Melamchi Water Supply Project: Cost and Benefit Analysis

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1. Executive Summary

This report conducts an economic appraisal of the Melamchi Water Supply Project in Nepal. Our analysis indicates that the base case cost benefit ratio is slightly negative. However, our sensitivity analysis reveals contradictory conclusions should the input parameters are allowed to vary from their conventional value. Another argument for the continuation of the project is that the direct benefit that consumers expect to enjoy exceeds the expected increase of water tariff. Furthermore, significant indirect benefits on labor market, business activities, and poverty reduction, which we considered qualitatively, cannot be easily captured in numbers. Therefore, while we do not recommend termination of the project, administrators should consider ways to better implement the project and amplify the benefits through social and economic means.

This report begins with the current water supply situation and a brief overview of the project. Despite abundant water resources in Nepal, drinking water supplies in most rural and urban areas are inadequate due to a lack of investment in improved services, and also as a direct result of failure to develop sustainable operation and management of those services. The future is bleak since current supply meets only less than half of the demand and the population of Kathmandu valley is growing at a pace of 3.3% annually.

Melamchi Water Supply project is designed to address this issue through the transfer of water from the Melamchi Valley into Kathmandu Valley, which hosts the capital city of Nepal. Despite its good intentions, the project has stirred up several controversies. First, opponents have argued that the project is too expensive for the amount of water provided, implying that the opportunity costs of the MWSP have not been carefully considered. The second argument surrounds over the fairness issues. The project is criticized for only benefiting the highest-income community in the country. Thirdly, environmental groups raised the concern over the environmental impact of the project. Our project is motivated by such concern as a careful cost and benefit analysis can illuminate further policy questions.

A few previous studies have attempted to quantity the benefits and cost that this project but the externality calculation has largely been missing. For example in Whittington's paper (2004), their benefit calculation only considered consumers' willingness-to-pay through contingent valuation without accounting for the associated public health benefits. Our study aims to analyze the project from an overall socioeconomic point of view including both positive and negative externalities that have never been captured in the previous reports. Relying mainly on NPV calculation, we also conducted sensitivity analysis on the input parameters to test the resilience of our model results.

Our result suggests that the net profit of project is negative, but in no meaning that the government should stop this. The reason is underlying benefits that it brings to people who consume water supplied, and indirect benefits of labor market, business activities, and poverty improvement, which we have treated in qualitative analysis, will make the NPV non-negative.

2. *Introduction*

2.1. Overview of the Project

Melamchi Water Supply Project (MWSP) is a mega scale drinking water project to alleviate drinking water shortage in the KathmanduValley with a long-term sustainable basis. This project aims to supply fresh water from the Melamchi River in the Sindhupalchwok district to the urban population of the Kathmandu Valley. The MWSP targets to bring 170 million liters per day(MLD) of water to the valley per day through a 26.5 km water diversion tunnel (WDT).The Yangri and Larke rivers, which lie in the upstream of the Melamchi River, are also being investigated as future supplementary supply sources. They can supply additional 170 MLD of water each day. The project is fragmented into three major sub-projects.

(i) Melamchi diversion scheme (sub-project 1) covers all activities in the Melamchi Valley. The large part of the sub-project is construction of the following facilities:WDTto divert about 170 MLD of water from the Melamchi River into the Kathmandu Valley, 43 km of new access roads and 29 km of upgraded roadsforthe project and a water treatment plant which has an initial capacity of at least 170 MLD and is expandable to treat 510 MLD.The other part is development and implementation of a social uplift program, including buffer-zone development, rural electrification, improvement on health, education, income and other community development activities.

(ii) Kathmandu Valley Water Supply and Sanitation Subproject (Subproject- 2) comprise of water distribution activities in Kathmandu Valley. It includes the rehabilitation and improvement of distribution networks and existing water supply system such as intakes, transmission lines, water treatment plants and service reservoirs, construction of a bulk distribution system, improvement of wasteful water systems in a phased manner and development of a shallow ground water well field in the Kathmandu Valley.

