according to the household income measure of poverty. According to the criteria, if a household was in the bottom 40% of the income distribution, it was classified as poor. The statistical tables to the Human Development Report 2009 determine the proportion of the poor with an income less than 1.25 USD/day at 55.1%.

The incomes in Kathmandu are about double that in the rest of Nepal, and it should be mentioned that the above value is a weighted average of urban and rural areas. Considering the above, for the purposes of this analysis, 40% of the project population is considered to be "poor".

Current consumption and effective demand

The composition of current demand was established by household surveys and reported in ADB documents (ADB RRP, 2000; ADB TA Report, 2006; ADB MCS, 2008). The main sources of water for households in the Kathmandu Valley are public taps, private wells, rainwater, neighbors reselling water, water tank or trucked water, and "free" sources of water (stone spouts). An important element is the added cost of storage and filtering for all of the households due to the uncertainty of supply in terms of quantity, continuity, and quality. After the project completion, the currently "free"[23] sources of water will be charged for and delivered to the homes of users and thus become "project" water. By the rehabilitation of currently out-of-use ***hitis*** and *public wells*, the project brings the sources of water nearer to the users.

The table on the "without project" (Annex 3.) scenario is based on the Asian Development Bank`s document on major changes to the Melamchi project design (ADB MCS, 2008); (total

[23] The use of some hitis can be „free" only if financial cost is considered. However, the economic cost of health risks and the time needed to fetch water are a hidden cost to using hiti water without the project. The awareness-raising and education component of the project aims – among other objectives – to make the residents acknowledge and accept this.

cost: own calculation). The ADB document stated that about 30% of total water consumption in the Kathmandu Valley is from alternative sources (not from the piped water supply network). However, having considered the rapid decline in municipal water supply safety and continuity, and the growing water scarcity in the Valley, for the purposes of this analysis **it has been assumed that 50% of total consumption** of the average 68 litre per capita per day for the Kathmandu Valley (ADB, 2004) is **from alternative water sources** (not from the piped supply network).

The average household in the Kathmandu Valley consumes 10.2 m3/household or 68 liter per capita per day (ADB, 2004). The section of the ADB document analyzing the without project scenario estimates that the average economic cost of obtaining water from the alternative sources is 243 Nrs/m3[24].

Based on ADB data	Source	Ratio	Volume (m3/hh/month)	Cost (NRs/m3)	Cost/month	Cost in 1m3
Alternative water sources (50% of total)	rainwater	0.16	0.816	5	4.08	0.8
	private wells	0.16	0.816	44	35.904	7.04
	public tap	0.21	1.071	70	74.97	14.7
	"free" sources (dug wells, stone spouts)	0.27	1.377	*243*	334.611	65.61
	Neighbours	0.1	0.51	256	130.56	25.6
	water tank/trucked water	0.1	0.51	1222	623.22	122.2
Total		1	5.1		1203.345	235.95

24 Cross-checking this with the weighted average cost of water from various alternative sources yields a result of 240.75 NRs/m3 , very near to the 243 NRs/m3 provided int he ADB document.

According to the table, the sources of water with the highest unit cost are the trucked water and water from neighbors. It is expected that changes in the demand for water and the consumption choices of residents will affect these two sources if a less costly alternative is offered in the project.

It is assumed that as a result of the project, the demand for water for both the poor and the non-poor households will change. This change relates to the use of various water sources and the quantity of water consumed as well. The following section describes the assumed effect of changing consumption patterns resulting from the project. The detailed tables on poor and non-poor consumption are shown in **Annex 3**.

Project impact on water demand

This section describes the proposed tariff structure, the impact of the project on water demand and consumption behaviour, and the effect of price and income changes on the households that participate in the project.

The end of the section presents the assumption on the changes in the number of participating households.

Tariff structure

The tariff structure was determined according to the principles set out in the ADB Technical Note "Beyond cost recovery: Setting User Charges for Financial, Economic, and Social goals" (ADB-ERD, 2004). The Technical Note states that in order for distributive effects to be beneficial for poor target groups *the tariff should be set at or below the willingness-to-pay level*.

It also adds that if customers use more water than the basic need, tariffs for the excess consumption can be set to raise revenue to subsidize poor user groups. Based on this, a two-tier tariff will be analyzed.

For simplicity, the tariffs proposed (for piped water) in the ADB TA Report (2006) will be adopted for the project water in this analysis. This also allows for the "smooth" transition from project to piped water when the Melamchi system starts up.

In order to satisfy the basic needs of "poor" households, the water tariff applied will be 0.43 USD/m3 up to a consumption of 45 lpcd.

Changes in water demand and consumption

Resulting from the project, the following changes in water demand are anticipated.

The most significant change is in the use of project water. The decreasing reliance on neighbors, private wells, and public taps is also noticeable. This assumed change is the result of the project design which produces a relatively cheap and safe water source for the population[25], thus inducing **a shift from the more expensive sources to the cheaper one**.

The fact that from a "free" resource, **stone spouts and some wells become a "non-free" water resource** does not affect this shift; because of the "water delivery" element in the project design and the proximity of the regenerated water source within neighborhoods (see the Alkwo Hiti case study described earlier). Even though the residents have to pay for the water, the amount paid is

[25] We must note that solely relying on the alternative project proposed here cannot solve the water scarcity problem of the total population of the Kathmandu Valley. The project is only sustainable within the limits of sustainable groundwater extraction and thus limited in the number of residents it can serve. However, water supply is only one of a number of project goals in addition to the social, environmental, and cultural goals described earlier.

still considerably less than the economic cost of collecting water and of health care in the "without the project" scenario.

It must be noted here that an important factor in the project is the "perceived" versus "non-perceived" cost of water. In this regard, the awareness-raising component has a key role in residents' understanding that even the "free" (without the project) water has substantial economic costs.

The change in the use of **public taps** can be explained by the fact that the majority of public taps in the project area (Lalitpur) run dry, while the original table quoted above represented the average for the Kathmandu Valley.

The use of private wells drops only to a relatively small extent due to the fact that private wells are usually operated by the "non-poor" households less sensitive to price changes who are consequently less willing to shift to the new community water source. It should be noted that even the non-poor households equipped with private wells purchase their water from a variety of sources due to the intermittent supply of electricity which impacts the use of electric pumps required to draw water from their wells.

For the same reason, households that invested in **rainwater collection** and storage prior to the project will be less willing to discontinue the use of their private facility that provides cheap water. To the extent that these households opt for the "project water", they do due to the convenience, continuity of supply, and quality considerations.

The above factors together explain the increase in consumption of water from an average 27% to 55-90% within the total water use attributed to "project water". The detailed poor and non-poor data tables are shown in the **Annex 3**. The basic data for the calculations are based on various sources (ADB, 2007 Feb.; ADB, 2008; CBS, 2004).

It is (optimistically) assumed that the volume of piped water from the municipal network does not decrease and its share of the total water consumed remains 50% for the full duration of the project[26]. Both consumer groups can initially increase their water consumption.

Regarding monthly total volume consumed (all sources of water, including piped water), **poor households** increase the volume from 6.75 m3 to 9 m3, while non-poor households from 12 to 15 m3. This can be translated into 30 lpcd instead of 22.5 lpcd for poor households and 50 lpcd instead of 40 lpcd for non-poor households. However, this will be moderated by the price and income effects during the lifetime of the project (to be presented later).

In the sections below, the assumptions related to the number of households are described, followed by the analysis of demand of poor and non-poor households.

Number of households

Households participating in the project

For the calculation of project benefits, it is also necessary to estimate the number of poor and non-poor households that will participate in the project. Concerning the number of households participating in the project, the following assumptions have been used:

1.) Assumptions related to households:

a) **Poor households:** 80% of poor households will use project water in the first year (80% of the 40% of total number of households), number of poor households in project increases by 5% every year,

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[26] As the volume and ratio of piped water within the total consumption was considered constant, the analysis does not take account of this water source for the duration of the project.

b) **Non-poor households:** 50% of non-poor households will use project water in the first year (half of 60% of the total number of households), number of non-poor households in project increases by 1% every year.

c) **Household size**: based on the Nepal Living Standards Survey 2003/2004 (CBS,2004), the average household in the analysis includes 5 residents.

The total number of households served by the project increases from 3,720 (Year 1) to 4,207 (Year 5) according to the assumptions described above. Within the total number of households the proportion of poor households changes from 51% in Year 1 to 55% in Year 5, a slight increase.

	Assumption	**Year 1**	**Year 5**
Poor households	initially 80% of poor hh take part, increase 5% per year	1920	2334
Non-poor households	initially 50% of non-poor hh take part, increase 1% per year	1800	1873

The detailed calculations are presented in **Annex 3.**

Households not participating in the project

It is assumed that high-income households will not consume project water and instead continue to extract and consume groundwater from the shallow aquifers. These households will be charged an aquifer user fee of 15 USD/month (equivalent to an assumed consumption of 15 m3/month at 1 USD/m3).

This is approximate to the NRs1,030/month WTP for good quality water of 525 litre per day described in the ADB document on major changes to the Melamchi project (ADB MCS, 2008). It is assumed that in order to keep the right to legally extract water from aquifers **high-income households whose water consumption is higher than 15 m3/month** are willing to pay this amount. It is expected that 50% of the non-poor households will not participate in the project. Assuming that the enforcement of the water rights regulation will not be efficient, 100 non-poor households not participating in the project will be assumed to actually pay the water rights fee.

The following section describes the consumption behavior of the individual household.

Poor households

Demand without the project

Effective demand without the project for poor households can be up to 45 lpcd or higher depending on the income of the relevant household. However, the current consumption is certainly lower than that due to the higher prices of safe water, the health care costs associated with unimproved water, and the time and effort required to collect water from public sources. A number of domestic functions, such as washing clothes, dishes, hair washing for small children, are undertaken at the water point and only 10 lpcd of water are actually carried home by the poorest households (ADB TA Report, 2006). Based on this it is inferred that the effective demand of poor households is higher than the 10 lpcd they are capable of carrying home each day.

Demand with the project

According to economic theory, poor households will seek to maximize their utility and thus consume 45 lpcd (the upper threshold for the 0.43 USD/m3 tariff). This means that demand for water with the project will increase. One factor in this increase in demand is the improved accessibility and safety of the water supplied from the traditional water sources. In addition, this demand will turn towards the relatively cheaper “project water”, shifting away from the other, more expensive sources (water purchased from neighbors, trucked water, etc.).

POOR HOUSEHOLDS' CONSUMPTION WITH PROJECT

Poor households	Source	Ratio	Volume (m3/hh/month)	Cost (NRs/m3)	Monthly cost	Cost in 1m3
	rainwater	0.01	0.05	5.00	0.23	0.05
	project water (dug wells, stone spouts)	0.90	4.05	32.25	130.61	29.03
	public tap	0.065	0.29	70.00	20.48	4.55
	neighbours	0.025	0.11	256.00	28.80	6.40
	water tank/trucked water	0.00	0.00	1,222.00	0.00	0.00
TOTAL		**1.000**	**4.50**		**180.11**	**40.03**

For the analysis of poor households` demand for project water, the following assumptions are used:

2. Assumptions on poor households` demand with project:

a) 80% of poor households (40% of total households *0.8) use project water in the 1st year.
b) 90% of their total water consumption is project water.
c) The number of participating poor households increases every year by 5%, starting from 1,920 in Year 1 and reaching 2,334 in Year 5. .

<u>Non-poor households</u>

Demand without the project

Effective demand without the project for non-poor households is estimated to be higher that 45 lpcd. Depending on their income, non-poor households can opt for various water sources ranging from bottled water and trucked water (the most expensive sources) to installing rainwater collection, storage, and/or pumps and private wells. These strategies and facilities reduce the uncertainty and economic cost (cost of time, health care) relating to the water supply of non-poor households. In addition to this, they reduce non-poor households' need for participation in the project due to their more independent water supply. In this analysis, it was assumed that the non-poor households that will participate in the project consume up to 100 lpcd.

