

# **COST EFFECTIVE IRRIGATION MODERNIZATION: NEPAL'S EXPERIENCES**

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## **ABSTRACT**

With rising cropping intensity and more and more adaptation of high yielding varieties, the level of irrigation service demanded by farmers is on the rise. This coupled with greater fluctuations in supply sources due to issues like climate change has been making the task of the irrigation water supply providers even more difficult. In order to meet this rising demand of service level, it is essential to have appropriate infrastructure and matching technology which needs to be established in the case of new schemes and continuously maintained and upgraded in the case of existing irrigation schemes. While new technologies are being developed to meet these requirements the other key challenge lies in making it efficient and cost effective.

This paper gives an overview of the context of Nepal and explains the need of making investments in irrigation more cost-effective. It mentions about the exercises that were carried out in large irrigation schemes using the approach and tool developed by the Food and Agriculture Organization on the United Nations (FAO) and discusses how the country was able to identify the needs and plan and implement the irrigation modernization works in a cost-effective way and produce optimum results using the limited available resources.

## **INTRODUCTION**

Nepal is a landlocked South Asian country located between India and China with a total area of 141,181 sq. km. Its resource base for agriculture is severely limited by topographical constraints. The terrain consists of 'Terai' (plain land) in the south, central hilly region and rugged Himalayas in the north with elevations extremes from 70m to 8,850m. Total arable land is about 2.64 million ha (16% of the country) with permanent crops on less than 1% (see Figure 1).

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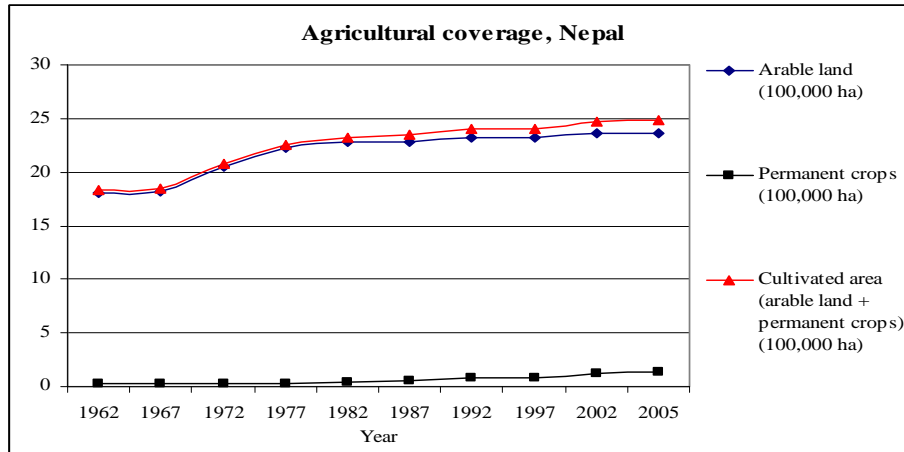


Figure 1. Agricultural Coverage and its Trend, Nepal (Source: FAO Database, 2009)

The country's population is approximately 28 million of which one-third lives below the poverty line. Agriculture provides livelihood for three-fourths of the population and accounts for about 33% of gross domestic product (GDP). Figure 2 shows the trend of increasing population and dependency on agriculture.