(iii) Development and implementation of the resettlement action plan, environmental management plan to mitigate direct and indirect project impacts.

The Melamchi Water Supply Project is estimated to cost around **$464** million including contingencies and taxes in the price level of 2000**.** The cost is $273 million (59%) in foreign currencies and $191 million (41 percent) in Nepal Rupee. The project is jointly funded by the Asian Development Bank, the government of Nepal and other donor/lender countries. The Ministry of Physical Planning and Works (MPPW) is the executing agency for the project and autonomous Melamchi Water Supply Development Board is formulated for the implementation. This project was started in 2001 and scheduled to complete in 2013.

2.2. Objective of the Melamchi Water Supply Project

The primary objective of the project is to alleviate chronic shortage of potable water in the Kathmandu Valley with reliable, affordable, consumer-oriented and sustainable supply to 1.5 million people in 180,000 households and thereby improve health and welfare of the residents, particularly of the poor. It is designed to serve water with quality satisfying the WHO guideline and improved distribution networks as set out by MWSP- subproject (ii).

Without the Project (WOP)

The Kathmandu valley is facing severe shortage of drinking water supply. Piped water delivery would continue to be limited to less than 2 hours every two days, pressures and water quality would be poor, and inequality would persist for water distribution. In particular, the poor will suffer the most — fetching water from shallow wells and polluted streams, or relying on public standpipes. Many only get water in the middle of the night or rely on purchasing it from their neighbors.

According to Water Supply Authority, daily water needs in the valley reach about 320 MLD. In average; however, only 140 MLD of water is supplied in the rainy season and 90 MLD during the dry season. The present water supply of Kathmandu meets less than half of the total demand. Besides, the population of the valley is increasing at the rate of 3.3%, accordingly water demand increases every year while per capita supply decreases. As a result, the price of water would rise from NRs40/m3 currently to NRs110/m3 in 2012.

With the Project (WP)

The project will bring 170 MLD of fresh water to the Kathmandu Valley per day that will meet nearly all the demand of people. The project can be easily expanded with lower cost so that it can supply additional water from two other rivers near Melamchi. The urban inhabitants will benefit from water supply with better water quality, increased quantity, stability, equity, extended service areas and better customer services. This project will also have positive poverty-reducing benefits to the Melamchi valley population (40,000) thanks to increased income from an expanded market and better education for children. The residents of Melamchi areas will also benefit from the access roads which will save traveling time. There are effects on the secondary market after the project such as increase in the prices of land and employment around the project area.

2.3. Goal of the Study

Some of the main arguments against the project cite the heavy investment involved does not justify for the amount of water provided, and that the opportunity costs of the MWSP have not been carefully considered. The main goal of our study is therefore to carry out the cost benefit analysis (CBA) of the Melamchi Water Supply Project in a more comprehensive manner than existing studies. Focused only on items with readily available monetary values, the quantification of externalities has been largely missing. For example, benefit analyses include only gross benefit calculation where willingness-to-pay is surveyed to derive the consumer surplus without careful calibration of the associated health benefits. Our study aims to analyze the project from an overall socioeconomic point of view including both positive and negative externalities that have never been captured in the previous reports. Moreover, we will see the patterns of gains and losses of the project and its financial sustainability through a sensitivity analysis. Based on this, we will propose some policy recommendation for further improvement of the project.

3. Financial and Economic Analysis

3.1. Benefits

It is estimated that about 70% of the residents of Kathmandu have a connection to the piped distribution network, but they typically receive poor quality water for only 1–2 hours per day. In addition, water is available randomly throughout the day, which implies that one member of the household has to station in the house all day to collect water when it is available. The benefits section therefore comprises of direct consumer surplus as well as the positive externalities that are expected to incur including: the saving of time and cost in fetching, carrying, pumping, purchasing, storing, and treating water; and the reduced risk of health issues.