NON-POOR CONSUMPTION WITH PROJECT

Non-poor households	Source	Ratio	Volume (m3/hh/month)	Cost (NRs/m3)	Monthly cost	Cost in 1m3
	rainwater	0.20	1.50	5.00	7.50	1.00
	project w.	0.50	3.75	32.25	120.94	16.13
	private wells	0.25	1.88	44.00	82.50	11.00
	public tap	0.00	0.00	70.00	0.00	0.00
	neighbours	0.00	0.00	256.00	0.00	0.00
	trucked w.	0.05	0.38	1,222.00	458.25	61.10
TOTAL		**1.00**	**7.50**		**669.19**	**89.23**

The non-poor households that will not participate are assumed to have individual wells and afford the purchase of trucked and bottled water in larger volumes. This latter group may opt for maintaining their existing consumption until the Melamchi project is completed. A certain percentage of these households will opt to pay the aquifer usage tariff proposed in the project[27].

Demand with the project

Non-poor households` demand was analyzed according to the two-phase tariff structure proposed.

Their consumption was analyzed based on the following assumptions:

Assumptions for non-poor households (up to 45 lpcd)

- 50% of non-poor households (0.5 * 60% of total households) use project water in the 1st year
- Due to favourable price changes and better service they increase their **total** consumption to 100 lpcd
- 50% of their total water consumption is alternative water (50 lpcd),
- 50% of alternative water consumption will be project water (25 lpcd or 3.75 m3/household/month.)
- every year +1% increased participation in project, starting with 1,800 participating households in Year 1, and reaching 1,873 households in Year 5. .

Income and price effects

The detailed tables on income and price effects are also presented in Annex 4.

27 See the section on non-participating households earlier.

Price and income effects on consumption have been assessed for the poor and the non-poor users of project water. **Project water** does not include trucked water, private wells, rainwater or other individual sources. It only represents water supplied from the community managed project. Consequently it represents 90% of the alternative water consumption of a poor household, and 50% of the alternative water consumption of a non-poor household participating in the project.

For the price and income elasticity, the values presented in the ADB Handbook (ADB,1998) were utilized. For the poor and non-poor households alike, price elasticity was estimated at -0.4 and income elasticity was 0.2. An annual price increase of 10% was assumed (a little above the average inflation rate in Nepal (Nepal Rastra Bank, 2007).

As for the income trends, a study funded and published by CMI, a Norway-based research centre (CMI, 2008) provided detailed information on the income trends of various quintiles of incomes classes in Nepal. The study is based on the analysis of the Nepal Living Standards Survey. For poor households annual income increase was calculated with 3%, while for the non-poor households, a 6% value has been applied.[28]

Resulting from the price and income effects, based on the assumptions described above, **the poor households** are assumed to **reduce their project water consumption** from 4.05 m3 per household per month in the first year of the project to 3.65 m3 per month in the fifth (last) year of the project. This represents a consumption of 22 liters **of project water** per person per day (or 110 liter per household) in the fifth year. In the same year, **the total consumption** is approximately 39 lpcd.

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[28] "…incomes gradually increase despite a low growth in some years. The growth rate has been on average 2% per year, with the exception of the recession in 2002 that followed the escalation of the war in November 2001, when the Maoists attacked the army for the first time…. Inequality has increased, in the sense that the rich have had a very high income growth (6.4% per year for the richest 20%, as compared to 3.7% for the next quintile, and 2.5% for the lowest 20%), see NLSS (2005)." (CMI,2008)

Non-poor households reduce their consumption of **project water** from 3.75 m3 per month to 3.35 m3 per month, representing a consumption of 110 litres per day per household. The total lpcd of project water in the non-poor households in the final year would be 89.26 as opposed to 100 lpcd in the first year.

The tables showing the effect on the income and price changes on consumption are presented in Annex 4.

Total consumption

The total consumption measured in liter per capita per day (lpcd) of **project water** (stone spouts, wells) will decrease by 10-17% during the five years of supplying project water. This is in line with the project objective to ensure that groundwater extraction approaches the sustainable level. This reduction translates into a change from 27 lpcd to 22 lpcd for poor households, and from 30 lpcd to 27 lpcd for non-poor households.

Considering the total consumption of project water by all the project households **(Annex 4.)**, this latter value decreases from 174,312 m3 (Year 1) to 174,003 m3 (Year 5). The proportion of poor households within the total consumption does not change significantly (48% in Year 1, 50% in Year 5).

Project water availability and consumption

The weighted average yield of hitis in Lalitpur has been calculated with a conservative method in which 90% of the days of the year have been considered "dry" days (neglecting the positive effect of the approximately 4 months of monsoon every year).

Based on this calculation the number of households that the **19 "top" hitis**[29] can potentially supply with 45 litre per capita per day totals 8,278. This has been corrected for sustainable consumption. The result of the calculation is that 4,967 households can be supplied from these hitis, considering the differing water demand of poor and non-poor households.

The volume consumed by the high income households not participating in the project must also be considered here due to the fact that a large part of their consumption also exploits the same water resource that feeds the hitis. Their consumption is 15 m3/household/month.

The total water volume potentially available from the nineteen hitis listed below is 1,862 m3/day, which exceeds the sum of total consumption of project water by project households (477 m3/day) and non-participating non-poor, high income households (15 m3/household/month or 0.5 m3/household/month by 1800 households), amounting to 1377 m3/day. The full data on hitis is presented in Annex 16.

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[29] The hitis with a weighted average daily flow of >10 m3.

	Stone Spout	Minimum Flow	Maximum Flow	Weighted average	Annual discharge
		(m3/day)	(m3/day)	Assumption: 90% of year = dry, 10% of year = wet season flow	
1	Alkva hiti	267.49	361.15	276.86	101 053.83
2	Konti hiti	248.83	412.13	265.16	96 783.98
3	Iku hiti	234.14	355.97	246.33	89 909.14
4	Cyasah hiti	129.60	600.48	176.69	64 491.12
5	Nay hiti	58.67	541.73	106.97	39 044.85
6	Tapah hiti	86.40	192.67	97.03	35 414.93
7	Sinci hiti	51.49	505.44	96.89	35 364.34
8	Sundhara hiti	89.68	142.56	94.97	34 664.31
9	Hiku hiti	81.22	158.11	88.91	32 450.54
10	Nah hiti	71.71	106.27	75.17	27 436.32
11	Amrit hiti	70.07	105.11	73.57	26 854.33
12	Misa hiti	34.56	266.11	57.72	21 066.05
13	Pulcowk hiti	19.87	371.52	55.04	20 088.51
14	Mangah hiti	29.40	177.12	44.17	16 121.47
15	Wasah hiti	42.16	29.81	40.93	14 938.54
16	Thapah hiti	15.29	80.35	21.80	7 956.60
17	Cawa hiti	14.69	25.06	15.72	5 739.55
18	Tangah hiti	0.00	144.29	14.43	5 266.51
19	Nagbah hiti	0.00	143.42	14.34	5 234.98
Total per year		564027.2	1722544.5	679878.2	678879.88
Total per day		1545.28	4719.3	1862.68	1859.94

Source: based on UNEP (1998), own calculations

Incremental and non-incremental water

The incremental and non-incremental water usage has been analyzed for the poor and the non-poor households separately. For the “without the project” cost, the average supply price of 243 Nrs/m3 (ADB(2004)), while for the “with the project” situation the average demand price of 32.25 Nrs/m3 (or 0.43 USD/m3 in ADB TA Report (2006)) was applied

As a result of the project, alternative water consumption will change in volume and composition as well, and there are benefits from increased water consumption. [30] For this analysis, the shadow pricing of the calculated benefits was not required, because there are no major distortions in Nepal according to ADB ERD No.11.(2004.), Appendix 1.

The total non-incremental + non-incremental benefit (or the sum of the consumer surplus and gross revenue) for poor and non-poor households participating in the project is presented below. The detailed calculations are presented in **Annex 5**.

	Total (Nrs, Year 1-5)
Non-poor households	
Total benefit	133,728,382
Total Consumer surplus (CS)	93,630,909
Total Gross revenue (GR)	18,496,842
Poor households	
Total benefit	112,127,752
Total CS	93,630,909
Total GR	18,358,862

[30] In calculating the non-incremental and incremental benefits (considering project water only!), the guidelines of ADB(1998) have been respected. ADB (1998). Handbook for the Economic Analysis of Water Supply Projects.

4.2.4 Economic cost-benefit analysis

The preferred project alternative is calculated based on the assumption that an effective water rights regulation at municipal level is in place. The regulation has a number of impacts on consumer behavior and consequently on water use.

The **regulation** determines the price of water for low and high-consuming households, sets the maximum ratio of price increases per year and the water rights fee payable for water extraction for households that opt out of the proposed system. It also describes the guidelines related to management, coordination, transparency, and technical requirements related to the project and the use of subsurface water sources. Permits for drilling groundwater wells will also be subject to a fee payable to the municipality and to be used for the maintenance fund for the water supply.

Without the municipal level regulation (Alternative "B"), high income households who do not wish to purchase water from the project continue to extract water without paying the water rights fee. In addition to this, the middle to high-income households who participated in the project in the preferred alternative, will not take part. These two impacts will be expressed as the reduction of project benefits. This will consequently affect the NPV. Alternative "B" will be **assessed as part of the sensitivity analysis**.

With water rights regulation

<u>Costs</u>

In order to calculate the economic costs of the project, the financial costs of the project components have to be established. The following step is to calculate the economic costs based on the grouping of the items into traded or non-traded and using the shadow exchange rate factor (for the traded) and the standard conversion factor (for the non-traded) items to find the economic value. For this analysis, the SERF, the SCF, and the SWRF applied by the ADB has been adopted (ADB-ERD No.11. (2004)).

The detailed cost breakdown and calculations have been presented in **Annex 7**. The following main cost items have been identified:

1. Capital costs
2. Operating costs
3. Labour
4. Other costs, including:
    - Economic cost of water (incl. the depletion premium)
    - Producers' loss: This is due to the changing consumption pattern of households, poor and non-poor alike. The main "losers" in the project are the neighbors that sell water and the companies that provide trucked water.

The project costs include the following main items:

Item	Note	Traded component	EP (domestic price numeraire, NRs)
Fund raising	a mix of voluntary work, web site, phone calls and correspondence cost	50%	633,000
Planning and design (incl. mapping data)	maps and the planning of interventions required for revitalization of systems and sealing of wells	0%	792,000
Training and meetings	stakeholder forums, awareness raising on water saving and purification and water fees, as well as training for local activists	0%	450,000
Publicity	news releases, press meets, local advertising, web site, photocopying of training brochures	0%	450,000
Machines and equipment	Pipe detection systems, pipe cleaning machines, water tanks	100%	9590,400
Technical interventions (unskilled and semi-skilled)	Technical interventions are planned in the first and second year of interventions with a total number of man-days estimated at 180. Technical interventions include pipe detection as well. 8 USD/man-day (average of skilled and semi-skilled).	0%	1,890,000

Item	Note	Traded component	EP (domestic price numeraire, NRs)
Water user fee collection	to be done by unskilled persons (gender preference for women) working in groups of 2 in 8 collection areas. Total 2880 day equivalents calculated with 5 USD/day.	0%	756,000
Administrative	Administrative work includes record-keeping, book-keeping, secretarial work. Skilled work. 4 persons at 10 USD/day.	0%	3,168,000
Maintenance (caretaker)	permanent service done by 10 persons for 10 days a month for 5 years. At 5 USD/day.	0%	1,575,000
Maintenance (seasonal)	mix of paid and voluntary work and the traditional customs related to waterworks maintenance (800 person days/year *5 years*5 USD/person-day)	0%	1,050,000
Construction&rehabilitation of system elements	material costs, construction related planning and permits, road surface breaking and rehabilitation (if reqd.), supervision.	40%	43,065,000
Fuel & energy		50%	4,162,500

The total cost of the project in domestic price numeraire, in domestic currency is 67,581,900 NRs.

Another important economic cost is **the producers' loss**, resulting from the consumers' changing water use behavior. Two kinds of producers suffer economic losses from the changing consumption behavior/effective demand of the consumers, the neighbors who sell water and the companies that sell trucked water. The total producers' loss in the 5 years of the project amount to 143.5 million NRs. The detailed calculations for the producers' loss are presented in **Annex 6.**

PRODUCERS' LOSS IN PROJECT

	Total (Nrs)
Producers' loss (Poor)	27,155,036.03
Producers' loss (non-poor)	116,426,967.06
TOTAL	**143,582,003.08**

The **depletion premium and the economic cost of water** calculations are presented in **Annex 7**. The economic cost of the groundwater, an increasingly scarce resource, for future generations, represents essentially the theoretical cost of regenerating the water resource. The final economic cost of water depends on the volume of groundwater extracted during the project lifetime. For the project, this essentially corresponds to the volume consumed by the poor and non-poor households in the project, supplemented with the economic cost of groundwater consumed by the households not participating in the project. In spite of the fact that it is *not* project water, the high-income households' consumption can be considered to deplete the groundwater resources, the very same resource that is the source of project water. On this basis, the total consumption of high-income households from private wells (or even the occasional trucked water) can be considered to deplete the shallow aquifers or the streams or ponds feeding them. For these calculations the cost of alternative resource was chosen to be 66.85 NRs (the higher WTP in ADB TA Report (2004)).

