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# DRINKING WATER COLLECTION AND COST-BENEFIT ANALYSIS OF A RURAL WATER SUPPLY SCHEME IN UTTARAKHAND STATE

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**ABSTRACT**

*In the State of Uttarakhand, availability of safe drinking water has been a serious problem. In order to tackle the problem, State government installed several rural water supply schemes in the past, but efforts could not yield desired results due to lack of community participation in operation and maintenance of these schemes. Few years back, State government with funding support from World Bank installed Rural Water Supply and Environmental Sanitation Projects with NGOs and community support. The idea was that with the installation of such projects, time used in water collection would be considerably saved which a rural household can utilise in economic activities to earn additional income. The total income, thus, earned would provide an economic advantage when such benefits exceeded the costs incurred in these projects.*

*The analysis in the paper focused on two issues. (i) The situational analysis of various dimensions of drinking water collection in the State. (ii) The cost-benefit analysis of a rural water supply scheme. The findings revealed that drinking water collection was arduous and a time-consuming activity for the rural households in the State. The economic benefits which resulted due to time savings from rural water supply scheme were higher than the investment made and rural water supply schemes of the Uttarakhand State provided a model of replicability in other hilly areas of the country.*

Availability of safe drinking water is one of the major problems in most of the rural areas of India. As a result, people in rural areas devote substantial part of their working hours in the arduous task of water collection. In order to minimise the scarcity of safe drinking water, state governments implemented large number of Rural Water Supply Schemes (RWSS). However, it is a known fact that most of these schemes became non-operational or functioning irregularly on account of non-participation of beneficiaries in their operation and maintenance. Therefore, the need was felt that a fresh strategy was to be evolved incorporating Government, community-based Non-Governmental Organisations (NGO's) and the community to support such water supply schemes to sustain for a longer period. The Government of Uttarakhand, with World Bank assistance, implemented such schemes in

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different districts of the State known as Rural Water Supply and Environmental Sanitation Projects (RWSESP). The core of the strategy was that water is to be treated like other commodities and benefits should exceed costs. The process involved a small Project Management Unit contracting large number of independent Non-Governmental Organisations to assist the communities in planning, implementation and maintenance of water supply schemes.

The paper examines, on the basis of primary data, the involvement of rural households in drinking water fetching by finding the time taken to collect safe drinking water, number of water collection trips undertaken and quantity of water collected. The quantification of time saving of households due to introduction of a Rural Water Supply Scheme was done. The cost-benefit analysis was attempted to ascertain the assumption that in case of a planned rural water supply scheme, estimated benefits are certainly higher than the costs incurred in terms of different types of investment made.

**Objectives**

The objectives of the paper are :

1. To estimate the time involved in collection of drinking water, number of trips undertaken for drinking water collection and the quantity of drinking water collected in rural hilly areas of Uttarakhand State.
2. To find out the time usage pattern of households for different activities and quantify it in value terms by finding out the local rural wage rate.
3. To estimate the possible savings in time after the introduction of a water supply scheme.
4. To estimate the benefits over the costs.
5. To draw conclusions and suggestions for wider replication of the model in other parts of the country.

**Methodology**

The above issues have been examined on the basis of primary data collected from 102 households, covering a population of 556 persons from 10 villages of two districts in Uttarakhand State. The districts of Almora and Pauri were randomly selected out of the districts where rural water supply schemes were proposed by the World Bank assisted Project Management Unit of the State. The villages and their households were also selected randomly. The financial viability has been analysed on the basis of costs and returns estimates provided by the Project Management Unit of the State. Data were collected through personal interviews from heads of households in ten sample villages which have been covered under drinking water supply schemes installed by the government. Results have been analysed in tabular form which presents number of trips per person and per household of different age groups involved in water collection. Quantity of water fetched per trip and time taken per trip have also been examined. In the analysis, data relating to number of sample households, average size of population and time use pattern of water collection have been analysed to calculate benefit-cost ratios. The details of sample design are shown in Table 1.

On the basis of above Table, it is evident that the sample consisted of 2 districts, 10 villages, 102 households and 556 population in Uttarakhand State.