Our assumed project life is 30 years and we assume constant inflation-adjusted return in the projection period. The official discount rate adopted in ADB funded project is 12%, which reflects the high opportunity cost usually entailed in developing countries' projects. In addition, the average household size in Kathmandu is 6.9 members. Since population is expected to grow at 3.3% per year, we expect that number of household will therefore grow at 0.049% (3.3%/6.9) per year in our projection period. In addition, we assume that real GDP will grow at a rate of 3.8% per year, the 5-year average. Time saving benefit, which is directly related to the wage of labor, will grow with the increase of GDP.

3.1.1. Affordability and Willingness to Pay

The main source of revenue is the monthly premium collected from the users. The project will certainly raise water tariffs, though the degree varies across different types of consumers. Median household income in Kathmandu Valley is estimated at NRs14,000 per month (ADB Report, 2001).For low-income households (income less than 3621 NRs), water tariffs as a percentage of household income increases from 0.724% to 1.9%. Where a low- income household is also connected to the sewerage system, the monthly charge further increases to2.8%. For median-income households consuming 125 lpcpd (or 19.1 m3 per month), tariff rises from 1.2% of household income to 3.2%. This is equivalent to RS550 (US$7.75) per month per household. Where such households are also connected to the sewerage system, tariffs will rise from 1.8%to 4.8%. On average, the expected water bill will be about thrice of the current level (RS 150, US$2.1). The expected annual user premium is therefore:

$7.75*12*180,000=16,740,000

When gauging consumer willingness-to-pay through contingent valuation, it is very difficult to isolate benefits such as time saving and health improvement because assuming household responses were rational, they would take into account of such saving and implicitly assigned a monetary value to it. Whether household assessment can accurately quantity the benefit is subject to debate, we shall draw any conclusions with caution and test our results with various scenario changes.

Based on a survey of a random sample of 1,500 households conducted in Kathmandu in 2001 (Whittington, 2002), a mean willingness-to-pay for improved water service was estimated to be US$14 per month per household. Specifically, the respondents were asked whether they would vote for a program that would deliver reliable water supply to their household if it resulted in a monthly water bill of a specific amount. Another study carried out by Water and Sanitation Program South Asia also concluded that even poor (who have less than US$51 per month income, who expends less than US$51 per month, and who use wood and cow-dung as a cooking fuel) are ready to pay US$7 to $8.5 per month.

At a first glance, the high household benefit valuation seems to indicate that the expected water tariff hike can be justified and that there might be further room for increase in water tariff. We will come back to this point later but we must note that contingent valuation is frequently criticized because the answers given by respondents are not tempered by their actual budget constraints.

3.1.2. Electricity

Electricity supply, like water supply, is highly unstable in Nepal. The second benefit item is the electricity saving to pump underground water. Currently an electric pump is required to pump water from ground because of the lack of surface water supply. The water supply project can result in two hours of electricity saving per day, approximately 1/6 of daily water usage. 180000 benefited household constitutes to roughly 1/10 of all domestic electricity consumers, and according to the annual report of Nepal's electricity commission, annual consumption of all domestic amounts to US $740 Million. Therefore, it is estimated that

740*(1/6) = 105 million of RS annually = US$1.5 million

can be saved annually.

3.1.3. Time

Time cost is another non-negligible component of the economic appraisal. As mentioned above, one member has to wait inside the house all day to collect water when it is available. The water supply project will therefore free up the labor resource for other activities. It is in the convention of the Inter-American Development Bank to assume that time savings should be valued at 50 percent of the market wage rate for unskilled labor. The minimum wage of unskilled labor in Nepalese Currency is NRS 6200, which converted to USD is 87.3. ($US1 = NRS 71). The per person per month time benefit is calculated as follows:

30 days/month x50%x$87.3 USD /(22 working days * 8 working hours/day)=7.44 USD/person/month

