FINANCIAL AND ECONOMIC ANALYSIS  
Nepal: Community Irrigation Project  

A. Approach and Methodology  

1. Methodology  

1. The Community Irrigation Project will support investments in small-scale farmer-managed surface irrigation systems and community-managed shallow tube wells (STWs). The sustainability of the infrastructure improvements will be supported by establishing and strengthening water user associations (WUAs), training for beneficiaries in appropriate agricultural practices, and expanding microfinance services. The project will include the following type of irrigation systems:  
   (i) in the hills and mountains, irrigation systems with small command areas measuring less than 25 hectares (ha) with surface springs or small rivers as sources and  
   (ii) on the Terai, or plains, both surface- and groundwater-fed irrigation systems for command areas measuring less than 200 ha.  

2. The project will adopt a sector approach through which subprojects will be identified, screened, and appraised using agreed procedures and criteria. This, combined with the project’s participatory approach, renders it impossible to predict the type and number of subprojects that will be implemented under the project. During project preparatory technical assistance (TA), economic and financial analyses were undertaken for three sample subprojects and for a typical STW cluster.  

3. The economic analysis methodology applied the basic concept of estimating a future flow of incremental benefits resulting from the direct investment costs in the subprojects’ irrigation infrastructure. Other costs—including subproject design and supervision, project management, and agricultural and other training—were taken into account in the sensitivity analyses. For the economic analysis, only direct, quantifiable benefits were considered. The analysis assumes a project life of 20 years.  

4. On the benefit side, current cropping patterns, intensities, and yields in the subprojects’ command areas were identified during project preparatory TA to assess the without-project situation and to project the with-project situation following the completion of the subproject infrastructure works and the agricultural training and associated demonstration programs.  

2. Prices and Costs  

5. The direct costs of the subprojects were estimated based on feasibility-level designs and bills of quantities, and on current cost norms for construction materials and skilled and unskilled labor. All costs, in financial terms, have been expressed in first quarter 2010 prices with possible taxes and duties separately identified where possible. An exchange rate of NRs73 to $1 was applied. Breakdowns in local and foreign currency were prepared.  

6. The economic analysis uses the world price numéraire. Economic prices exclude taxes and are converted from financial prices by applying a standard conversion factor of 0.91.\(^1\) A shadow wage rate factor (SWRF) of 0.85 was applied to unskilled wage rates to reflect the  

\(^1\) This is in line with conversion factors used in other recent projects in Nepal.
relative abundance of unskilled labor, though in some locations at some times of year this may undervalue unskilled labor due to the temporary migration of labor to other parts of Nepal or India.²

7. Financial prices for inputs and outputs were based on surveys conducted during project preparatory TA of recent local farm-gate and market prices, supplemented by Government of Nepal data on market prices for a wide range of commodities in the various districts of the country. Economic prices for such traded inputs and outputs as rice, wheat, maize, and chemical fertilizers were estimated using average international commodity prices for the final quarter of 2009.

3. Crop Budgets and Benefits

8. The project’s quantified benefits are the increased agricultural outputs expected when farmers gain reliable access to irrigation. Gains occur in two ways. Firstly, yield increases are achieved when farmers are able to irrigate crops that were rain fed without the project or that were only partly (and unreliably) irrigated. Second, cropping intensity increases because land that was not previously cultivated, particularly in the dry season, is brought under cultivation in both seasons.

9. Cropping patterns for the present situation were based on field observations and farmers’ information collected during project preparatory TA. Future cropping patterns were designed taking into account the likely impact of access to reliable irrigation, market situations, and, particularly for labor-intensive crops such as vegetables, estimates of the cropping area that households can manage using their own labor.

10. Crop budgets were prepared based on information on current yields and inputs provided by farmers to project preparatory TA consultants, supplemented with crop production data for each district compiled by the Department of Agriculture. Data from similar projects, such as the on-going Community-Managed Irrigated Agriculture Sector Project,³ were also referred to. Inputs for with-project crop budgets are based as far as possible on information about current good practice in similar areas. Estimated with-project yields were guided by published Department of Agriculture information on attainable yields in each district, but for the economic analysis lower yields were assumed.