TOTAL ECONOMIC COST OF WATER (INCL. DEPLETION PREMIUM)

Economic cost of water	TOTAL
Annual consumption poor households (m3)	480,096
Annual consumption non-poor households (m3)	390,461
Annual consumption of high-income households not participating in the project (m3)	1,587,274
Total consumption (all participating households) (m3)	2,457,832
Economic cost of water including depletion premium (NRs)	**136,157,486**

The total **economic cost of water** exceeds 136 million NRs in domestic price numeraire/domestic currency. According to the calculations, the **total** economic cost of the project is **347,321,389 Nrs** in domestic price numeraire/domestic currency.

The exchange rate used throughout the analysis was 75 NRS/USD.

Benefits

The main benefits of the project include the value of healthy life days saved, the time value of water fetching (time savings), the consumer surplus of the project households, and the value of water rights sold to consumers (existing and new consumers). The total benefits amount to 356 690 669 NRs, while the net benefit is 9 369 281 NRs. The calculation of benefits is presented in **Annex 5.** According to the ADB ERD No.11. (2004), there are no major wage and commodity prices distortions in Nepal, which does not require the shadow pricing of benefits.[31]

Without water rights regulation

The ‘without water rights regulation’ scenario will be analysed as part of the sensitivity analysis. The impacts of no water rights regulation can be summarized as follows:

- The high-income households that do not participate in the project do not pay the water rights fee, but still continue to extract water through their private wells. Benefits from high-income households will be non-existent, while the economic price of their consumption will still need to be considered.
- Non-poor households do not participate in the project.

31 ADB ERD No.11.(2004.), Appendix 1. Conversion factors for selected projects 1999-2003., NEP-1464 Fourth Rural Water Supply and Sanitation Sector 24 Sep 96 (p.25.): „With no major distortions in wage and commodity prices in Nepal, the benefits have not been shadow priced.”

4.3 Results

4.3.1 Net Present Value, Benefit/Cost ratio, Economic Internal Rate of Return

The Net Present Value (NPV) is calculated after discounting the costs and the benefits streams for the lifetime of the project. In this analysis, the project lifetime is calculated for 10 years, in spite of the fact that the project will not supply water after five years of operation due to the start of the Melamchi water supply which will displace other sources of household water use. However, some administrative costs related to project closure and maintenance costs related to the maintenance of the hitis and wells for their cultural and touristic value will be incurred. Benefits for Year 6-10 have been omitted.

It has not been possible to quantify the touristic and cultural benefits that the higher ecological and aesthetic value of well-maintained ponds, stone spouts, and wells represents to the city of Lalitpur due to the lack of relevant data regarding similar projects in Nepal. However, it must be noted that such benefits do exist.

The NPV is positive, and the EIRR is higher than the 12% discount rate chosen for the analysis.

NET PRESENT VALUE	1,603,105
B/C	1.03
EIRR (%)	15.9-15.97%

The above results indicate that the project is economically viable, if the regulation on subsurface water use is introduced. With this premise, the project is justified.

However, this is highly dependent upon the validity of the assumptions used for the analysis and project design. The majority of assumptions have been cross-checked with different sources and an extensive literature review was carried out to analyze the project from a number of aspects.

Factors that can seriously affect the NPV and the IRR include the number of participating households, consumption choices, change of costs of major cost items. These can be quantified and the respective sensitivity indicator and the switching values be calculated. Other, non-quantifiable factors can include political unrest, non-supportive attitude of local municipalities and/or residents, and technical/hydrological obstacles, and depletion due to industrial water use, as well as cultural values attached to the hitis and the water channels.

4.3.2 Sensitivity analysis

The sensitivity analysis has been performed for the following scenarios:

1. Delay in project implementation: benefits only start to materialize in Year 2, benefits from Year 1 deleted.
2. No regulation on water rights: high-income households do not pay user fee
3. Depletion premium: cost of alternative resource increased by 2%
4. Higher costs: project costs 5% higher than envisaged

The summary table of switching values is presented below. The detailed calculations are presented in the Annexes 10-13.

	Base		**Change of variable**	**New**		**SV [%]**
		NPV			**NPV1**	
Benefit (delay)	356,690,669	1,603,105	1st year = 0 benefit	307,322,311	-42,475,786	**0.503**
Benefit (no regulation)	356,690,669	1,603,105	no revenue from high-income households	350,425,319	-2,587,800	**0.672**
Cost (EP of water, depletion premium)	347,321,389	1,603,105	cost of alternative resource up by 2%	484,916,491	-97,299,719	**-0.642**
Cost	347,321,389	1,603,105	project cost up by 5%	350,700,484	-889,904	**-0.626**

The very low switching values indicate that the project is highly sensitive to changes in benefits and costs resulting from the changes in the variables selected. In the case of benefits, a reduction of benefits by 0.5-0.6% can cause the NPV to become 0. Costs only need to increase by 0.6% for the NPV to become 0. The change in the economic cost of water has a striking impact on the NPV. This can be due to the inclusion of high-income households with a high (15m3/month/hh) consumption in the EP of water calculations.

The above results underline the importance of the regulation of water rights to protect shallow aquifers and ensure that high-income households exploiting the water resource also contribute to its maintenance.

The other important project element contributing to the realization of benefits is the training and publicity measures which promote higher participation rates in the project, whereby the higher number of households generate a higher level of economic benefits in the project.

4.3.3 Poverty impact Analysis

The role of the poverty impact analysis is to determine the extent to which the main target group (poor households) have benefited from the project in proportion to the total benefits. For this purpose, the poverty impact ratio (PIR) is calculated to determine the proportion of net benefits accruing to the poor households. This has been made easier by representing the poor and non-poor households separately. The PIR is calculated by dividing the net benefits accruing to the poor by the total net economic benefits. The PIR value is 0.53. Considering that 40% of the households in the project area are poor households the project has a positive poverty reducing impact. The calculations are presented in **Annex 15.**

CHAPTER 5: CONCLUSION

This thesis attempted to apply an orthodox economic analysis tool to an unorthodox project. More specifically, this paper has sought to answer the following questions: What are the criteria for economic viability of an alternative WSP in Lalitpur as analysed in relation to the ADB-funded Melamchi project?

Alternative water supply projects based on the rehabilitation of the traditional system of stone spouts, wells, ponds, and streams are not uncommon in Lalitpur. They have sprang from community need to respond to a serious supply deficit in piped water supply both in terms of quantity and quality. The gravity of the situation is underlined by the fact that in the summary of various water related statistics for 18 Asian Cities prepared by the Asian Development Bank (2004), Kathmandu has the worst ranking in terms of water production/population with a value of 0.11 m3/day/capita.

This has raised a number of challenges. For instance, in an orthodox water supply project, it is a piped network that is planned, and consequently it is assumed that consumption from all other water resources will be completely displaced by the new resource. In our case, the project results in a shift from certain modalities of water extraction to others, but complete displacement is not possible, at least for the first five years of the project focusing on water from shallow aquifers.

The above factors and the inconsistency of the data has made the analysis more complex, because it required frequent comparisons and cross-checks between databases (UN, World Bank, ADB, Nepal Rasthra Bank) and the data quoted in various research papers relevant to the topic.

Furthermore, the coping costs and the willingness-to-pay methods used to estimate demand and benefits from water supply projects are highly dependent on the sample size and other related factors.

By using the economic analysis method it was possible to identify key success/failure factors and determine the related costs and benefits. In spite of the fact that ecological, aesthetic, touristic, and cultural benefits of the project have not been quantified and included in the project economic statement, the project has a positive NPV , an EIRR higher than the chosen 12% discount rate, and a B/C ratio slightly higher than 1. This latter value indicates that the project should be fairly sensitive to changes in either costs or benefits, as the sensitivity analysis also demonstrated. The sensitivity analysis by calculating switching values has shown that only a slight change in benefits (reduction of 0.5-0.6%) or costs (increase by 0.6%) is sufficient to bring the NPV to 0.

After concluding the economic analysis, it is possible to add the following policy implications. First, for water supply in developing countries, there can be a viable water supply project which is different from the standard all- piped water supply project. An alternative is to use the local situation in the traditional communities. Second, the alternative water supply project as presented in this analysis does have a positive poverty reduction impact as the PIR demonstrates. Third, for an alternative water supply project to be economically viable, it requires a good combination of financial mobilization, strong community and local authority support, as well as an ambitious awareness-raising and promotion campaign to maximise the number of households participating in the project.

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ANNEXES

1. Project identification table

PROBLEM/NEED	WHY SOLVE IT?	CAUSE OF PROBLEM?	SOLUTION?	BENEFICIARIES/BENEFITS	NEW CHALLENGES/NEW PROBLEMS
Acute water scarcity in Lalitpur (Kathmandu Valley) with current water demand of 43 mld and supply only 22 mld (deficiency of supply 21 million litres per day). *The ADB-funded Melamchi Water Project is not to be completed prior to 2014 which raises the need for intermediate, relatively low-cost solutions for water supply in Lalitpur.*	The scarcity causes losses of economic activity, disease, and hinders normal daily life. To provide safe water to the residents and businesses of Lalitpur.	Water infrastructure development has not kept pace with unplanned urbanization and population increase Less precipitation, changing climate Outdated water network / leakages up to 40% on network/ less precipitation.	1. An integrated project that includes required technical interventions as well as sustainable legal and institutional arrangement for the operation of the infrastructure and the protection of subsurface water sources. 2. Purchase of equipment: for water network mapping and fault detection 3. Mapping of traditional network and the boundaries of the aquifer to be protected 4. Detection of faults in the system. 5. Work: rehabilitation of the traditional water infrastructure (stone spouts, related pipelines , etc.) and of faulty pipe sections in the project area	<u>Beneficiaries</u> 1. Residents 2. Local communities of Lalitpur Metropolitan area 3. Local municipality 4. Businesses 5. Visitors to Lalitpur <u>Benefits</u> 1. Protection of aquifers 2. Conservation of cultural heritage 3. Water supply 4. water quality improvement 5. Health benefits 6. Increased access 7. Job creation 8. Detailed aquifer and utility map	Ensuring the long-term sustainability of technical interventions related to the rehabilitation of the traditional system (the challenge of maintenance) by providing continued commitment for funding of maintenance

2. Logical framework

Narrative summary	Objectively Verifiable Indicators	Means of verification	Assumptions
Goal To contribute to the social and economic development and conserve the underground water resources in the of Lalitpur sub-metropolitan area	Number of days without safe drinking water supply/month (reduced) Seasonal variation in access to water reduced.	Surveys on water use, Interviews with water user association representatives, Project Entity database.	The improvement of livelihoods in the Valley and the consequent increase in the population and the use of natural resources remain within the limits of environmental, social and economic sustainability. The influx of internal refugees stops resulting in less population increase and less pressure on water sources, The use of subsurface water resources monitored. Project Entity and fees integrated with the Melamchi Project after its completion (presumably in 2014).

Narrative summary	Objectively Verifiable Indicators	Means of verification	Assumptions
<u>Purpose</u> To ensure access to improved drinking water with the revitalisation of the traditional water supply and distribution system and the protection of shallow aquifers.	Increased access to safe water (% of residents), Reduced time to access water for residents, Improved water quality,	Residents` testimonies (interviews), Records of water user organisations, Water quality tests of water at source	Management structures ensure effective distribution of water Number of paying users ensure sustainability of Project Entity, Water user fee collection is efficient, Project Entity and Municipality cooperate in aquifer protection (incl. water rights control),

Narrative summary	Objectively Verifiable Indicators	Means of verification	Assumptions
<u>Outputs</u> A plan for local legislation on aquifer protection and water use is prepared. Local residents trained in disinfection and water saving. Local ordinance on protection/utilisation of shallow aquifer prepared with stakeholders. Water user associations set up or trained, Dug wells disinfected and resealed. Underground flows/aquifer boundaries mapped. Water spouts and systems revitalised.	number of common wells disinfected/resealed, length of canals mapped and reconstructed, number of waterspouts renovated,	Drilling logs, Official permits issued by the local authorities, List of participants on training sessions,	The cost of subsurface water extraction and distribution can be borne by the users Stakeholders other than the Beneficiary Group remain committed to the action plan agreed at workshops, Non-poor members of local community cooperate with the project, Expertise for mapping available.