**Table 1 : Sampling Design of the Study**

| Districts | Blocks | Villages | Households | Population |
|---|---|---|---|---|
| Almora | Bageshwar | 1. Nandigaon | 10 | 61 |
| | | 2. Karuli | 10 | 62 |
| | | 3. Chirang | 10 | 50 |
| | | 4. Anarsa | 10 | 52 |
| | | 5. Choura | 10 | 60 |
| Pauri | Pauri | 6. Thalli | 12 | 58 |
| | | 7. Rawat-ka Falna | 10 | 45 |
| | | 8. Pali | 10 | 53 |
| | | 9. Padul | 10 | 59 |
| | | 10. Sirauli | 10 | 56 |
| Total 2 | 2 | 10 | 102 | 556 |

*Households and Population :* Out of total 102 households, 6.86 per cent households were of scheduled castes, 1.96 per cent of backward castes and 91.18 per cent of upper castes. The average family size was 5.45 persons. The sex ratio was 100 males per 94 females. The ratio of males in total population was 52 per cent versus 48 per cent of females. The details are shown in Table 2.

**Table 2 : Population, Family Size and Sex Ratio**

| Particulars | Scheduled Castes | Backward Castes | Upper Castes | Total |
|---|---|---|---|---|
| No. of Households | 7 (6.86) | 2 (1.96) | 93 (91.18) | 102 (100.00) |
| Population : | 36 | 12 | 508 | 556 |
| Male | 22 | 5 | 263 | 290 |
| Female | 14 | 7 | 245 | 266 |
| Family Size | 5.14 | 5.5 | 5.47 | 5.45 |
| Sex Ratio | 64 | 120 | 94 | 94 |

Source : Primary data based.

*Occupational Characteristics :* The occupational characteristics of the sample population revealed that 74.23 per cent of total workers were dependent on agriculture for employment in the State. It became evident that the workers were employed in four occupational groups namely, agriculture, agricultural labour, household industry and services. Though agriculture was the most important activity followed by the services which provided employment to 23.60 per cent of total workers.

*Sources of Water :* The village community in the State depended upon four types of water sources. These were Dhara, Naula, tap and river. The average volume of water collected was found to be 118.6 litres from Dharas, followed by 74.44 litres, 29.59 litres and 8.55 litres from Naulas, taps and rivers, respectively. On an average, 30 litres of potable water was collected per household. The tap water supply was observed to be erratic, interrupted and undependable. The natural sources of water were found to be unprotected, exposed to various sanitational hazards to be unfit and unsafe. Table 3 shows source-wise water collected.

**Table 3 : Source-wise Volume of Water Collected**

| Water Source | No. of households | Volume collected | Percentage of water collected | Average per household |
|---|---|---|---|---|
| Dhara | 80 | 12097 | 51.30 | 118.60 |
| Naula | 38 | 7593 | 32.20 | 74.44 |
| Tap | 59 | 3018 | 12.80 | 29.59 |
| River | 43 | 872 | 3.70 | 8.55 |
| Total | 220 | 23580 | 100.00 | 231.18 |

Source : Primary data based.

*Source-wise Time Taken to Collect Water :* Average time taken to fetch water depends upon the speed of walking to the water source and the location of a water source. On an average, sample households required 30.18 minutes to reach water sources in each trip to get water from different sources. Time required to take water from tap worked out to be 7 minutes. Actual time taken to fetch water from each source was used to arrive at average time taken to fetch water. Since frequency of water fetching from each source varies, this has been used as weight. Actual number of trips to each source was added and percentage of trips to each source in total trips was drawn. Thus, source-wise time taken to fetch water is shown in Table 4.

**Table 4 : Source-wise Average Time Taken to Collect Water**

| Source | Actual Time | Weights | Weighted Values |
|---|---|---|---|
| Dhara | 35.15 | 0.27 | 9.49 |
| Naula | 38.40 | 0.30 | 11.52 |
| Tap | 7.00 | 0.28 | 1.96 |
| River | 48.03 | 0.15 | 7.21 |
| Average Time | 31.17 | 1.00 | 30.18 |

Source: Primary data based.

*Average Distance Between Households and Water Sources :* Average distance of households from the existing sources of water worked out to be 900 metres in case of Dhara, 950 metres in case of Naula, 310 metres and 2100 metres in case of tap and river, respectively as given in Table 5. It is evident that distance covered for water fetching was a time-consuming activity as people had to walk roughly a distance of 1 km. to get water which required more than half an hour in each trip.

**Table 5 : Average Distance of Water Sources from Households**

| Source | Distance (in Metres) |
|---|---|
| Dhara | 900 |
| Naula | 950 |
| Tap | 310 |
| River | 2100 |
| Average Distance | 1065 |

Source: Primary data based.