11. Besides the quantifiable benefits related to increased agricultural productivity, subprojects will generate other benefits. Some subprojects will have environmental benefits such as reduced pressure on nearby forests achieved by eliminating the need for brushwood to build and rebuild temporary off-take structures. Landless and other households in and near subproject sites are expected to benefit from increased labor demand resulting from increased agriculture production. Increased demand for labor is unlikely to be large overall, but it could be significant for individual households. Production increases, especially the production of cash crops of various sorts, will benefit local markets and trade in subproject areas.

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² Some recent projects in Nepal have used SWRFs as low as 0.70. The “true” SWRF certainly varies in Nepal across regions and sectors. For this analysis, a conservative estimate was selected for the SWRF to ensure that this factor did not artificially inflate the subprojects’ estimated internal rates of return or net present values.

³ ADB. 2004. Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the Kingdom of Nepal for the Community-Managed Irrigated Agriculture Sector Project. Manila.
B. Sample Subprojects: Current Situation, Infrastructure Improvements, and Quantified Benefits

12. Three surface irrigation subprojects and a typical STW cluster subproject were selected for economic and financial analyses. The Majhkot subproject is new irrigation development in the hills, the Patana subproject improves an existing irrigation system on the Terai, and the Buddhi subproject is new irrigation development on the Terai. These three subprojects and the STW cluster subproject are representative of the types of subprojects that will be in the project.

1. Majhkot Subproject

13. The Majhkot subproject includes the Ghaya Kholsi tank irrigation scheme in Pyuthan District. The subproject has a command area of 16 ha. Rain-fed crops are cultivated in the command area by 96 households who hold an average of less than 0.2 ha each, though most of them also have land outside the command area. A spring is the source of the water. Only limited supplies are available for agriculture, as the spring also provides drinking water to a number of villages.

14. The subproject will convey water from the spring to the command area, which comprises two separate blocks, one of 2 ha and the other of 14 ha. To use the limited spring water as efficiently as possible, a piped reticulation system will be provided with tap stands at a density of one stand per 0.5 ha. Two new storage tanks will be provided, one for each of the two blocks. Farmers would adopt simple micro-irrigation technology to irrigate their crops.

15. The subproject will provide supplementary irrigation in the rainy season and limited irrigation water during the dry season. The subproject is expected to bring significant increases in vegetable and potato production, as well as modest changes in cereal production. Some farmers in the command area already produce vegetables to sell to merchants who come to the area to buy vegetables to supply markets on the Terai and in north India. This area has an advantage over local producers in the market area in being able to supply vegetables in a different season. With-project cropping intensity is assumed to increase to 208%, a 12% increase over the present intensity.

2. Patana Subproject

16. The Patana subproject covers the Kothibandh irrigation system in Kapilvastu District. The system is probably more than 150 years old. It has a 5 kilometer (km) main canal and eight secondary canals. To divert the water from the Kothi River, farmers have to build a brushwood weir. Because the weir is frequently damaged by flooding, much of the 172 ha command area cannot be reliably irrigated, so crops are largely rain fed. The weir needs to be replaced 5–15 times per year, which requires collecting a considerable volume of small tree trunks and branches from the nearby forest.

17. The system’s command area supports 135 households. The 93 marginal households make up 69% of the total and have an average farm size of 0.5 ha. There are 27 households that have small farms averaging 2.1 ha, 14 that have medium-sized farms averaging 4.2 ha, and 1 large farm measuring 8.1 ha. Outside the command area, a total of 35.6 ha is held by 106 of these households.

18. The subproject will replace the brushwood weir with a semi-permanent gabion weir with riverbank and riverbed protection works and a new intake structure. The main canal will be reshaped to improve flow, and division boxes at the off-takes of the secondary canals will be constructed to improve water distribution within the system. The gabion weir will reduce labor
requirements for reconstructing and maintaining the weir and will provide an environmental benefit, as it will no longer be necessary to collect material from the forest.

19. The current average cropping intensity in the subproject command area is 171%. At present some crops are only partly irrigated, and some areas receive only limited irrigation. With the proposed interventions, the whole command area will receive reliable irrigation. Further, sufficient water will be available to supply system requirements even in April, the driest month. This will allow relatively large increases in the harvests of cereals and vegetables, as well as of oilseeds and pulses. The average cropping intensity for the area is expected to increase to 195%, a 14% increase over the present intensity.