Multiplying by 180,000 households and 12 months,

Total: 7.44x180,000=1339261 USD/month * 12 = 16071136 USD/year

3.1.4. Access Road

Access roads, originally built to tranport machinaries and other necessary physical components, will be made available to the locals for their transportation needs. This would provide access to markets for Melamchi Valley inhabitants To value the benefit incurred, we reasoned that much of the benefit involved the additional time saving in transportation for the residents in the remote neighborhood. There are currently 440,000 people living in areas that can utilize the access roads to travel to Kathmandu and result in approximately 6 hours of time saving per round-trip. Assuming that they make a minimum of 2 trips per year to Kathmandu and the same assumption over value of time applies, the benefit is therefore as follows:

440000people*2trips/year*6hours*$87.3/(22*8)*0.5 =119,045 USD/year

3.1.5. Health Benefits

Waterborne diseases are one of the biggest causes of sickness in the country and the health benefits that the Melamchi Water Supply Project is expected to bring through cleaner supply of water is therefore a significant portion of our benefit calculation. The benefits consist of the value of man-days and health expenditure saved from the avoidance of waterborne diseases.

The following data are used to estimate the benefits. Annual health expenditure per capita in Nepal is $19.61. This is the sum of public and private expenditures. An unskilled labor works for 22 days and earns $87.3 per month. 1.5 million people in 180,000 households will get benefit from the project.

Since there is no prediction about the number of patients of waterborne diseases before/after the project, we extrapolate the results of a similar water supply project in India to our calculation. The reference project was held in Kerala State in India, supported by the World Bank. There are four assumptions based on the reference project. First, 15% of the population is susceptible to waterborne diseases each year. Second, once a person gets a waterborne disease, s/he will be absent from work for 7 days. Third, waterborne diseases will decrease by 25.8% thanks to the new water supply. Finally, 67% of health expenditure is on waterborne diseases.

The annual decrease in waterborne diseases is the product of the population, susceptibility of diseases and rate of decrease, which equals 1500000*0.15*0.258 = 58050. By multiplying this by 7 days, 406350 working days will be saved each year. Since the daily wage is $87.3/22, the value of the saved working days will be 406350*87.3/22 = $1612470.68 per year.

The amount of health expenditure saved each year is the product of the decrease in waterborne diseases and annual health expenditure on waterborne diseases. The first element equals 58050 as we have just calculated. The second one amounts to 19.61*0.67 = $13.1387. Hence, 58050*13.1387 = $762701.54 of health expenditure will be saved each year. In total, the annual health benefits will be $2375172.22. Per household, the benefits will be $12.92.

3.2. Cost

3.2.1. Project Cost

The total cost of the project is estimated as 464 million USD in 2000 price. The costs are adjusted to reflect their real opportunity cost. Originally the cost was designed to finance four major sectors including infrastructure development, social and environmental support, institutional reform and project implementation support. The raw water supply component of the project (intake weir, tunnel and access roads) only accounts for one-third of the project. The bulk distribution system, water treatment system and rehabilitation of the existing pipe network represent the majority of project cost. The previously done economic appraisal has taken the expected annual loss due to earthquake since Kathmandu is earthquake prone region. The details of the cost and time profile for the different cost of the Melamchi Water Supply Project are shown in the table 1.

Item	Total Cost (Million USD)
Base	
Infrastructure	276.39
Social and Environment	12.44
Institutional Reform	2.56
Project Implementation	32.6
Subtotal	**324.0**
Contingencies	
Physical	32.4
Price	30.8
Subtotal	**63.2**
Interests	**40.8**
Taxes and Duties	**36**
Total	**464.0**

Table 1. Cost Estimates of Melamchi Water Supply Project

3.2.2. Cost to the fishing Industry

According to the environmental Management Plan of Melamchi Water Supply Project nearly 200 people are engaged in the fishing activities will be affected after the project start to divert water from the Melamchi river. Using the minimum wage of labor as the estimated income loss and an estimated of 200 people will be displaced from their current job, they will loss 209577 USD annually which is shown by the calculation below.