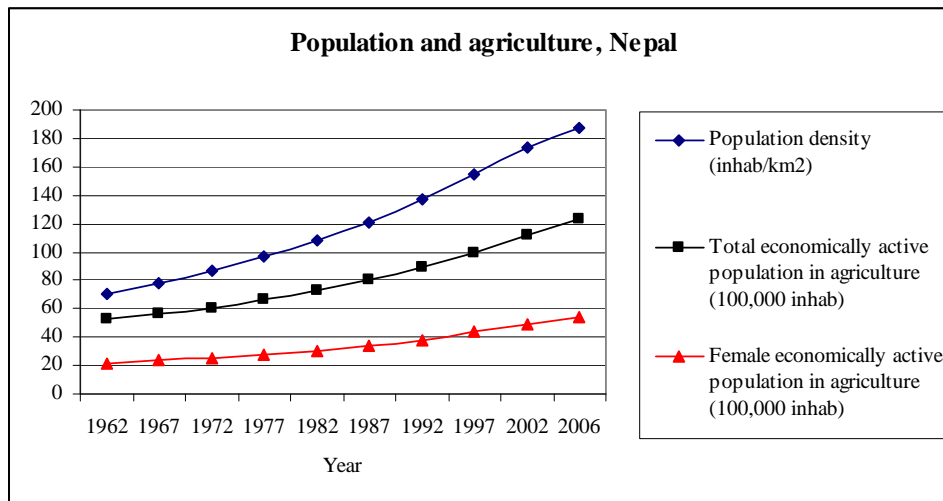


Figure 2. Population and Agriculture, Nepal (Source: FAO Database, 2009)

Agricultural practice is highly dependent on rainfall due to inadequate irrigation infrastructure or facilities. This dependency on rainfall, awaiting monsoon, significantly influences the sowing and harvesting time. Irrigated land makes about 1,170,000 ha and total annual renewable water resource is about 210 cubic km. The majority (96%) of the total fresh water withdrawal (10.18 cu km/yr; 375 cu m/capita) goes to the agriculture sector.

The Government of Nepal, with and without the support of international donors, has made continuous efforts for the development of the irrigation sector of the country over the last five decades. Despite large investments in the sector, only 51% of arable land presently has irrigation facilities while the rest remains rainfed. Furthermore, only 40% of

the area having irrigation facilities gets year round irrigation while the remaining 60% receives only seasonal irrigation.

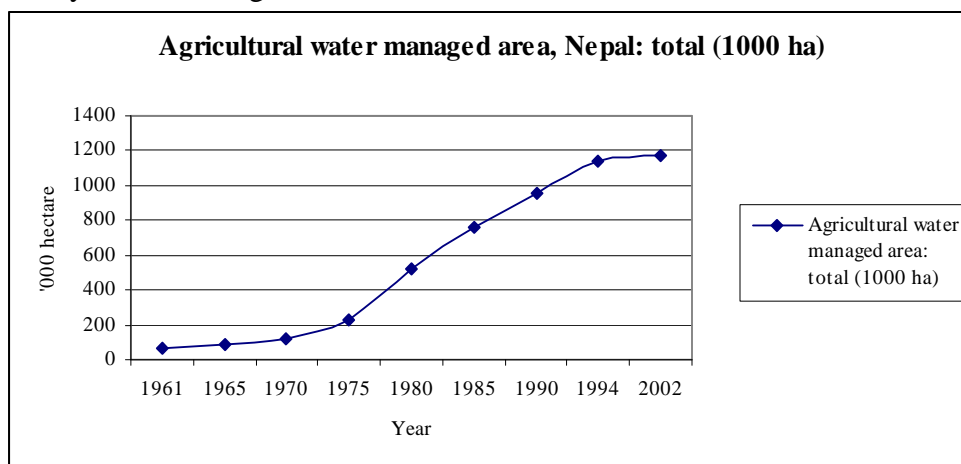


Figure 3. Agricultural Water Managed area, Nepal (Source: FAO Database, 2009)