3. Buddhi Subproject

20. The Buddhi subproject includes the planned Janakalyan lift irrigation system in Kapilvastu District. Of the 123 households that have land in the planned command area, 81% have marginal farms with an average landholding of 0.3 ha. Of the remaining 23 households, 21 have small farms averaging 1.2 ha, and 2 households have medium-sized farms that together occupy 5.6 ha. Eleven landless households live in the command area. Thirty-one of the households (25%) also have land outside the subproject command area; these additional holdings are mostly less than 1 ha per household.

21. The farmers have started irrigation development in the area by constructing an intake channel on the Gudrung Khola River, the base for an electric pump set, and a base on top of the river bank for a water distribution tank. Electric transmission lines to the pump site have been installed, and farmers have applied for electricity supply. The system was tested during the 2009 rainy season, irrigating about 3 ha.

22. The subproject will improve and protect the intake site and provide three electric pump sets of 5 horsepower each, intake and delivery pipes, a pump house, the water distribution tank and a 1.7 km canal system with associated structures for the 64 ha command area.

23. The introduction of irrigation will significantly increase agricultural production in the command area. At present, crops are rain fed, so crop yields and cropping intensity are expected to increase. The current cropping intensity of 178% is projected to rise to 207%, a 16% gain. The subproject will increase the production of both cereals and cash crops.

4. Typical Shallow Tube Well Cluster

24. During project preparatory TA, several STW projects on the Terai were reviewed to assess their general characteristics. The command area of a single STW cluster can vary, but for the economic and financial analysis a typical STW cluster is defined as comprising 10 wells, each serving 4 ha. Further, it is assumed that a STW cluster of 40 ha has 160 farm households, each with a farm of 0.25 ha. This is consistent with the data available from several existing STW schemes in Kapilvastu and nearby districts.

25. The tube well, pump, and motor will be installed by the STW group. The project will facilitate access to microfinance institutions willing to provide group loans to the STW group for installing the STWs. The project will also connect STW clusters within a maximum distance of

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4 Terai farms are defined as follows: marginal <1.0 ha., small 1.0–2.5 ha, medium-sized 2.5–5.0 ha, and large >5.0 ha.

5 Because of the cost of establishing a connection to the grid, STW clusters smaller than 40 ha should not be considered if a new grid connection is required unless there are other clusters nearby that could use the same grid connection.
1.5 km from the national grid and electrify the STWs in the cluster. Some clusters will not require such connection, as they will be near the national grid.

26. Operating costs for farmers are relatively low because the electric motors and pumps are simple and cheap to maintain. Further, electricity supplied to farmers for irrigation is subject to a 50% subsidy, which makes electric pumps a more viable option than diesel. Although the supply of electricity can be erratic in some areas, the number of pumping hours required for irrigating 4 ha is relatively low. Farmers are flexible and will pump water when power is available. Operation and maintenance costs have been estimated based on data collected from existing STW clusters in Kapilbastu District. They include estimated annual pumping costs (which are therefore not included in the crop budgets) and an annual allowance for replacing hoses, which typically last 3 years. Annual operating and maintenance costs are estimated to be NRs241,667 per tube well cluster (or NRs310,667 in economic prices, with the removal of the subsidy for electricity).

27. With the development of STWs, the fundamental change is from mostly rain-fed to irrigated production for all crops, as with the Buddhi subproject. Yields of all crops will respond to the improved water regime, and cropping intensity will also increase. Farmers are expected to increase their production of vegetables, both for their own consumption and as cash crops. Cropping intensity is expected to increase to 206%, a 15% increase over present intensity. This is a conservative estimate, and some farmers may achieve higher cropping intensities.

C. Economic Analysis of Sample Subprojects

28. Economic internal rates of return (EIRRs) and sensitivity results for the three sample surface irrigation subprojects and the typical STW cluster are in Table 1. The EIRR for the Majhkot subproject is 20.4%, Buddhi 17.7%, and Patana 19.1%. A typical STW cluster of 40 ha with a 1 km connection to the national grid has an EIRR of 24.2%. These results were estimated using all subproject costs, including capital and noncapital costs, and the benefits summarized in the preceding sections. In general, the sensitivity results show that the EIRRs are robust to changes in the main cost and benefit variables. They show that the EIRRs remain acceptable with changes in the main cost and benefit variables. However, in the worst case of a 20% increase in capital costs and a 20% decrease in subproject benefits, the EIRR for the Buddhi subproject falls below 10%. However, the prospect of both of these conditions occurring together is rather unlikely, in particular benefits falling by 20% over the whole life of the project.