Narrative summary	Objectively Verifiable Indicators	Means of verification	Assumptions
Inputs Assess the needs of the Beneficiary communities. Present project in community forums, Organise workshops for stakeholders. Trainings on water saving and disinfection, Water quality tests for technical interventions, Map the traditional network/Implement technical interventions.	successful test drillings, meetings and workshops held + no. of participants, ratio of water quality test/water source machinery/equipment purchased, network maps approved by local stakeholders, technical interventions	Minutes of meetings, List of participants, drilling permits issued, invoices, Drilling and canal inspection logs, On-site work logs.	A donor is found, sufficient funds and personnel are available for the tests and drillings, Community and other stakeholders support the project, machinery, equipment, labour is made available, Official permits for boreholes for test drilling are granted by local authorities.

3. Current consumption without the project

Assumption: A) 50% of consumption is from alternative sources, 50% of consumption is from piped network. B) Filtering and storage costs relate to 80% of the total water sources consumed.								
Based on ADB data	**Source**	**Proportion** (multiplier)	**Volume (lpcd)**	**Volume (lphh/month)**	**Volume (m3/hh/month)**	**Cost (NRs/m3)**	**Cost of monthly consumption (NRs)**	**Cost paid (for part within 1m3 consumption)**
Alternative water sources (assumed to be 50% of total water consumption)	rainwater	0.16	5.44	816.00	0.82	5.00	4.08	0.80
	private wells	0.16	5.44	816.00	0.82	44.00	35.90	7.04
	public tap	0.21	7.14	1,071.00	1.07	70.00	74.97	14.70
	"free" sources (dug wells, stone spouts)	0.27	9.18	1,377.00	1.38	243.00	334.61	65.61
	neighbours	0.10	3.40	510.00	0.51	256.00	130.56	25.60
	water tank/trucked water	0.10	3.40	510.00	0.51	1,222.00	623.22	122.20
Subtotal		1.00	34.00	5,100.00	5.10		1,203.35	235.95
storage and filtering (out of total)		0.80		8,160.00	8.16	6.00	48.96	4.80

Assumption: A) 50% of consumption is from alternative sources, 50% of consumption is from piped network. B) Poor households store and filter 50% of their total lpcd.								
poor households	**Source**	**Proportion** (multiplier)	**Volume (lpcd)**	**Volume (lphh/month)**	**Volume (m3/hh/month)**	**Cost (NRs/m3)**	**Cost of monthly consumption (NRs)**	**Cost paid (for part within 1m3 consumption)**
Alternative water sources	rainwater	0.10	2.25	337.50	0.34	5.00	1.69	0.50
	private wells	0.00	0.00	0.00	0.00	44.00	0.00	0.00
	public tap	0.30	6.75	1,012.50	1.01	70.00	70.88	21.00
	"free" sources (dug wells, stone spouts)	**0.50**	11.25	1,687.50	1.69	**243.00**	410.06	121.50
	neighbours	0.05	1.13	168.75	0.17	256.00	43.20	12.80
	water tank/trucked water	0.05	1.13	168.75	0.17	1,222.00	206.21	61.10
Subtotal		1.00	22.50	3,375.00	3.38		732.04	216.90
storage and filtering (out of total)		0.50	22.50	3,375.00	3.38	6.00	20.25	3.00
Total (including piped water)			**45.00**	6,750.00	**6.75**			

Assumption: A) 50% of consumption is from alternative sources, 50% of consumption is from piped network. B) Non-poor households store and filter 50% of their total lpcd.								
non-poor households	**Source**	**Proportion** (multiplier)	**Volume (lpcd)**	**Volume (lphh/month)**	**Volume (m3/hh/month)**	**Cost (NRs/m3)**	**Cost of monthly consumption (NRs)**	**Cost paid (for part within 1m3 consumption)**
Alternative water sources	rainwater	0.20	8.00	1,200.00	1.20	5.00	6.00	1.00
	private wells	0.35	14.00	2,100.00	2.10	44.00	92.40	15.40
	public tap	0.08	3.20	480.00	0.48	70.00	33.60	5.60
	"free" sources (dug wells, hitis)	0.15	6.00	900.00	0.90	243.00	218.70	36.45
	neighbours	0.02	0.80	120.00	0.12	256.00	30.72	5.12
	trucked water	0.20	8.00	1,200.00	1.20	1,222.00	1,466.40	244.40
Subtotal (alternative water)		1.00	40.00	6,000.00	6.00		1,847.82	307.97
storage and filtering		0.50	40.00	6,000.00	6.00	6.00	36.00	3.00
Total (including piped water)			80.00	12,000.00				

	NRs/m3		Volume consumed / month (m3)		Monthly cost			
Per household	Cost ("free water"=project water, m3)	Cost of alternative water/m3 (NRs)	"Free" / project water	Alternative water	Cost (project water, monthly)	Cost (alt. water, monthly, NRs)		
ADB (average)	243.00	240.75	1.38	5.10	335.34	1,227.83		
Poor	243.00	216.90	1.69	3.375	410.67	732.04		
Non-poor	243.00	307.97	0.90	6.00	218.70	1,847.82		

4. Number of households and total consumption

	Poor households	80% of poor households (40% 0f total *0.8) use project water in the 1st year / 90% of their total alternative water consumption is project water, every year +5% increased participation in project.					
	BASIC DATA	Year 1	Year 2	Year 3	Year 4	Year 5	**TOTAL**
I.	total no. of hh in project area	6,000.00	6,000.00	6,000.00	6,000.00	6,000.00	
II.	no. of poor hh (40% of I.)	2,400.00	2,400.00	2,400.00	2,400.00	2,400.00	
III.	no. of poor hh in project (80% of II.)	1,920	2,016	2,117	2,223	2,334	
IV	**Price (USD/m3, increase 10%/year)**	0.43	0.47	0.52	0.57	0.63	
	PROJECT WATER DATA						
V	original (end of previous year)	4.05	4.05	3.91	3.78	3.65	
VI	effect of Pe=-0.4 (price increase 10% per year) on quantity consumed	4.05	(0.16)	(0.16)	(0.15)	(0.15)	
VII	effect of Ye= 0.2 (income increase 3% per year) on quantity consumed	4.05	0.02	0.02	0.02	0.02	
VIII	Calculated (m3/household)	4.05	3.91	3.78	3.65	3.53	
IX	Consumption (all project hh/month, m3, *X.*× *III.*)	7,776	7,887	8,000	8,114	8,230	
X	Project water cost (USD, hh/month)	1.74	1.85	1.97	2.09	2.22	
XI	Project water cost (USD, all hh. / month, *III*× *XII.*)	3,344	3,731	4,162	4,644	5,182	
	ANNUAL PROJECT WATER DATA						
XII	Consumption (all project households/year, m3)	93,312	94,646	96,000	97,373	98,765	**480,096**
XIII	In-project water cost (USD, total hh / year)	40,124	44,768	49,949	55,729	62,179	**252,749**

	Non-poor households	50% of non-poor households (60% of total *0.5) use project water in the 1st year / 50% of their total alternative water consumption is project water/ every year +1% increased participation in project.					
	BASIC DATA	Year 1	Year 2	Year 3	Year 4	Year 5	**TOTAL**
I.	total no. of hh in project area	6,000.00	6,000.00	6,000.00	6,000.00	6,000.00	
II.	no. of non-poor hh	3,600.00	3,600.00	3,600.00	3,600.00	3,600.00	
III.	no. of non-poor hh in project	1,800	1,818	1,836	1,855	1,873	
IV	Price (USD/m3, increase 10%/year)	0.43	0.47	0.52	0.57	0.63	
	PROJECT WATER DATA (MONTH, HOUSEHOLD)						
V	original (end of previous year)	3.750	3.750	3.65	3.54	3.44	
VI	Pe=-0.4 (price increase 10% per year)	3.750	(0.15)	(0.15)	(0.14)	(0.14)	
VII	Ye= 0.2 (income increase 6% per year)	3.750	0.05	0.04	0.04	0.04	
VIII	Calculated (m3/household)	3.750	3.65	3.54	3.44	3.35	
IX	Consumption (all project hh/month, m3, *X.*× *III.*)	6,750	6,627	6,505	6,387	6,270	
X	Project water cost (USD, hh/month)	1.61	1.72	1.84	1.97	2.11	
XI	Project water cost (USD, all hh. / month, *III*× *XII.*)	2,903	3,134	3,385	3,655	3,947	
	ANNUAL PROJECT WATER DATA						
XII	Consumption (all project households/year, m3)	81,000	79,519	78,066	76,639	75,238	**390,461**
XIII	In-project water cost (USD, total hh / year)	34,830	37,613	40,618	43,863	47,367	**204,290**

No.	Note	Number of households	Year 1	Year 2	Year 3	Year 4	Year 5
I	based on the sustainable 30000 = 5 persons / household	total no. of hh in project area	6,000	6,000	6,000	6,000	6,000
II	40% of total	no. of poor hh	2,400	2,400	2,400	2,400	2,400
III	60% of total	total no. of non-poor hh	3,600	3,600	3,600	3,600	3,600
		In project					
IV	initially 80% of poor hh take part, increase 5% per year	Poor households	1,920	2,016	2,117	2,223	2,334
V	initially 50% of non-poor hh take part, increase 1% per year	Non-poor households	1,800	1,818	1,836	1,855	1,873
VI		**Total number of households in project**	3,720	3,834	3,953	4,077	4,207
VII	based on price and income elasticity , non-poor households	Calculated consumption (non-poor households, total project hh m3, 6.75 m3/month)	81,000	79,519	78,066	76,639	75,238
VIII	based on price and income elasticity, poor households	Calculated consumption (poor households, total project hh m3)	93,312	94,646	96,000	97,373	98,765
IX	non-poor and poor households, m3/year	**Total consumption in project**	174,312	174,166	174,066	174,011	174,003
X		Poor households	Year 1	Year 2	Year 3	Year 4	Year 5
XI	from 4.05 m3/hh/month	Consumption / household (m3, project water)	48.60	46.95	45.35	43.81	42.32
XII	90% of alternative watr consumption = project water	lpcd (project water)	27.00	26.08	25.20	24.34	23.51
XIII	2/3 of total water consumption = alternative water sources	lpcd (alternative water)	30.00	28.98	27.99	27.04	26.12
XIV		lpcd (total water)	45.00	43.47	41.99	40.56	39.19
XV		Non-poor households)	Year 1	Year 2	Year 3	Year 4	Year 5
XVI	from 3.75 m3/hh/month	Consumption / household (m3, project water)	45	44	43	41	40
XVII	50% of alternative water consumption	lpcd (project water)	25	24	24	23	22

XVIII	60% of total water consumption	lpcd (alternative water)	50.00	48.60	47.24	45.92	44.63
XIX		lpcd (total water)	100.00	97.20	94.48	91.83	89.26