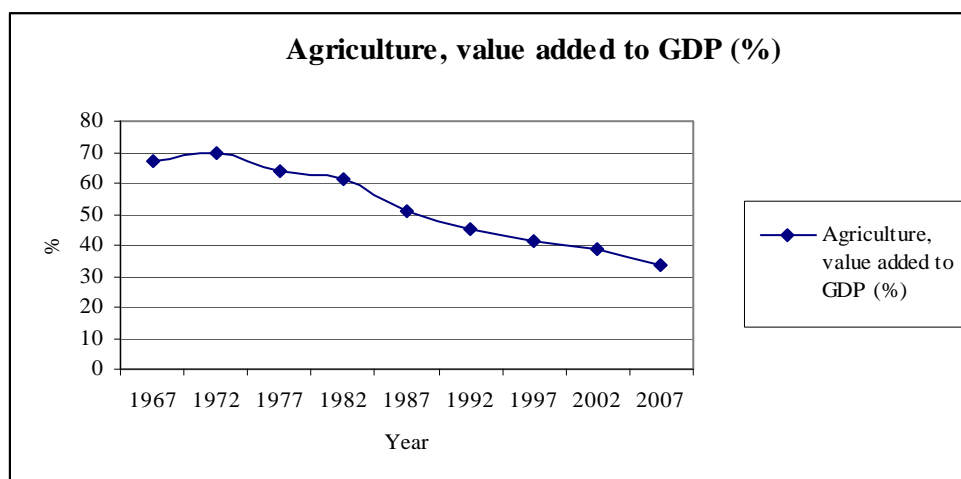


Figure 4. Agriculture, Value Added to GDP, Nepal (Source: FAO Database, 2009)

To sum up, it is evident from the above statistics that pressure on land resources (cropping intensity) is on the rise. Nepal has made notable gains in the extent of water managed area during the period from 1965 to 1995 owing to large investments made in the irrigation sector, but the relative contribution to the agriculture sector proved to be otherwise due to its continually declining share in the total economy as is evident from Figure 4 above. Hence, the country presently faces a stiff challenge of making the agriculture /irrigation sector more efficient.

### HISTORICAL PREVIEW OF IRRIGATION DEVELOPMENT IN NEPAL

Nepal has a strong history of traditional canal systems that were built by farmers since time immemorial and are still serving almost half the total irrigated area in the country. These systems were conceived and constructed mainly for supplemental irrigation by the local farmers themselves, based on their local knowledge, experience, and values. It was

done by mobilizing necessary resources at community level, without any technical input and financial support from the state or external donors.

Typically, they are run-of-the river gravity irrigation systems diverting water from a creek using some temporary brush-wood type diversions which get washed away with each flood and/or requires frequent maintenance. They were constructed of local materials such as wood, clay, stones, etc. The size of command areas varies from less than a hectare to a few thousand hectares. Water regulating structures, generally fewer than in modern irrigation systems, mostly have on and off type wooden planks. Operations are primarily based on proportional distribution system with very limited flow regulations, but closely follow the principles of equity, which fostered the collective and self-sustaining enterprise of collective management.

These systems divert much more water than the crop water requirements to make up for the extensive leakage and seepage along the water distribution secondary and tertiary canal networks and poor drainage structures. Local drains frequently interfere with canal water flows. On-farm water management structures are virtually non-existent and flood and furrow irrigation are common methods of water application at the farm level.

Local and collective resource mobilization practices by the local farmers through self-governed water users associations in the form of labor and kind have been crucial and exemplary for long sustained operation and maintenance of such irrigation systems both in the hills and Terai (Pradhan, 1989; Prasad et al, 1998). Performance of such irrigation systems in terms of their agricultural productivity levels have often been reported to be superior to the same in the irrigation systems constructed and managed by the government (agency) (ibid). The over acquisition and distribution of water, initially considered as a waste, has later been observed by irrigation experts to be often re-used by the downstream farmers and other water users.

In the 17th century, the state started extending support to irrigation development and the construction of a few irrigation facilities was financed and carried out by the state, e.g. Raj Kulos (King's Canals). The first major effort of the government towards irrigation development was made in 1920 with an agreement between Nepal and (the then British) India over the sharing of Sharda (Mahakali) River water for irrigation and power. The first modern canal irrigation system in the country the Chandra Canal in the eastern Terai with command area of 10,000 hectares, was constructed during 1922-28 with the assistance of Indian engineers. During 1928-51, a few more canal irrigation systems were constructed by the then Public Works Department (PWD): Jagadishpur in 1942 (1,000 ha) (renamed as Banganga in 1978 after expansion) and Juddha Canal in 1946 (2,000 ha) (renamed as Manushmara in 1976 after extension).