<table>
<thead>
<tr>
<th>Table 1: Economic Internal Rates of Return and Sensitivity Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Majhkot Subproject</strong></td>
</tr>
<tr>
<td><strong>Base case</strong></td>
</tr>
<tr>
<td>Change (%)</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>Capital costs</td>
</tr>
<tr>
<td>(20)</td>
</tr>
<tr>
<td>All benefits</td>
</tr>
<tr>
<td>(20)</td>
</tr>
<tr>
<td>Costs +20%; benefits –20%</td>
</tr>
<tr>
<td>Project life, 10 years</td>
</tr>
<tr>
<td>13.5</td>
</tr>
</tbody>
</table>

6 For the economic and financial analyses of a typical STW subproject, the cropping patterns and crop budgets developed for the Buddhi subproject were applied.

7 The Buddhi subproject is a lift irrigation subproject; it is expected that few subprojects under CIP will be of this type.
### D. Financial Analysis of Sample Subprojects

29. The financial impact of the sample subprojects on farm household income is summarized in Table 2. Incremental income is that which accrues at full development of subproject production in the farm and crop budget models, which is between 6 and 8 years. In general, smaller farms have relatively greater increases in incremental income than do larger farms. This is because households with smaller landholdings generally have more household labor available per hectare than do larger farms and are therefore more likely on average to have in their cropping patterns a higher proportion of labor-intensive crops (vegetables and potatoes in the analysis for the project).

<table>
<thead>
<tr>
<th>Subproject</th>
<th>Farm Size</th>
<th>Households (%)</th>
<th>Average Area (hectares)</th>
<th>Present Income (NRs)</th>
<th>Incremental Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Majhkot</td>
<td>All farms</td>
<td>100</td>
<td>0.167</td>
<td>8,260</td>
<td>9,370</td>
</tr>
<tr>
<td>Buddhi</td>
<td>Medium &amp; small</td>
<td>29</td>
<td>1.290</td>
<td>33,690</td>
<td>24,380</td>
</tr>
<tr>
<td></td>
<td>Marginal</td>
<td>81</td>
<td>0.343</td>
<td>10,180</td>
<td>15,190</td>
</tr>
<tr>
<td>Patana</td>
<td>Large &amp; medium</td>
<td>11</td>
<td>4.447</td>
<td>138,720</td>
<td>74,520</td>
</tr>
<tr>
<td></td>
<td>Small &amp; marginal</td>
<td>89</td>
<td>0.878</td>
<td>35,860</td>
<td>44,400</td>
</tr>
<tr>
<td>STW Cluster</td>
<td>All farms</td>
<td>100</td>
<td>0.250</td>
<td>7,474</td>
<td>10,891</td>
</tr>
</tbody>
</table>

NRs = Nepalese rupees, STW = shallow tube well.

30. Small and marginal farm households will benefit from the subprojects relatively more than households with larger farms. The impact on poverty, while positive, is not large. As can been in Table 2, an average marginal farm household in the Buddhi subproject area will, at full development, have an income from farm production of NRs25,370 per year. In the Patana subproject, where marginal farm households are 69% of all households, income from the average marginal farm will be only NRs47,000 per year. Some of these households also have land outside the command areas of the subprojects, but these areas are also not large. Households often also have off-farm sources of income. And, as has been noted elsewhere, labor migration to other areas in Nepal, to India, and further afield can be a much more significant source of income than crop production.

E. Conclusions

31. Economic analyses of the three surface irrigation subprojects and the typical STW subproject show that all types of subprojects are economically viable and that economic indicators are generally robust under likely variations in key cost and benefit variables. Other subprojects that will be selected under the project during implementation will include rehabilitation, improvement, and development options different from those covered by the four subprojects, but the general types represented by these sample subprojects provide a basis for broad conclusions about the overall viability of the project.

32. For assessing the economic feasibility of future subprojects without requiring a full cost–benefit analysis, cost ceilings for the different types of subprojects have been assessed.