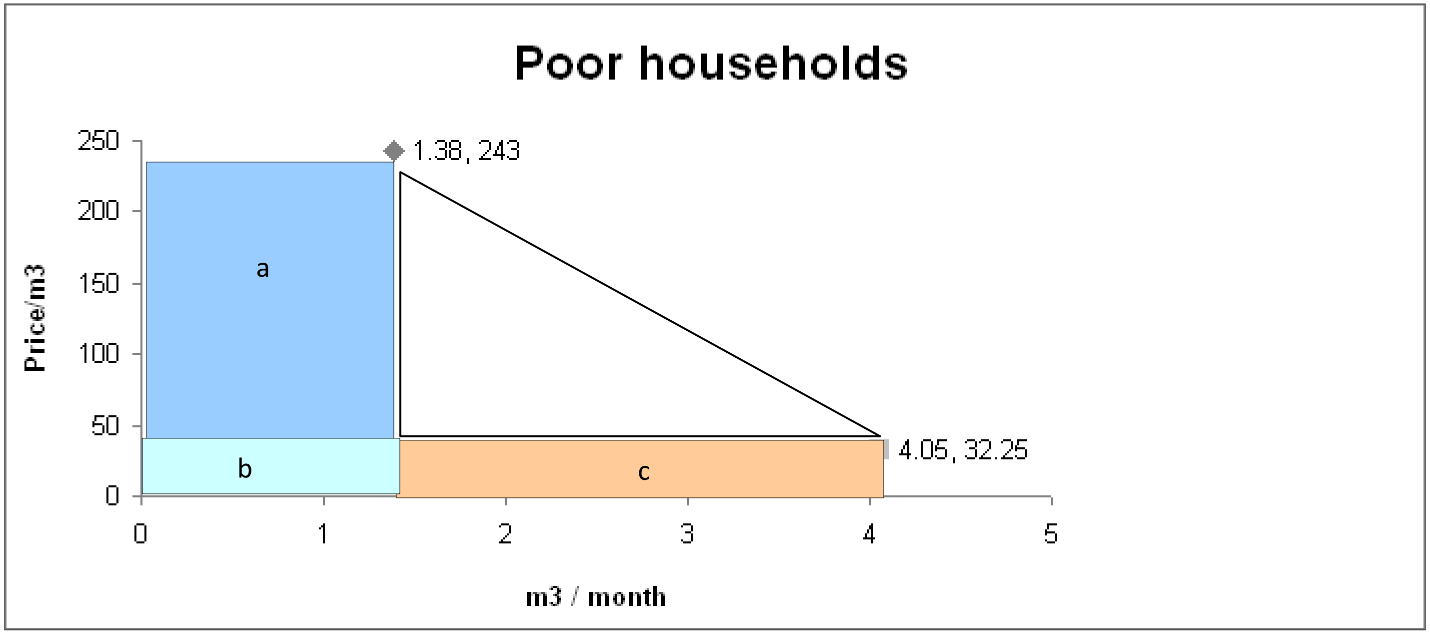
5. Effective demand with project and project benefits

Poor households	Source	Ratio	Volume (lpcd)	Volume (lphh/month)	Volume (m3/hh/month)	Cost (NRs/m3)	Monthly cost (NRs)	Cost paid (for part within 1m3 consumption)
Alternative water sources (30 lpcd)	rainwater	0.01	0.30	45.00	0.05	5.00	0.23	0.05
	project water (dug wells, stone spouts)	**0.90**	**27.00**	**4,050.00**	**4.05**	**32.25**	**130.61**	**29.03**
	public tap	0.065	1.95	292.50	0.29	70.00	20.48	4.55
	neighbours	0.025	0.75	112.50	0.11	256.00	28.80	6.40
	water tank/trucked water	0.00	0.00	0.00	0.00	1,222.00	0.00	0.00
TOTAL		**1.000**	**30.00**	**4,500.00**	**4.50**		**180.11**	**40.03**
storage and filtering (out of total)		0.50	15.00	2,250.00	2.25	6.00	13.50	3.00

non-poor households	**Source**	**Ratio**	**Volume (lpcd)**	**Volume (lphh/month)**	**Volume (m3/hh/month)**	**Cost (NRs/m3)**	**Monthly consumption (NRs)**	**Cost paid (for part within 1m3 consumption)**
Alternative water sources (50 lpcd)	rainwater	0.20	10.00	1,500.00	1.50	5.00	7.50	1.00
	project w.	**0.50**	**25.00**	**3,750.00**	**3.75**	**32.25**	**120.94**	**16.13**
	private wells	0.25	12.50	1,875.00	1.88	44.00	82.50	11.00
	public tap	0.00	0.00	0.00	0.00	70.00	0.00	0.00
	neighbours	0.00	0.00	0.00	0.00	256.00	0.00	0.00
	trucked w.	0.05	2.50	375.00	0.38	1,222.00	458.25	61.10
TOTAL		**1.00**	**50.00**	**7,500.00**	**7.50**		**669.19**	**89.23**
storage and filtering		1.00	50.00	7,500.00	7.50	6.00	45.00	6.00

POOR HOUSEHOLDS	Notes	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL OF 5 YEARS
Cost	per m3 of project water	243.00	32.25	35.48	39.02	42.92	47.22	
Volume	m3 / month	1.38	4.05	3.86	3.67	3.49	3.33	
A		0.00	290.8	840.5	787.4	734.3	683.3	
B		0.00	44.5	49.0	53.8	59.2	65.2	
C		0.00	86.1	88.0	89.4	90.6	92.1	
D		0.00	281.4	257.3	233.6	211.1	190.9	
CS (a+d)	consumer surplus	0.00	572.2	1,097.8	1,020.9	945.4	874.2	
GR (b+c)	gross revenue	0.00	130.6	137.0	143.2	149.8	157.2	
Project benefit (c+d)	incremental benefit	0.00	367.5	345.3	322.9	301.6	283.0	
GB (a+b+c+d)	gross benefit	0.00	702.8	1,234.7	1,164.1	1,095.2	1,031.4	
number of households	poor households in the project	2,400.00	1,920	2,016	2,117	2,223	2,334	
Total GB	household values multiplied by number of households and multiplied by 12 to	0	16,192,483.2	29,870,675.3	29,570,594.4	29,209,991.8	28,884,637.7	###########

	translate monthly to annual							
Total project benefit	as above	0	8,466,249.6	8,353,865.3	8,202,504.3	8,045,394.9	7,924,495.5	40,992,509.7
Total CS	as above	0	13,183,171.2	26,557,513.1	25,932,998.9	25,214,819.5	24,481,017.2	###########
Total GR	as above	0	3,009,312.0	3,313,162.1	3,637,595.5	3,995,172.3	4,403,620.5	18,358,862.4



NON-POOR HOUSEHOLDS	Notes	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL OF 5 YEARS
Cost	per m3 of project water	243.00	32.25	44.34	48.77	53.65	59.01	
Volume	m3	0.90	3.75	3.65	3.54	3.44	3.35	
A		0.00	189.7	745.0	708.0	670.9	633.6	
B		0.00	29.0	39.9	43.9	48.3	53.1	
C		0.00	91.9	121.7	128.9	136.5	144.4	
D		0.00	300.3	272.7	256.7	240.8	225.1	
CS (a+d)	consumer surplus	0.00	490.0	1,017.6	964.6	911.7	858.8	
GR (b+c)	gross revenue	0.00	120.9	161.6	172.8	184.8	197.5	
Project benefit (c+d)	incremental benefit	0.00	392.2	394.4	385.6	377.3	369.6	
GB (a+b+c+d)	gross benefit	0.00	610.9	1,179.3	1,137.4	1,096.4	1,056.3	
number of households	non-poor households in the project	1,800.00	1,800.0	1,818.0	1,836.2	1,854.5	1,873.1	
Total benefit	household values multiplied by number of households and multiplied by 12 to translate monthly to annual	0	13,196,115.0	25,726,630.4	25,062,240.8	24,400,738.7	23,742,027.8	###########
Total incremental project benefit	as above	0	8,472,195.0	8,603,666.5	8,495,607.6	8,396,621.0	8,306,538.8	42,274,628.8
Total CS	as above	0	10,583,865.0	22,200,743.7	21,254,976.3	20,289,074.2	19,302,250.5	93,630,909.7
Total GR	as above	0	2,612,250.0	3,525,886.6	3,807,264.5	4,111,664.4	4,439,777.3	18,496,842.9

Time value of water fetching (non-poor households)

	Without Project	Year 1	Year 2	Year 3	Year 4	Year 5	**TOTAL**
I	Time spent with fetching water (workday equivalents/year/household)	45.6	45.6	45.6	45.6	45.6	
II	Number of households (/persons)	1,800	1,818	1,836	1,855	1,873	
III	Time lost from work (8 hour day equivalent)	82,080	82,901	83,730	84,567	85,413	
IV	Time value (Nrs/year)	16,416,000	16,580,160	16,745,962	16,913,421	17,082,555	83,738,098
	With the project	Year 1	Year 2	Year 3	Year 4	Year 5	

V	Time spent with fetching water (workday equivalents/year)	22.81	22.81	22.81	22.81	22.81	
VI	Number of households	1,800	1,818	1,836	1,855	1,873	
VII	Time lost from work (8 hour day equivalent)	41,058	41,469	41,883	42,302	42,725	
VIII	Time value (Nrs/year)	8,211,600	8,293,716	8,376,653	8,460,420	8,545,024	41,887,413
IX	Benefit attributable to project	8,204,400	8,286,444	8,369,308	8,453,002	8,537,532	41,850,686

Healthy life days and wage equivalent (non-poor households)

	Without project	Year 1	Year 2	Year 3	Year 4	Year 5	
I	Number of households affected (20% of non-poor households, -5% every year)	720.00	684.00	649.80	617.31	586.44	
II	Time spent economically inactive/hospitalised (workday equivalents/year/household)	12.00	12.00	12.00	12.00	12.00	
III	Time lost from work (8 hour day equivalent)	8,640.00	8,208.00	7,797.60	7,407.72	7,037.33	
IV	Time value (Nrs/year)	1,728,000.00	1,641,600.00	1,559,520.00	1,481,544.00	1,407,466.80	
V	**With project**	Year 1	Year 2	Year 3	Year 4	Year 5	
VI	Number of households affected (10% of non-poor households, -10% every year)	360.00	324.00	291.60	262.44	236.20	
VII	Time spent economically inactive/hospitalised (workday equivalents/year/household)	6.00	6.00	6.00	6.00	6.00	
VIII	Time lost from work (8 hour day equivalent)	2,160.00	1,944.00	1,749.60	1,574.64	1,417.18	
IX	Time value (Nrs/year)	432,000.00	388,800.00	349,920.00	314,928.00	283,435.20	
X	Benefit attributable to project (NRs)	1,296,000.00	1,252,800.00	1,209,600.00	1,166,616.00	1,124,031.60	6,049,047.60

Time value of water fetching (poor households)

	Without Project	Year 1	Year 2	Year 3	Year 4	Year 5	**TOTAL**
I	Time spent with fetching water (workday equivalents/year/household)	45.6	45.6	45.6	45.6	45.6	
II	Number of households (/persons)	1,920	2,016	2,117	2,223	2,334	
III	Time lost from work (8 hour day equivalent)	87,552	91,930	96,526	101,352	106,420	
IV	Time value (Nrs/year)	17,510,400	18,385,920	19,305,216	20,270,477	21,284,001	96,756,013
	With the project	Year 1	Year 2	Year 3	Year 4	Year 5	
V	Time spent with fetching water (workday equivalents/year)	22.81	22.81	22.81	22.81	22.81	
VI	Number of households	1,920	2,016	2,117	2,223	2,334	
VII	Time lost from work (8 hour day equivalent)	43,795	45,985	48,284	50,698	53,233	

VIII	Time value (Nrs/year)	8,759,040	9,196,992	9,656,842	10,139,684	10,646,668	48,399,225
IX	Benefit attributable to project	8,751,360	9,188,928	9,648,374	10,130,793	10,637,333	48,356,788

Healthy life days and wage equivalent (poor households)

	Without project	Year 1	Year 2	Year 3	Year 4	Year 5	**TOTAL**
I	Number of households affected (50% of poor households, -5% every year)	1,200.00	1,140.00	1,083.00	1,028.85	977.41	
II	Time spent economically inactive/hospitalised (workday equivalents/year/household)	12.00	12.00	12.00	12.00	12.00	
III	Time lost from work (8 hour day equivalent)	14,400.00	13,680.00	12,996.00	12,346.20	11,728.89	
IV	Time value (Nrs/year)	2,880,000.00	2,736,000.00	2,599,200.00	2,469,240.00	2,345,778.00	
V	Time value (USD/year)	38,400.00	36,480.00	34,656.00	32,923.20	31,277.04	
	With project	Year 1	Year 2	Year 3	Year 4	Year 5	
VI	Number of households affected (40% of poor households, -10% every year)	960.00	864.00	777.60	699.84	629.86	
VII	Time spent economically inactive/hospitalised (workday equivalents/year/household)	6.00	6.00	6.00	6.00	6.00	
VIII	Time lost from work (8 hour day equivalent)	5,760.00	5,184.00	4,665.60	4,199.04	3,779.14	
IX	Time value (Nrs/year)	1,152,000.00	1,036,800.00	933,120.00	839,808.00	755,827.20	
X	Time value (USD/year)	15,360.00	13,824.00	12,441.60	11,197.44	10,077.70	
XI	Benefit attributable to project (NRs)	1,728,000.00	1,699,200.00	1,666,080.00	1,629,432.00	1,589,950.80	8,312,662.80