200*6200RS*12/71=209577USD

3.2.3. Potential water disruption cost

A flow of 0.2 m^3 per second is being used for irrigation of the agricultural land in the Melamchi valley. After the diversion of water from the river, it might cause the social and economic problems. The opportunity cost attached with the loss of gross returns of paddy in the Melamchi basin is US$350/ha/per crop season. The total economic loss of spring paddy of 110 ha downstream of the project intake would be about US$39,000 per year (Bhattarai & Pant, 2004)

3.2.4. Water Mills

The project adversely affects the poor who have less bargaining power and less voice in the society because of their poor socio-economic status. For example traditional water mill owners and the minority water users will be affected seriously. The operation of water mills is the primary sources of income for their households. According to the EMP, 15 water mills will be dropped because of low water flow after the water diverted from the Melamchi river. It is difficult to calculate the loss because of the loss of employment as well as the disappearances of traditional knowledge inherited from the generation. Furthermore, these mills are used by the poor since it is more affordable compared to other alternatives.

3.2.5. Air and Noise Pollution, Crime

The construction would cause air pollution to the valley and also noise disturbance. Additionally, there would be a large number of people who temporarily work and stay around the construction site could make the pollution worse and also increase the numbers of case committed to crimes.

4. Secondary Market

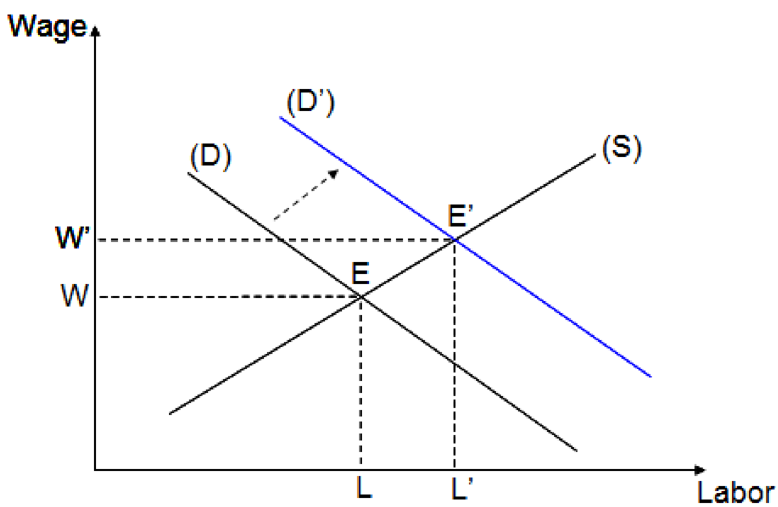
Beside the benefits and costs the implementation of Melamchi Water Supply project brings on, it also has impact to other sectors, considering as secondary markets – labor and land in Melamchi, Kathmandu Valley.

4.1. Labor market

Initially, we tried to monetize the benefit that project would create to labor market by number of local people employed during and after the construction. However, due to time and data resource constraints, we could not figure out the benefit in money.

In process, there have been a number of local employments recruited for permanent/ temporary jobs of projects. Based on the research of Khadka and Khanal, nearly 1,020 skilled and semiskilled workers will be working at Melamchi Diversion Scheme and 1,420 jobs would be available every day during the construction of Bulk Distribution System, Water Treatment Plant and Waste Water Treatment Plant, among them 60% should be local. That demand would be met by current unemployed workers staying in Melamchi and Kathmandu valleys, and people from other areas nearby.

Moreover, increased business activities that resulted from higher demand for associated services in the construction site would create more jobs for local people. In the labor market, the increase in demand would lead to more labor recruited, and average wage level would goes up, from L to L' and W to W' respectively (in graph 1).