33. The Majhkot subproject has an EIRR of 20.4%, Patana 19.1%, and Buddhi 17.7%. These estimates are based on yield increases generally not exceeding 20%, except where there is a change from rain-fed to irrigated production, and increases in cropping intensity of 8% for Majhkot, 14% for Patana and 16% for Buddhi. The capital costs per hectare for the subprojects are NRs104,000 for Majhkot, NRs56,000 for Patana, and NRs109,600 for Buddhi.\(^8\)

34. In preparing with-project cropping patterns, an increase in the areas sown with vegetables and potatoes (which can be proxies for all cash crops) is generally assumed, though they are usually small increases. For the two Terai surface irrigation subprojects, areas currently under rain-fed crops—the whole command area in Buddhi and 25% in Patana—will change to irrigated crops after subproject implementation. In both cases, these changes and the higher yields that come from irrigation are sufficient to ensure subproject viability without a change in the basic cropping pattern. Since conditions are likely to be substantially similar at most other Terai locations,

(i) subprojects with costs below $1,000/ha that upgrade at least 25% of the command area from rain-fed to irrigated production, and where the increase in cropping intensity can reasonably be expected to be at least 10%, are highly likely to be economically viable;

(ii) subprojects that convert the whole command area from rain-fed to irrigated production and have costs up to $1,500/ha are likely to be economically viable without any change in cropping pattern and highly likely to be viable where any increase in cropping intensity greater than 10% can reasonably be expected; and

(iii) diversification toward relatively highly profitable potatoes and vegetables increases the likelihood of economic viability.

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\(^8\) The noncapital costs are, on average, equivalent to 52% of the capital costs.
35. Capital costs above $1,500/ha can be considered for new schemes on the Terai that will upgrade 100% of the command area from rain-fed to irrigated cultivation, with an accompanying increase of the cropping intensity by at least 15% but preferably by about 20%. However, increases of 20% may be difficult to achieve.

36. The smaller hills and mountains subprojects can support costs of up to $1,500/ha, provided that they expand the irrigated area in the dry season and shift cropping patterns toward more vegetables, potatoes, or other high-value crops, which should probably be grown on at least 25% of the command area in the course of the year. Cropping intensity should increase by at least 10%. Capital costs of up to $2,000/ha may be acceptable where market conditions can reasonably be expected to support up to 50% of the command area being planted to vegetables each year.

37. The STW subprojects fall under the same parameters as the surface irrigation subprojects in the Terai. Most STW schemes will convert 100% of command area from rain-fed to irrigated cultivation. As the estimated capital cost for a typical 40 ha STW cluster varies from NRs83,000/ha when a new connection to the electricity grid is required to NRs41,000/ha when electricity is already available in the area, it is difficult to imagine circumstances in which these schemes would not be economically viable. The sensitivity analysis demonstrates that if the economic cost of a cluster increases to NRs170,000/ha, the EIRR will be below 12%. In financial prices, the upper limit of cost per hectare for viability is therefore NRs187,000/ha.

38. The conclusions of this review are summarized in the table, which can be used as guidelines for determining the probable viability of subprojects.

<table>
<thead>
<tr>
<th>Location</th>
<th>Cost per Hectare (NRs)</th>
<th>Cost per Hectare ($)</th>
<th>Cropping Intensity Change (%)</th>
<th>Vegetables as % command area</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terai, existing</td>
<td>&lt;73,000</td>
<td>&lt;1,000</td>
<td>&gt;10</td>
<td></td>
<td>25% increase in area irrigated Up to all of command area converted from rain-fed to irrigated</td>
</tr>
<tr>
<td>Terai, new</td>
<td>&lt;110,000</td>
<td>&lt;1,500</td>
<td>&gt;10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terai, STW</td>
<td>&lt;187,000</td>
<td>&lt;2,560</td>
<td>None</td>
<td></td>
<td>Assume all rain-fed converted to irrigated</td>
</tr>
<tr>
<td>Hills and mountains, existing</td>
<td>&lt;110,000</td>
<td>&lt;1,500</td>
<td>&gt;10</td>
<td>&gt;25%</td>
<td>Increase in high-value crop production needed</td>
</tr>
<tr>
<td>Hills and mountains, new</td>
<td>110,000–145,000</td>
<td>1,500–2,000</td>
<td>&gt;15</td>
<td>up to 50%</td>
<td>Increase in high-value crop production needed</td>
</tr>
</tbody>
</table>

NRs = Nepalese rupees, STW = shallow tube well.

Vegetables and other high-value crops.

Table 3: Cost per Hectare Guidelines