Later, after the formation of the then Canal Division in 1951 (now, the Department of Irrigation -DoI) the government of Nepal embarked upon full-fledged planned development of irrigation, specifically from 1957. DoI still remains, the principal government institution responsible for the planning, development and management of irrigation schemes in the country (DoI, 2008). International agreements with India on the

use of the Koshi River water in April 1954 and on the Gandak (Narayani) River water in December 1959, initiated the construction of large-scale irrigation systems in the Terai. However, until the early 1960s, the country lacked adequate technical manpower and financial resources to implement large scale irrigation works and only a few medium-sized irrigation systems were constructed during the first five-year development plan period (1957-62).

Minor Irrigation Program was introduced in the second three-year development plan (1962-65) to provide low-cost irrigation facilities to farmers within a short period of time. The program included the construction of small wells, tanks, pumps and other low-cost and short duration irrigation implements. Although it was planned to provide irrigation facilities to 4,455 hectares by the end of the Plan period, the actual achievement was insignificant. The Third Plan Period (1966-70) also saw a countrywide implementation of the Minor Irrigation Program with the emphasis on participation of the beneficiaries, but the program was not very successful because of lack of awareness among the beneficiaries.

From the early 1970s, the government became more active in the construction and management of new irrigation schemes. Investment in large irrigation development in the Terai increased tremendously. This was mainly due to the increase of international capital in the form of loans and grants for the country's overall economic development. This is also reflected by the surge in irrigation development targets in the subsequent five-year development plans- from the Fourth Plan (1970-75) onwards.

Until the middle of the 1980s, irrigation development by the government remained focused on the construction of physical infrastructure and very little attention was given to the management of the completed systems. Farmers and other beneficiaries were generally at the receiving end with a passive role. Improved irrigation service to the farmers, who still were expected to pay for the irrigation water to the state, did not receive any attention. The service fee assessments were based on the gross area covered with no reference to service delivery criteria and conditions. Consequently, service fee collections remained at a meager level; hardly enough to cover even the regular operation and maintenance costs (Prasad et al, 1998). Justifying agriculture as a priority and populist sector, the technocrats of state agencies gave continuity to this unaccountability by continuing allocation of operation and maintenance funds from the state's coffer with no connection to the level of service or associated fee collections.

Improved management of government-operated irrigation systems caught attention from 1985 onwards ([www.doi.gov.np](http://www.doi.gov.np)). This is reflected in the implementation a command area development project in the mid 1980s and a number of other management-oriented projects during the period 1985-89: the USAID-funded Irrigation Management Project (IMP) in 1985, the Irrigation Line of Credit (ILC) in 1988 financed by the World Bank, the Irrigation Sector Project (ISP) in 1988 financed by the Asian Development Bank (ADB), and the Irrigation Sector Support Project (ISSP) in 1989 under the co-financing of the UNDP, the World Bank and ADB.

Most management oriented projects were pushed by the external donors during 1985-1989. This was immediately followed by the promulgation of relevant acts and regulations that reinforced greater collaboration with irrigators in all phases of irrigation projects. The strategy of increasing farmer participation was mainly based on the recognition that government resources alone were inadequate to meet the country's irrigation development objectives and sustain the management of government-built irrigation systems after their completion. The government aimed to expedite the pace of irrigation development and devolve maximum responsibility in the operation and maintenance of completed irrigation systems over to the farmers.

Participatory approaches and management transfer reforms were promoted and implemented as part of the solution for cost-effective and sustainable irrigation services. Eleven medium to large agency managed systems have been partially or fully turned over to the water users through the Irrigation Management Transfer Project (IMTP). However, mixed results were obtained. Some of the findings have been: i) water users of large schemes currently face the challenge of resource mobilization and severe financial constraints, and ii) users are not up to the task when it comes to technical decisions of operation and maintenance and again turn to the government for assistance.