6. Producers' loss

POOR HOUSEHOLDS (trucked water)	Notes	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL OF 5 YEARS
		0	1	2	3	4	5	
Cost	Nrs/m3, assumption: annual 10% price increase	1,222.00	1,344.20	1,478.62	1,626.48	1,789.13	1,968.04	
Total water consumption (alternative water)	m3 / hh/ month	3.38	4.50	4.35	4.20	4.06	3.92	
Ratio of trucked water out of total alt. consumption	tw/total	0.05	0.00	0.00	0.00	0.00	0.00	
Volume consumed	m3 / hh/month	0.17	0.00	0.00	0.00	0.00	0.00	
monthly fee paid for consumption of trucked water	per household (NRs)	206.21	0.00	0.00	0.00	0.00	0.00	
Producers' loss	per household/month	0.00	206.21	206.21	206.21	206.21	206.21	
number of households	poor households in the project	2,400.00	1,920.0	2,016.0	2,116.8	2,222.6	2,333.8	
Total Producers' loss	Producers' loss/household/month mulltiplied by number of households and multiplied by 12 to translate monthly to annual	0	4,751,136	4,988,693	5,238,127	5,500,034	5,775,036	26,253,025.6
Discounted Producers' loss	as above discounted with discount rate 0.12	0	4,242,086	3,976,955	3,728,396	3,495,371	3,276,910	18,719,717.9

POOR HOUSEHOLDS (neighbours)	Notes	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL OF 5 YEARS

		0	1	2	3	4	5	
Cost	Nrs/m3, assumption: annual 10% price increase	256.00	281.60	309.76	340.74	374.81	412.29	
Total water consumption (alternative water)	m3 / hh/ month	3.38	4.50	4.35	4.20	4.06	3.92	
Ratio of water from neighbours out of total consumption	tw/total	0.050	0.025	0.025	0.025	0.025	0.025	
Volume consumed	m3 / hh/month	0.17	0.11	0.11	0.10	0.10	0.10	
monthly fee paid for consumption of water purchased from neighbours	per household (NRs)	43.20	31.68	33.66	35.77	38.01	40.39	
Producers' loss	per household/month	0.00	11.52	9.54	7.43	5.19	2.81	
number of households	poor households in the project	2,400.00	1,920.0	2,016.0	2,116.8	2,222.6	2,333.8	
Total Producers' loss	Producers' loss/household/month mulltiplied by number of households and multiplied by 12 to translate monthly to annual	0	265,421	230,715	188,722	138,434	78,719	902,010.5
Discounted Producers' loss	as above discounted with discount rate 0.12	0	236,983	183,925	134,328	87,977	44,667	687,880.4

Poor households (Year)	**0**	**1**	**2**	**3**	**4**	**5**	**Total**
Trucked water	0.00	4,751,136.00	4,988,692.80	5,238,127.44	5,500,033.81	5,775,035.50	26,253,026
Neighbours	0.00	265,420.80	230,715.04	188,721.64	138,433.63	78,719.36	902,010
Total	0.00	5,016,556.80	5,219,407.84	5,426,849.08	5,638,467.45	5,853,754.87	27,155,036

NON-POOR HOUSEHOLDS (trucked water)	Notes	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL OF 5 YEARS
		0	1	2	3	4	5	
Cost	Nrs/m3, assumption: annual 10% price increase	1,222.00	1,344.20	1,478.62	1,626.48	1,789.13	1,968.04	
Total water consumption (alternative water)	m3 / hh/ month	6.00	7.50	7.29	7.09	6.89	6.69	
Ratio of trucked water out of total consumption	tw/total alternative water	0.20	0.05	0.05	0.05	0.05	0.05	
Volume consumed	m3 / hh/month	1.20	0.38	0.36	0.35	0.34	0.33	
monthly fee paid for consumption of trucked water	per household (NRs)	1,466.40	504.08	538.96	576.25	616.13	658.77	
Producers' loss	per household/month	0.00	962.33	927.44	890.15	850.27	807.63	
number of households	non-poor households in the project	2,400.00	1,920.0	2,016.0	2,116.8	2,222.6	2,333.8	
Total Producers' loss	Producers' loss/month mulltiplied by number of households and multiplied by 12 to translate monthly to annual	0	22,171,968	22,436,701	22,611,163	22,678,142	22,618,013	112,515,987.1

NON-POOR HOUSEHOLDS (neighbours)	Notes	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL OF 5 YEARS
		0	1	2	3	4	5	
Cost	Nrs/m3, assumption: annual 10% price increase	256.00	281.60	309.76	340.74	374.81	412.29	
Total water consumption (altern ative)	m3 / hh/ month	6.00	7.50	7.29	7.09	6.89	6.69	
Ratio of water form neighbours out of total consumption	tw/total	0.02	0.00	0.00	0.00	0.00	0.00	
Volume consumed	m3 / hh/month	0.12	0.00	0.00	0.00	0.00	0.00	

monthly fee paid for consumption of water purchased from neighbours	per household (NRs)	30.72	0.00	0.00	0.00	0.00	0.00	
Producers' loss	per household/month	0.00	30.72	30.72	30.72	30.72	30.72	
number of households	non-poor households in the project	2,400.00	1,920.0	2,016.0	2,116.8	2,222.6	2,333.8	
Total Producers' loss	Producers' loss/month mulltiplied by number of households and multiplied by 12 to translate monthly to annual	0	707,789	743,178	780,337	819,354	860,322	3,910,979.9

Non-poor households (Year)	**0**	**1**	**2**	**3**	**4**	**5**	**Total**
Trucked water	0.00	22,171,968.00	22,436,701.30	22,611,162.77	22,678,142.46	22,618,012.62	112,515,987
Neighbours	0.00	707,788.80	743,178.24	780,337.15	819,354.01	860,321.71	3,910,980
Total	0.00	22,879,756.80	23,179,879.54	23,391,499.92	23,497,496.47	23,478,334.33	116,426,967
Discounted total (r=0.12)	0	20,428,354.29	18,478,858.05	16,649,607.61	14,933,083.81	13,322,237.42	**83,812,141**

Producers' loss (Year, NRs)	0	1	2	3	4	5	Total
Producers' loss (Poor)	0	5,016,556	5,219,407	5,426,849	5,638,467	5,853,754	27,155,036
Producers' loss (non-poor)	0	22,879,756	23,179,879	23,391,499	23,497,496	23,478,334	116,426,967
TOTAL Producers' loss	0	27,896,313	28,399,287	28,818,349	29,135,963	29,332,089	143,582,003

7. Depletion premium and economic cost of water

Depletion premium

The current rate of extraction W/O the project lowers the groundwater table by 4 m/year on average. Yearly extraction: 720000 m3. Sustainable (rainwater recharged) extraction: 315000 m3. The calculation has been based on the formula in ADB(1997), Appendix XVI.

Assumption: It becomes uneconomical to extract groundwater from >150m depth for drinking water consumption in the Valley. Cost of exhausting resource: 46.5 NRs/m3.

Cost of alternative resource (NRS/m3)		66.85	*e=*	*2.7183*
Year		Cost/m3	Depletion premium	Economic price
	0	46.50	6.13	52.63
	1	46.50	6.91	53.41
	2	46.50	7.79	54.29
	3	46.50	8.79	55.29
	4	46.50	9.91	56.41
	5	46.50	11.17	57.67
	6	46.50	12.59	59.09
	7	46.50	14.20	60.70
	8	46.50	16.01	62.51
	9	46.50	18.05	64.55

Economic cost of water	year 1	year 2	year 3	year 4	year 5	TOTAL
Economic price of water (Nrs/m3)	53.4	54.3	55.3	56.4	57.7	
Annual consumption poor households	93,312	94,646	96,000	97,373	98,765	480,096
Annual consumption non-poor households	81,000	79,519	78,066	76,639	75,238	390,461
Number of non-poor households in the project	1,800	1,818	1,836	1,855	1,873	
Number of non-poor households **not** in the project	1,800	1,782	1,764	1,745	1,727	
Annual consumption of high-income households not participating in the project (15 m3/hh*1800 hh*12, every year -2% consumed)	324,000	320,760	317,488	314,182	310,844	1,587,274
Total consumption (all participating households)	498,312	494,926	491,553	488,194	484,847	2,457,832
Economic cost of water including depletion premium	26,609,861	26,869,515	27,177,972	27,539,009	27,961,129	**136,157,486**

8. Project costs (O&M, Investment)

Item	Note	Total cost (financial, USD)	Traded component (USD)	Non-traded component (USD)	Economic price (traded) in domestic price numerarie	Economic price (non-traded) in domestic price numerarie	Economic price total (domestic price numeraire, USD)	Economic price total (domestic price numeraire, NRs)
Communication, fund-raising		32,000						**2,325,000**
Fund raising		8,000	4,000	4,000	4,440	4,000	8,440	633,000
Planning and design (incl. mapping data)		12,000	0	12,000	0	10,560	10,560	792,000
Training and meetings		6,000	0	6,000	0	6,000	6,000	450,000
Publicity		6,000	0	6,000	0	6,000	6,000	450,000
Machine and equipment		115,200	115,200	0	127,872	0	127,872	**9,590,400**
Pipe detection system (integrated, mobile)		40,000	40,000	0	44,400	0	44,400	3,330,000
Pipe detection system (small units)		18,000	18,000	0	19,980	0	19,980	1,498,500
Pipe cleaning machines		7,200	7,200	0	7,992	0	7,992	599,400
Water tank (2800 litre, with filter&pump)		50,000	50,000	0	55,500	0	55,500	4,162,500
Labour*					0	0	0	8,439,000
Technical interventions (unskilled and semi-skilled)		36,000	0	36,000	0	25,200	25,200	1,890,000
Water user fee collection		14,400	0	14,400	0	10,080	10,080	756,000
Administrative		48,000	0	48,000	0	42,240	42,240	3,168,000
Maintenance (caretaker)		30,000	0	30,000	0	21,000	21,000	1,575,000
Maintenance (seasonal)		20,000	0	20,000	0	14,000	14,000	1,050,000
Other								**47,227,500**
Construction&rehabilitation of system elements		550,000	220,000	330,000	244,200	330,000	574,200	43,065,000
Fuel & energy		50,000	50,000	0	55,500	0	55,500	4,162,500
Total								**67,581,900**
OER (NRs/USD)		77.73	**Nepal Rastra Bank (Note: for convenience the 75 NRs/USD exchange rate was used in the**					

		calculations).
SER (NRs/USD)	83.25	calculated based on SERF
SERF	1.11	based on ADB, ERD No. 11 (2004)
SCF	0.9	based on ADB, ERD No. 11 (2004)
SWRF1 (unskilled)	0.7	based on ADB, ERD No. 11 (2004)
SWRF2 (skilled)	0.88	based on ADB, ERD No. 11 (2004)
Discount rate	0.12	

Technical interventions are planned in the first and second year of interventions with a total number of man-days estimated at 180. Technical interventions include pipe detection as well. 8 USD/man-day (average of skilled and semi-skilled). Total: 36000 USD .
Water user fee collection to be done by unskilled persons (gender preference for women) working in groups of 2 in 8 collection areas. 3 days/month for 5 years. 2880 day equivalents calculated with 5 USD/day.
Administrative work includes record-keeping, book-keeping, secretarial work. Contracted out/part-time. 20 days/month for 5 years. Skilled work. 4 persons at 10 USD/day.
Maintenance works (caretaker): permanent service done by 10 persons for 10 days a month for 5 years. At 5 USD/day.
Maintenance (labor, seasonal) relies on a mix of paid and voluntary work and the traditional customs related to waterworks maintenance (800 person days/year *5 years*5 USD/person-day)
Construction and rehabilitation of system elements includes material costs, construction related planning and permits, road surface breaking and rehabilitation (if reqd.), supervision.