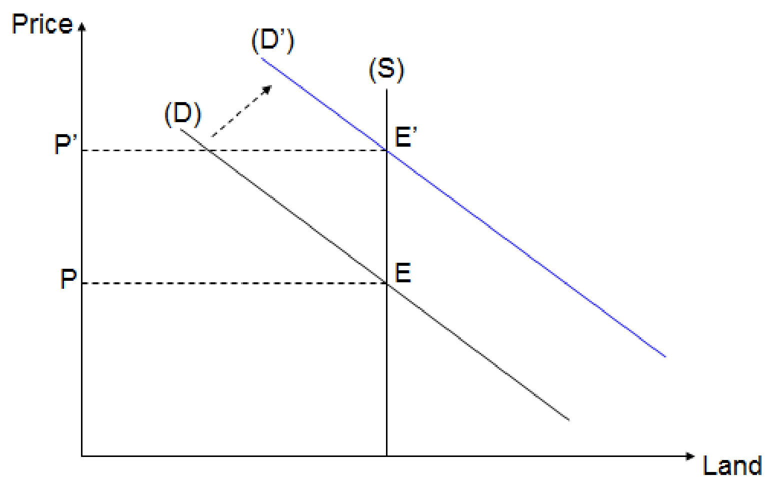


Graph 1: Demand and Supply in Labor market

4.2. Land market

Without the project, there were few proper access roads to the site of Melamchi River, and to neighbor areas. There is only one highway between Kathmandu and Melamchi area which is disconnected in the mid-way.

When the project was introduced and implemented, people in these areas have 42.2 kms of road to be constructed and upgraded, which will improve access to the upland and near-river areas along the Melamchi River. Furthermore, more business activities on site and in two valleys would create more incentives for people to move and live in these areas. As the land supply would considered as stable all the time, increase in demand of land in these sites would cause land price goes up from P to P' (Graph 2)



Graph 2: Demand and Supply in Land market

With the project, there are indirect benefits brought to other business activities. By increasing wages of labor in the area, it could help to improve the living condition of people and reduce poverty.

5. Summary

After considering all the above costs and benefits using the assumptions mentioned above, we derived a NPV of -$12,884,326, equivalent to a cost-benefit ratio of -0.97. Despite the associated financial and economic benefits, the large capital investment does not seem to be justified based solely on the NPV criterion. However, the expected increase in water tariff appears to be still less than the consumers' willingness-to-pay for 24-hour potable-piped water, implying that water tariff might be increased further to raise revenue. In addition, some of the increase in welfare brought upon by this project cannot be measured easily. For example, the project would eliminate current groundwater mining, which if continued would cause land subsidence. In addition, reliable water availability can spur business development in the region, sustain and stimulate GDP growth. These are all indirect benefits that cannot be measured easily in addition to the secondary market benefits mentioned above.

Is the NPV really negative?

In the base case, the NPV of the project is -$12,884,326. Should the government of Nepal quit this project? The answer is not so clear-cut. A small amount of indirect benefits from the labor market and business activities, which we have treated as qualitative benefits, will make the

NPV nonnegative. In this section, we calculated the threshold value of the indirect benefits, i.e. the value that makes the NPV exactly zero.

The calculation method is as follows. Let x be the real value of the annual indirect benefits. Since the discount rate is 12%, the discounted sum of the indirect benefits is:

$$x\sum_{t=0}^{30}\left(\frac{1}{1.12}\right)^{t} = x\frac{1-1/1.12^{31}}{1-1/1.12} = 9.055184x$$

The sum should be equal to 12,884,326 to make the new NPV zero. Hence, x = $1422867.46. $7.90 of annual indirect benefits is needed per household. This is only 0.755% of annual household income. Given that the annual willingness-to-pay per household is 14*12 = $168, the indirect benefits are definitely beyond $7.90 and the NPV should be positive.