### INTRODUCTION OF MASSCOTE IN NEPAL

MASSCOTE (MApping System and Services for Canal Operation Techniques) was introduced in Nepal with the idea of evaluating the performances of some of the agency-managed irrigation systems and developing appropriate plans for modernizing them. It was first carried out in Sunsari Morang Irrigation System (SMIS) in May 2003 and later in Narayani Irrigation System (NIS) in November 2003.

MASSCOTE is a methodology developed by FAO on the basis of its own experience on modernization programs in Asia between 1998 and 2008. It aggregates all the pieces into a consistent framework, complementing tools such as Rapid Appraisal Process (RAP) and Benchmarking<sup>2</sup>, to allow a complete sequence of diagnosis of external and internal indicators of performance and practical solutions for an improved management and operation of the system.

MASSCOTE aims at organizing the project development into a stepwise revolving frame including:

- mapping system characteristics, water context and all factors influencing management
- delineating manageable sub-units
- defining strategy for service and operation for each units
- aggregating and consolidating canal operation strategy at the main system level

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<sup>2</sup> Rapid Appraisal Process (RAP) is a tool developed by Irrigation Training and Research Center (ITRC) of California Polytechnic State University to quickly assess irrigation system performance while Benchmarking is a similar tool developed through the initiative of the World Bank.

MASSCOTE is an iterative process based on 10 successive steps. Some steps need to be re-discussed and refined several times before reaching consistency. The ten steps are as follows:

<b><i>1. INITIAL ASSESSMENT</i></b>	
<b>1. Rapid Diagnosis</b>	Initial rapid diagnosis and assessment through RAP or others. Objectives: <ol style="list-style-type: none"> <li>i. to get an initial sense of what and where the problems are, how they should be prioritized, etc.;</li> <li>ii. to start mobilizing the energy of the actors (managers and users) for modernization;</li> <li>iii. to generate a baseline assessment, against which progress will have to be measured.</li> </ol>
<b><i>2. MAPPING THE SYSTEM CHARACTERISTICS</i></b>	
<b>2. System Capacity and Sensitivity Mapping</b>	<ol style="list-style-type: none"> <li>a) Assessment of the physical capacity of irrigation structures to perform their function of transport, control, measurement, etc.</li> <li>b) Assessment of sensitivity of irrigation structures (offtakes and regulators) and identification of singular points.</li> <li>c) Mapping the sensitivity.</li> </ol>
<b>3. Perturbation Analysis</b>	Perturbations analysis: causes, magnitudes, frequency and options for coping with it.
<b>4. Mapping Water Networks and Water Accounting</b>	<ol style="list-style-type: none"> <li>a) Assessment of hierarchical structure and the main features of irrigation and drainage networks, on the basis of which partition of the system into sub-systems will be made.</li> <li>b) Water accounting exercise considering both surface and groundwater and mapping their opportunities and constraints</li> </ol>
<b><i>3. MAPPING THE SERVICE: COST OF OPERATION AND DEMAND PER SUB-COMMAND AREAS</i></b>	
<b>5. Mapping Service Options</b>	Mapping options for services to users: farmers, crops and other users.
<b>6. Mapping the Cost of Operation</b>	Mapping the cost for current operation techniques and services, disaggregating the elements entering into the cost, costing options for various levels of services with current techniques and with improved techniques.
<b>7. Mapping the Demand for Canal Operation</b>	<ol style="list-style-type: none"> <li>a) Assessing means, opportunities and demand for canal operation.</li> <li>b) A spatial analysis of the entire command area, with preliminary identification of Sub-Command Areas (management, service, etc).</li> </ol>
<b><i>4. DESIGN SUB-UNITS FOR SERVICE &amp; OPERATION</i></b>	
<b>8. Partitioning in Management Units</b>	Division of irrigation system and the command area into SUB-UNITS [sub-systems and/or sub-command areas] which are homogeneous, and/or separate from one to the other with a singular point or a particular borderline.
<b>9. Canal Operation Improvements</b>	Identification of improvement options for each Management Unit for (i) Water control (ii) Water management and (iii) Canal operation (service and cost-effectiveness).
<b><i>5. AGGREGATING AND CONSOLIDATING</i></b>	
<b>10. Aggregating &amp; Consolidating Management</b>	<ol style="list-style-type: none"> <li>a) Aggregation of options at the system level, and consistency check.</li> <li>b) Consolidating and designing an overall cost-effective</li> </ol>