9. NPV, EIRR, B/C

							MELAMCHI WATER PROJECT COMPLETION				
Project Economic Statement, National Currency and Domestic Price Level (NRs)	**TOTAL (YEAR 1-10)**	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Capital Costs											
Fund-raising	633,000	633,000	0	0	0	0	0	0	0	0	0
Planning, design, training, publicity	1,692,000	564,000	282,000	282,000	282,000	282,000	0	0	0	0	0
Machinery and equipment	9,590,400	0	7,672,320	1,918,080	0	0	0	0	0	0	0
Construction and rehabilitation of system elements	43,065,000	0	30,145,500	4,306,500	4,306,500	4,306,500	0	0	0	0	0
Total Capital Costs	54,980,400	1,197,000	38,099,820	6,506,580	4,588,500	4,588,500	0	0	0	0	0
Operating costs											
Fuel&energy	4,162,500	466,000	866,000	666,000	666,000	666,000	166,500	166,50	166,50	166,50	166,50

								0	0	0	0
Labour											
Technical interventions	1,890,000	0	1,145,000	445,000	200,000	100,000	0	0	0	0	0
Fee collection, administrative	3,924,000	0	784,800	784,800	784,800	784,800	784,800	0	0	0	0
Maintenance (incl. caretaker, seasonal)	2,625,000	0	437,500	437,500	437,500	437,500	437,500	437,500	0	0	0
Total operation and maintenance	12,601,500	466,000	3,233,300	2,333,300	2,088,300	1,988,300	1,388,800	604,000	166,500	166,500	166,500
Producers' loss and EP of water											
Producers' loss (on poor households)	27,155,036	5,016,557	5,219,408	5,426,849	5,638,467	5,853,755	0	0	0	0	0
Producers' loss (on non-poor households)	116,426,967	**22,879,757**	**23,179,880**	**23,391,500**	**23,497,496**	**23,478,334**	0	0	0	0	0
EP of water (with depletion premium)	136,157,486	26,609,861	26,869,515	27,177,972	27,539,009	27,961,129	0	0	0	0	0
Total producers' loss and EP of water	279,739,489	54,506,174	55,268,803	55,996,321	56,674,973	57,293,218	0	0	0	0	0
Total Costs	**347,321,389**	**56,169,174**	**96,601,923**	**64,836,201**	**63,351,773**	**63,870,018**	**1,388,800**	**604,000**	**166,500**	**166,500**	**166,500**
Health benefits (Non-poor)	6,049,048	1,296,000	1,252,800	1,209,600	1,166,616	1,124,032	0	0	0	0	0

Health benefits (Poor)	8,312,663	1,728,000	1,699,200	1,666,080	1,629,432	1,589,951	0	0	0	0	0
Time value of water fetching (saved, poor)	48,356,788	8,751,360	9,188,928	9,648,374	10,130,793	10,637,333	0	0	0	0	0
Time value of water fetching (time saved, non-poor)	41,850,686	8,204,400	8,286,444	8,369,308	8,453,002	8,537,532	0	0	0	0	0
non-incremental + incremental project benefit (poor)	133,728,382	16,192,483	29,870,675	29,570,594	29,209,992	28,884,638	0	0	0	0	0
non-incremental + incremental project benefit (non-poor)	112,127,753	13,196,115	25,726,630	25,062,241	24,400,739	23,742,028	0	0	0	0	0
Water rights sold (1 USD/m3, 100 hh, +10% per year)	6,265,350	0	1,350,000	1,485,000	1,633,500	1,796,850	0	0	0	0	0
Total benefits	**356,690,669**	**49,368,358**	**77,374,678**	**77,011,198**	**76,624,073**	**76,312,362**	**0**	**0**	**0**	**0**	**0**
NET BENEFIT	9,369,281	-6,800,816	-19,227,245	12,174,998	13,272,300	12,442,344	-1,388,800	-604,000	-166,500	-166,500	-166,500
NET PRESENT VALUE	**1,603,105**	**-6,072,157**	**-15,327,842**	**8,665,923**	**8,434,787**	**7,060,120**	**-703,609**	**-273,219**	**-67,247**	**-60,042**	**-53,609**
B/C	**1.03**										
EIRR (%)	**15.9-15.97%**										
OER (NRs/USD)	77.73	Nepal Rastra Bank **(Note: for convenience the 75 NRs/USD exchange rate was used in the calculations).**									
SERF	86.2803										
SERF	1.11	based on ADB, ERD No. 11 (2004)									

SCF SWRF	0.9	based on ADB, ERD No. 11 (2004)
Discount rate	**0.12**	

10. Sensitivity analysis: no benefits in Year 1

Project Economic Statement, National Currency and Domestic Price Level (NRs)	**TOTAL (YEAR 1-10)**	year 1 (no benefits due to project delay)	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Capital Costs											
Fund-raising	633,000	633,000	0	0	0	0	0	0	0	0	0
Planning, design, training, publicity	1,692,000	564,000	282,000	282,000	282,000	282,000	0	0	0	0	0
Machinery and equipment	9,590,400	0	7,672,320	1,918,080	0	0	0	0	0	0	0
Construction and rehabilitation of system elements	43,065,000	0	30,145,500	4,306,500	4,306,500	4,306,500	0	0	0	0	0

Total Capital Costs	54,980,400	1,197,000	38,099,820	6,506,580	4,588,500	4,588,500	0	0	0	0	0
Operating costs											
Fuel&energy	4,162,500	466,000	866,000	666,000	666,000	666,000	166,500	166,500	166,500	166,500	166,500
Labour											
Technical interventions	1,890,000	0	1,145,000	445,000	200,000	100,000	0	0	0	0	0
Fee collection, administrative	3,924,000	0	784,800	784,800	784,800	784,800	784,800	0	0	0	0
Maintenance (incl. caretaker, seasonal)	2,625,000	0	437,500	437,500	437,500	437,500	437,500	437,500	0	0	0
Total operation and maintenance	12,601,500	466,000	3,233,300	2,333,300	2,088,300	1,988,300	1,388,800	604,000	166,500	166,500	166,500
Producers' loss (on poor households)	27,155,036	5,016,557	5,219,408	5,426,849	5,638,467	5,853,755	0	0	0	0	0
Producers' loss (on non-poor households)	116,426,967	**22,879,757**	**23,179,880**	**23,391,500**	**23,497,496**	**23,478,334**	0	0	0	0	0
EP of water (with depletion premium)	136,157,486	26,609,861	26,869,515	27,177,972	27,539,009	27,961,129	0	0	0	0	0
Total producers' loss and EP of water	279,739,489	54,506,174	55,268,803	55,996,321	56,674,973	57,293,218	0	0	0	0	0
Total Costs	**347,321,389**	**56,169,174**	**96,601,923**	**64,836,201**	**63,351,773**	**63,870,018**	**1,388,800**	**604,000**	**166,500**	**166,500**	**166,500**

Health benefits (Non-poor)	4,753,048	0	1,252,800	1,209,600	1,166,616	1,124,032	0	0	0	0	0
Health benefits (Poor)	6,584,663	0	1,699,200	1,666,080	1,629,432	1,589,951	0	0	0	0	0
Time value of water fetching (saved, poor)	39,605,428	0	9,188,928	9,648,374	10,130,793	10,637,333	0	0	0	0	0
Time value of water fetching (time saved, non-poor)	33,646,286	0	8,286,444	8,369,308	8,453,002	8,537,532	0	0	0	0	0
non-incremental + incremental project benefit (poor)	117,535,899	0	29,870,675	29,570,594	29,209,992	28,884,638	0	0	0	0	0
non-incremental + incremental project benefit (non-poor)	98,931,638	0	25,726,630	25,062,241	24,400,739	23,742,028	0	0	0	0	0
Water rights sold (1 USD/m3, 100 hh, +10% per year)	6,265,350	0	1,350,000	1,485,000	1,633,500	1,796,850	0	0	0	0	0
Total benefits	**307,322,311**	**0**	**77,374,678**	**77,011,198**	**76,624,073**	**76,312,362**	**0**	**0**	**0**	**0**	**0**
NET BENEFIT	-39,999,078	-56,169,174	-19,227,245	12,174,998	13,272,300	12,442,344	-1,388,800	-604,000	-166,500	-166,500	-166,500
NPV	**-42,475,786**	**-50,151,049**	**-15,327,842**	**8,665,923**	**8,434,787**	**7,060,120**	**-703,609**	**-273,219**	**-67,247**	**-60,042**	**-53,609**

11. Sensitivity analysis: no regulation – no water rights revenue

Capital Costs	Total	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Fund-raising	633,000	633,000	0	0	0	0	0	0	0	0	0
Planning, design, training, publicity	1,692,000	564,000	282,000	282,000	282,000	282,000	0	0	0	0	0
Machinery and equipment	9,590,400	0	7,672,320	1,918,080	0	0	0	0	0	0	0
Construction, and rehabilitation of system elements	43,065,000	0	30,145,500	4,306,500	4,306,500	4,306,500	0	0	0	0	0
Total Capital Costs	54,980,400	1,197,000	38,099,820	6,506,580	4,588,500	4,588,500	0	0	0	0	0
Operating costs											
Fuel&energy	4,162,500	466,000	866,000	666,000	666,000	666,000	166,500	166,500	166,500	166,500	166,500
Labour											
Technical interventions	1,890,000	0	1,145,000	445,000	200,000	100,000	0	0	0	0	0
Fee collection, administrative	3,924,000	0	784,800	784,800	784,800	784,800	784,800	0	0	0	0
Maintenance (incl. caretaker, seasonal)	2,625,000	0	437,500	437,500	437,500	437,500	437,500	437,500	0	0	0
Total operation and maintenance	12,601,500	466,000	3,233,300	2,333,300	2,088,300	1,988,300	1,388,800	604,000	166,500	166,500	166,500
Producers' loss and EP of water											
Producers' loss (on poor households)	27,155,036	5,016,557	5,219,408	5,426,849	5,638,467	5,853,755	0	0	0	0	0
Producers' loss (on non-poor households)	116,426,967	**22,879,757**	**23,179,880**	**23,391,500**	**23,497,496**	**23,478,334**	0	0	0	0	0
EP of water (with depletion premium)	136,157,486	26,609,861	26,869,515	27,177,972	27,539,009	27,961,129	0	0	0	0	0
Total producers' loss and EP of water	279,739,489	54,506,174	55,268,803	55,996,321	56,674,973	57,293,218	0	0	0	0	0
Total Costs	**347,321,389**	**56,169,174**	**96,601,923**	**64,836,201**	**63,351,773**	**63,870,018**	**1,388,800**	**604,000**	**166,500**	**166,500**	**166,500**

Health benefits (Non-poor)	6,049,048	1,296,000	1,252,800	1,209,600	1,166,616	1,124,032	0	0	0	0	0
Health benefits (Poor)	8,312,663	1,728,000	1,699,200	1,666,080	1,629,432	1,589,951	0	0	0	0	0
Time value of water fetching (saved, poor)	48,356,788	8,751,360	9,188,928	9,648,374	10,130,793	10,637,333	0	0	0	0	0
Time value of water fetching (time saved, non-poor)	41,850,686	8,204,400	8,286,444	8,369,308	8,453,002	8,537,532	0	0	0	0	0
non-incremental + *incremental project benefit (poor)*	133,728,382	16,192,483	29,870,675	29,570,594	29,209,992	28,884,638	0	0	0	0	0
non-incremental + *incremental project benefit (non-poor)*	112,127,753	13,196,115	25,726,630	25,062,241	24,400,739	23,742,028	0	0	0	0	0
Total benefits	**350,425,319**	**49,368,358**	**76,024,678**	**75,526,198**	**74,990,573**	**74,515,512**	**0**	**0**	**0**	**0**	**0**
NET BENEFIT	3,103,931	-6,800,816	-20,577,245	10,689,998	11,638,800	10,645,494	-1,388,800	-604,000	-166,500	-166,500	-166,500
NET PRESENT VALUE	**-2,587,800**	**-6,072,157**	**-16,404,054**	**7,608,929**	**7,396,668**	**6,040,539**	**-703,609**	**-273,219**	**-67,247**	**-60,042**	**-53,609**