Furthermore, even if there are no indirect benefits, annual increase in the water premium, which equals (7.75-2.1)*12 = $67.8, is less than the sum of annual direct benefits and consumer surplus will become larger. The direct benefits is composed of time saving, electricity saving and health benefits and they are $89.95, $8.33 and $12.92 per household, respectively.

6. Sensitivity Analysis

The value of our economic analysis is highly sensitive towards the input parameters and may lead to vastly different conclusions. In using sensitivity analysis, this session seeks to explore the resilience of the conclusion that we drew from the base scenario. The results are summarized in table 2.

Holding the other parameters constant, we varied the discount rate from 8% to 16% and the NPV changed drastically. The discount rate reflects the opportunity cost of capital and a different discount rate should be used in different development stage of the country. In the 8% discount rate scenario, the NPV becomes positive and if policy makers based their decision solely on evaluation criterion, the project should be pursued. However, when discount rate is increased to 16%, we had the original conclusion that the projection is unprofitable and different water alternatives should be seek.

Since time cost is a big component of economic appraisal, we expected that changing the unit time cost would alter our valuation significantly. In our sensitivity analysis scenario, we varied the unit time cost across the spectrum of 25% to 75% of wages of unskilled labor holding other parameters constant. When unit time is only valued at 25% of unskilled labor wages, the NPV becomes negative and swings to positive if it is increased to 75%. In both scenarios, wage is expected to grow with real GDP. While it is difficult to decide whether 50% is a good assessment of time in this particular project, the different conclusions that we can draw by varying unit time cost indicates that the project is not very fundamentally resilient.

Finally, we also let the project period to diverge from the original 30-year estimate. In the case where the life of the project is extended to 40 years, NPV swings to positive and when project life is stretched to 50 years, the benefit it brings is even greater.

Parameter	**Value**	**NPV**
Discount Rate	8%	$159,217,084
	16%	-$108,446,567
Time Saving	25% of Unskilled labor wages	-$116,797,973
	75% of Unskilled labor wages	$91,029,320
Time Period	40 years	$4,507,770
	50 years	$12,281,210

Table 2. Results of Sensitivity Analysis

7. Conclusions

The primary goal of this report is to conduct an economic appraisal of the Melamchi Water supply project in Nepal, a mega-scale infrastructure improvement project that approximates to 7% of the country's GDP. Our results indicate that the base case NPV is -$12,884,326, equivalent to a cost-benefit ratio of -0.97. While the massive capital investment does not seem to be justified in this scenario, the sensitivity analysis reveals contradictory conclusions should we lax our assumptions on the input parameters. Since indirect benefits cannot be observed directly, we also conducted an analysis to determine the threshold value that will make the NPV 0. Our analysis shows that an additional $7.9 per household per annum would make the associated benefit equal to the cost of the project, a mere 0.755% of average annual household income. This increase in benefit can be achieved through a larger-than-expected increase of real GDP or population growth.

Improvements on our analysis can be made in several aspects. First, the issue on water equity can be more thoroughly addressed. Since Melamchi area is the rural area and is considerably poorer compared to Kathmandu, the transfer of water from Melamchi to

Kathmandu can be considered as a resource transfer from the poor to the rich, opposite from the conventional income transfer program in the developed countries. While we have in our analysis calculated the potential cost to the fishing and agriculture industry in the Melamchi area, a distributional weight might need to apply to the Melamchi inhabitants to amplify the cost imposed on them. In addition, because there is no publicly available data on land price and regional employment, we were not able to quantitatively assess the impact of the project to these secondary markets. Another area of improvement lies in the assessment of the risk associated with project of such scale. The project has already been delayed considerably, and opportunity cost entail is significant. Another considerable risk is the currency risk. More than half of the project is funded by US dollars – should the NRs experiences volatile movement, the interest payment would fluctuate greatly and can become a huge burden to the Nepalese government. These are risks that should be well understood by the administrators.

Acknowledgement

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