	Information System for supporting operation and Service Oriented Management (SOM).
<b>A Plan for Modernization and Monitoring &amp; Evaluation</b>	<ul style="list-style-type: none"> <li>a) Modernization strategy and progressive capacity development</li> <li>b) Select/choose/decide/phasing the options for improvements</li> <li>c) Plan for monitoring and evaluation of the project inputs and outcomes.</li> </ul>

MASSCOTE exercises were carried out in SMIP and NIS through which quantified performances in terms of water delivery service at each canal level were determined. Through field rating and analysis, major constraints of both these systems were identified.

### ANALYSIS OF IRRIGATION COSTS AND SERVICES

Another important part of the MASSCOTE exercise in the two systems was the analysis of their irrigation cost and services. Analysis of cost of operation not only revealed the cost-effectiveness of current operation and identified how it is affected by changes in the different inputs (water, staff, energy, office, communication and transportation) but also provided a good basis for cost-effectiveness of the improvements.

The estimated annual O&M cost for most large projects in the Terai was more than 400 Nepalese Rupees per hectare (NRs.400/ha) (US\$1 = NRs72), with operation costs as shown in Table 1 (DoI, 1996):

Table 1. Breakdown of Operation Costs for the Level of Infrastructure in SMIS, Nepal

Component:	Operation Cost (NRs./ha)	% of total Cost of Operations
Headworks	35	10
Main Canal	50	15
Secondary & Sub-secondary Canals	120	35
Tertiary Canals & Water Courses	125	40
Total	260	100

At that time, the project operation for the SMIS consumed an annual maintenance budget of NRs. 770/ha (DOI, 2001). According to the then managers, the O&M cost in the SMIS should be NRs. 1,500/ha, with NRs. 500 for operation and NRs. 1,000 for maintenance. This amount would correspond to about 3.3 percent of the gross product in the command area for 2005. According to Pradhan *et al.* (1998), it would correspond to about 10 percent of the net income per hectare provided.

Part of the differences in the figures for O&M costs can be explained by inflation and by the increase in cropping intensity from one irrigated crop per year (rice) to more than two on average (the cropping intensity is currently 215 percent). With year-round irrigation,



the service is provided for a much longer period of time and the cost of O&M increases. Therefore, a figure of NRs. 1,500/year for irrigation was considered for O&M.

This figure was compared with the cost to individual farmers of pumping groundwater. The RAP estimated this cost at NRs. 2,000–3,000 per crop/season, meaning that two crops per year would cost NRs. 4,000–6,000 with this type of supply (even more expensive where the farmer has to rent the equipment). This O&M cost corresponded to the then service level, which in many regards is not able to satisfy demand in winter and spring. Responding to the users’ demand with more flexible service would demand an increment in inputs and consequently result in higher annual O&M cost.

Many farmers that have poor service from a canal, or none at all, had moved to groundwater pumping wherever it is accessible at a reasonable cost. Thus, they usually pay a high cost for an adequate, reliable and flexible service. The cost of pumping varied with the context. In Terai, Nepal, farmers spend NRs. 3,000 per season for rice. The average cost of energy for pumping groundwater to cultivate sugarcane in one hectare is about NRs. 15,100 which is much higher than the canal water fee of sugarcane in the project (see Figure 5). Therefore, it seems reasonable to consider the option of upgraded service from surface supply allowing two crops at about NRs.1,800/ha/yr (the increase being mainly due to operation). This cost was expected to be acceptable to users provided that the service really improves.