12. Sensitivity analysis: higher economic cost of water

Project Economic Statement, National Currency and Domestic Price Level (NRs)	**TOTAL (YEAR 1-10)**	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Capital Costs											
Fund-raising	633,000	633,000	0	0	0	0	0	0	0	0	0
Planning, design, training, publicity	1,692,000	564,000	282,000	282,000	282,000	282,000	0	0	0	0	0
Machinery and equipment	9,590,400	0	7,672,320	1,918,080	0	0	0	0	0	0	0
Construction and rehabilitation of system elements	43,065,000	0	30,145,500	4,306,500	4,306,500	4,306,500	0	0	0	0	0
Total Capital Costs	54,980,400	1,197,000	38,099,820	6,506,580	4,588,500	4,588,500	0	0	0	0	0
Operating costs											
Fuel&energy	4,162,500	466,000	866,000	666,000	666,000	666,000	166,500	166,500	166,500	166,500	166,500
Labour											
Technical interventions	1,890,000	0	1,145,000	445,000	200,000	100,000	0	0	0	0	0
Fee collection, administrative	3,924,000	0	784,800	784,800	784,800	784,800	784,800	0	0	0	0
Maintenance (incl. caretaker, seasonal)	2,625,000	0	437,500	437,500	437,500	437,500	437,500	437,500	0	0	0
Total operation and maintenance	12,601,500	466,000	3,233,300	2,333,300	2,088,300	1,988,300	1,388,800	604,000	166,500	166,500	166,500
Producers' loss	27,155,036	5,016,557	5,219,408	5,426,849	5,638,467	5,853,755	0	0	0	0	0

(on poor households)											
Producers' loss (on non-poor households)	116,426,967	**22,879,757**	**23,179,880**	**23,391,500**	**23,497,496**	**23,478,334**	0	0	0	0	0
EP of water (with depletion premium), new counted	137,595,102	26,841,454	27,123,781	27,459,363	27,854,453	28,316,052	0	0	0	0	0
Total producers' loss and EP of water	417,334,591	81,347,628	82,392,583	83,455,683	84,529,426	85,609,270	0	0	0	0	0
Total Costs	**484,916,491**	**83,010,628**	**123,725,703**	**92,295,563**	**91,206,226**	**92,186,070**	**1,388,800**	**604,000**	**166,500**	**166,500**	**166,500**
Health benefits (Non-poor)	6,049,048	1,296,000	1,252,800	1,209,600	1,166,616	1,124,032	0	0	0	0	0
Health benefits (Poor)	8,312,663	1,728,000	1,699,200	1,666,080	1,629,432	1,589,951	0	0	0	0	0
Time value of water fetching (saved, poor)	48,356,788	8,751,360	9,188,928	9,648,374	10,130,793	10,637,333	0	0	0	0	0
Time value of water fetching (time saved, non-poor)	41,850,686	8,204,400	8,286,444	8,369,308	8,453,002	8,537,532	0	0	0	0	0
non-incremental + incremental project benefit (poor)	133,728,382	16,192,483	29,870,675	29,570,594	29,209,992	28,884,638	0	0	0	0	0
non-incremental + incremental project benefit (non-poor)	112,127,753	13,196,115	25,726,630	25,062,241	24,400,739	23,742,028	0	0	0	0	0
Water rights sold (1 USD/m3, 100 hh, +10% per year)	6,265,350	0	1,350,000	1,485,000	1,633,500	1,796,850	0	0	0	0	0
Total benefits	**356,690,669**	**49,368,358**	**77,374,678**	**77,011,198**	**76,624,073**	**76,312,362**	**0**	**0**	**0**	**0**	**0**
NET BENEFIT	- 128,225,822	- 33,642,270	-46,351,026	- 15,284,365	- 14,582,153	- 15,873,707	- 1,388,800	- 604,000	- 166,500	- 166,500	- 166,500
NET PRESENT VALUE	**-97,299,719**	**- 30,037,741**	**-36,950,754**	**- 10,879,109**	**-9,267,222**	**-9,007,168**	**-703,609**	**- 273,219**	**-67,247**	**-60,042**	**-53,609**

Economic cost of water	year 1	year 2	year 3	year 4	year 5	TOTAL
Economic price of water (Nrs/m3)	53.9	54.8	55.9	57.1	58.4	
Annual consumption poor households	93,312	94,646	96,000	97,373	98,765	480,096
Annual consumption non-poor households	81,000	79,519	78,066	76,639	75,238	390,461
Number of non-poor households in the project	1,800	1,818	1,836	1,855	1,873	
Number of non-poor households **not** in the project	1,800	1,782	1,764	1,745	1,727	
Annual consumption of high-income households not participating in the project (15 m3/hh*1800 hh*12, every year -2% consumed)	324,000	320,760	317,488	314,182	310,844	1,587,274
Total consumption (all participating households)	498,312	494,926	491,553	488,194	484,847	2,457,832
Economic cost of water including depletion premium	26,841,454	27,123,781	27,459,363	27,854,453	28,316,052	**137,595,102**

Assume: cost of alternative resource is 2% higher than estimated.				
Cost of exhausting resource (NRs/m3)	46.5			
Cost of alternative resource (NRS/m3)	68.187	*e*=		*2.7183*
Year		Cost/m3	Depletion premium	Economic price
0	46.50		6.53	53.03
1	46.50		7.36	53.86
2	46.50		8.30	54.80
3	46.50		9.36	55.86
4	46.50		10.56	57.06
5	46.50		11.90	58.40
6	46.50		13.42	59.92
7	46.50		15.13	61.63

	8	46.50	17.06	63.56
	9	46.50	19.23	65.73
Year		Cost/m3	Depletion premium	Economic price

13. Sensitivity analysis: higher project costs (investment and maintenance)

Project Economic Statement, National Currency and Domestic Price Level (NRs)	**TOTAL (YEAR 1-10)**	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Total capital cost (new)	57,729,420	1,256,850	40,004,811	6,831,909	4,817,925	4,817,925	0	0	0	0	0
Total operation and maintenance (new)	13,231,575	489,300	3,394,965	2,449,965	2,192,715	2,087,715	1,458,240	634,200	174,825	174,825	174,825
Producers' loss (on poor households)	27,155,036	5,016,557	5,219,408	5,426,849	5,638,467	5,853,755	0	0	0	0	0
Producers' loss (on non-poor households)	116,426,967	**22,879,757**	**23,179,880**	**23,391,500**	**23,497,496**	**23,478,334**	0	0	0	0	0
EP of water (with depletion premium)	136,157,486	26,609,861	26,869,515	27,177,972	27,539,009	27,961,129	0	0	0	0	0
Total producers' loss and EP of water	279,739,489	54,506,174	55,268,803	55,996,321	56,674,973	57,293,218	0	0	0	0	0
Total Costs	**350,700,484**	**56,252,324**	**98,668,579**	**65,278,195**	**63,685,613**	**64,198,858**	**1,458,240**	**634,200**	**174,825**	**174,825**	**174,825**

Health benefits (Non-poor)	6,049,048	1,296,000	1,252,800	1,209,600	1,166,616	1,124,032	0	0	0	0	0
Health benefits (Poor)	8,312,663	1,728,000	1,699,200	1,666,080	1,629,432	1,589,951	0	0	0	0	0
Time value of water fetching (saved, poor)	48,356,788	8,751,360	9,188,928	9,648,374	10,130,793	10,637,333	0	0	0	0	0
Time value of water fetching (time saved, non-poor)	41,850,686	8,204,400	8,286,444	8,369,308	8,453,002	8,537,532	0	0	0	0	0
non-incremental + incremental project benefit (poor)	133,728,382	16,192,483	29,870,675	29,570,594	29,209,992	28,884,638	0	0	0	0	0
non-incremental + incremental project benefit (non-poor)	112,127,753	13,196,115	25,726,630	25,062,241	24,400,739	23,742,028	0	0	0	0	0
Water rights sold (1 USD/m3, 100 hh, +10% per year)	6,265,350	0	1,350,000	1,485,000	1,633,500	1,796,850	0	0	0	0	0
Total benefits	**356,690,669**	**49,368,358**	**77,374,678**	**77,011,198**	**76,624,073**	**76,312,362**	**0**	**0**	**0**	**0**	**0**
NET BENEFIT	5,990,186	-6,883,966	-21,293,901	11,733,004	12,938,460	12,113,504	- 1,458,240	- 634,200	- 174,825	- 174,825	- 174,825
NET PRESENT VALUE	**-889,904**	**-6,146,398**	**- 16,975,368**	**8,351,320**	**8,222,625**	**6,873,528**	**-738,790**	**- 286,880**	**-70,609**	**-63,044**	**-56,289**

14. Switching values

Sensitivity analysis with SV

	Base	NPV	Change of variable	New	NPV1	SV
Benefit (delay)	356,690,669	1,603,105	1st year = 0 benefit	307,322,311	-42,475,786	**0.503**
Benefit (no regulation)	356,690,669	1,603,105	no revenue from high-income hh	350,425,319	-2,587,800	**0.672**
Cost (EP of water, depletion premium)	347,321,389	1,603,105	cost of alternative resource up by 2%	484,916,491	-97,299,719	**-0.642**
Cost	347,321,389	1,603,105	project cost up by 5%	350,700,484	-889,904	**-0.626**

15. Poverty impact ratio

PROJECT BENEFITS	**Total**	1	2	3	4	5	6	7	8	9	10
Health benefits (Poor)	8,312,663	1,728,000	1,699,200	1,666,080	1,629,432	1,589,951	0	0	0	0	0
Time value of water fetching (saved, poor)	48,356,788	8,751,360	9,188,928	9,648,374	10,130,793	10,637,333	0	0	0	0	0
non-incremental + incremental project benefit (poor)	133,728,382	16,192,483	29,870,675	29,570,594	29,209,992	28,884,638	0	0	0	0	0
Benefits to the poor	190,397,833	26,671,843	40,758,803	40,885,049	40,970,217	41,111,921	0	0	0	0	0
Total benefits	356,690,669	49,368,358	77,374,678	77,011,198	76,624,073	76,312,362	0	0	0	0	0
PIR	**0.53**										

16. Hitis in Lalitpur

Stone Spout	Minimum Flow (m3/day)	Maximum Flow (m3/day)	Weighted average Assumption: 90% of year = minimum,dry, 10% of year = maximum, wet season flow	Annual discharge
Alkva hiti	267.49	361.15	276.86	101,053.83
Konti hiti	248.83	412.13	265.16	96,783.98
Iku hiti	234.14	355.97	246.33	89,909.14
Cyasah hiti	129.60	600.48	176.69	64,491.12
Nay hiti	58.67	541.73	106.97	39,044.85
Tapah hiti	86.40	192.67	97.03	35,414.93
Sinci hiti	51.49	505.44	96.89	35,364.34
Sundhara hiti	89.68	142.56	94.97	34,664.31
Hiku hiti	81.22	158.11	88.91	32,450.54
Nah hiti	71.71	106.27	75.17	27,436.32
Amrit hiti	70.07	105.11	73.57	26,854.33
Misa hiti	34.56	266.11	57.72	21,066.05
Pulcowk hiti	19.87	371.52	55.04	20,088.51
Mangah hiti	29.40	177.12	44.17	16,121.47
Wasah hiti	42.16	29.81	40.93	14,938.54
Thapah hiti	15.29	80.35	21.80	7,956.60
Cawa hiti	14.69	25.06	15.72	5,739.55
Tangah hiti	0.00	144.29	14.43	5,266.51
Nagbah hiti	0.00	143.42	14.34	5,234.98
Jawalakhyo	6.91	26.78	8.90	3,248.21
Makah hiti	7.17	10.37	7.49	2,734.11
Subah hiti	0.00	69.98	7.00	2,554.42
Gaa hiti	6.05	8.64	6.31	2,302.13
Gairi hiti	3.46	19.44	5.05	1,844.86
Tyagah hiti	2.59	18.14	4.15	1,513.73
Bya hiti	3.46	5.01	3.61	1,318.20
Bhole hiti - 2	0.00	20.74	2.07	756.86
Mandap hiti	0.00	11.23	1.12	409.97
Kanibah hiti	0.26	2.59	0.49	179.69
Bhole hiti	0.00	2.59	0.26	94.61
Sainthu G.	0.00	0.00	0.00	0.00
Balkumari hiti	0.00	0.00	0.00	0.00
Guita hiti	0.00	0.00	0.00	0.00
Saugah hiti	0.00	0.00	0.00	0.00
Loh hiti	0.00	0.00	0.00	0.00
Thusa hiti	0.00	0.00	0.00	0.00
Loh hiti	0.00	0.00	0.00	0.00
Bhindyolachhi	0.00	0.00	0.00	0.00
total	1 575.157	4 596.436	1,909.14	696,836.65
Average (m3)	41.45	129.34	50.24	18,337.81

Source: UNEP (1998)