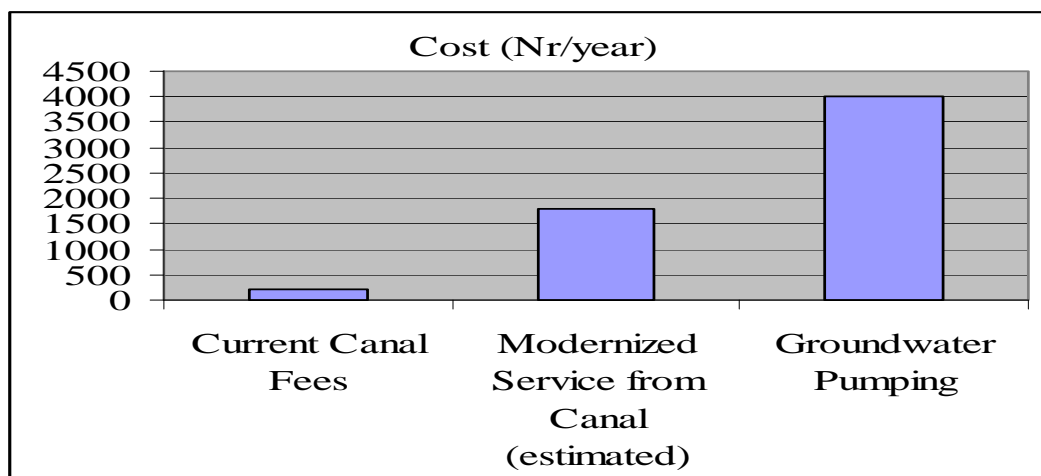


Figure 5. Comparison of Costs (Cost Analysis during MASSCOTE Exercise)

Cost analysis was also carried out for NIS. With reference to the irrigated area, the cost of operating the system is NRs. 233/ha. From the breakdown of the actual cost for different levels and items, a rough estimation of the service cost was determined for two options:

Option 1 aimed mainly at improving water management and deliveries along the main canal through tapping additional water from natural surface streams, an improved information system and better operation. This option did not target much improvement within the secondary CAs. The service (in terms of reliability and equity) to farmers would be only slightly improved. The main system level inputs would be increased

significantly to face these challenges while some new allocation would be made in order to develop the local management capacity in Block 13–15. Under this option, the cost of operating the system would be about NRs. 244/ha.

Option 2 targeted Option 1 plus significant improvements in the service delivery to farmers, which basically means two crops a year and improved reliability and equity. In order to realize this option, an increase in the staff capacity at main canal level and increase in many more inputs at the secondary canal level would be required. For this option, the cost of operating the system would be about NRs 360/ha.

### **CONSEQUENCES AND RESULTS OF MASSCOTE EXERCISE IN NEPAL**

The MASSCOTE exercises conducted in Nepal contributed both in terms of capacity building and in terms of real actions. A total of 80 irrigation related professional (27 during SMIP MASSCOTE, 24 during NIS MASSCOTTE and 29 during the summing up exercise conducted in April 2006) received exposure to the tool. The workshops were very useful in making the participants more analytical in their job assignment instead of the ‘business as usual approach’.

Its impact was also in the form of actions in the ground. Modernization plans with different options were developed through MASSCOTE exercises for both these systems. In the consequent years the operation and maintenances works in those systems were carried out very much along the lines of the recommendations of the MASSCOTE results. Due to fund constraints, even though modernization plan could not be fully executed as in SMIS, government made the funds available for NIS and option 1 recommendation of MASCOTTE was executed during 2006 and 2007. The level of service is reported to have significantly increased after the modernization works. Thus, the MASSCOTE exercise and the consequent modernization plans were very useful in providing a guideline for increasing cost-effectiveness of irrigation management in the two large irrigation systems in Nepal

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