*Number of Trips Undertaken to Collect Water :* Average number of trips undertaken per day to collect water by all sample households worked out to be 4.89 (Table 6). Data showed that females made more trips per day to collect water as against males irrespective of their age-groups. The females in the age-group of 40-59 years made maximum number of trips, i.e. 6.21 trips which were three times more trips made by males in the same age group. Results also indicated that those involved in water fetching made at least more than two trips in a day. The number of trips increased to six which depended upon the age-group.

*Average Time Taken to Collect Water :* Table 7 explains average time taken by a male or female of different age groups on a trip to fetch water. On an average, a person had taken

**Table 6 : Number of Trips for Water Collection by Gender and Age-Group**

| Age-Group | Gender | Number of Trips |
|---|---|---|
| 10 - 15 | Male | 4.04 |
| | Female | 5.10 |
| 15 - 40 | Male | 3.21 |
| | Female | 5.91 |
| 40 - 59 | Male | 2.23 |
| | Female | 6.21 |
| 59 & Above | Male | 2.78 |
| | Female | 3.36 |
| Total | Male | 3.96 |
| | Female | 5.44 |
| Grand Total | | 4.89 |

Source: Primary data based.

30.18 minutes to fetch water. Data showed that average trip time of males and females in the age-group of 40-59 years was lowest, i.e. 23.07 minutes and 26.67 minutes, respectively. Maximum members of this age-

**Table 7 : Average Time Taken per Person to Collect Water by Gender and Age**

| Age Group | Gender | Time per person (Minute) |
|---|---|---|
| 10 - 15 | Male | 32.79 |
| | Female | 39.91 |
| 16 - 40 | Male | 27.94 |
| | Female | 30.49 |
| 41 - 59 | Male | 23.07 |
| | Female | 22.67 |
| 60 & Above | Male | 25.21 |
| | Female | 27.11 |
| Total | Male | 30.41 |
| | Female | 29.67 |
| Grand Total | | 30.18 |

Source: Primary data based.

group in both the sexes were also involved in water fetching. On the whole, average time taken per person to fetch water appeared to be quite high.

*Trip-wise Time Consumed in Water Collection :* Table 8 presents trip-wise average time taken in fetching water. It was observed that average distance covered to reach water sources was more than 1 km. As a result, time spent on a trip was quite long. It is reflected from the Table that on an average 30.18 minutes were needed for a trip to fetch water. Out of these, 30.18 minutes, 10.35 minutes and 12.25 minutes were needed for going and returning, respectively and remaining was the waiting time at the water source. Since availability of water from Dhara, Naula and tap was not enough, people had to wait and then collect water from these sources. As a result, average waiting time during water collection worked out to be 4.76 minutes.

**Table 8 : Average Time Consumed in Water Collection**

| Activity | Time (In Minutes) |
|---|---|
| Going | 10.35 |
| Waiting | 4.76 |
| Collecting | 2.82 |
| Returning | 12.25 |
| Total | 30.18 |

Source : Primary data based.

*Trip-wise Time Consumed in Allied Activities During Water Fetching :* People also go to water sources for washing clothes, fetching water for animals and for other requirements. They spent around 13.43 minutes on washing clothes and 6.28 minutes on fetching water for animals. Thus, 20.81 minutes were spent per trip on these activities. Table 9 showed trip-wise average time spent in allied activities during water fetching.

**Table 9 : Average Time Spent in Allied Activities during Water Fetching**

| Activity | Time (in Minutes) |
|---|---|
| Gossiping | 1.10 |
| Washing clothes | 13.43 |
| Water fetching and batching of animals | 6.28 |
| Total | 20.81 |

Source : Primary data based.

*Volume of Water Collected, Trips Taken and Water Collected per Trip :* Primary data relating to volume of water collected, number of trips undertaken and volume of water fetched per trip were processed to get an idea as to how much average volume of water was being collected and average number of trips were undertaken per household in the State. The average volume of water fetched per trip was also analysed. The analysis of data on these aspects is presented in Table 10.

The above Table revealed that on an average 231.18 litres of water was being collected per household. Average size of household was found to be 5.45 persons. When average volume of 231.18 litres of water collected per household was divided by average household size of 5.45 persons, we got per capita water consumption of 42.42 litres. Average number of trips taken per household was found to be 12 in the aggregate sample and 19.22 litres of water was being collected per trip. In this way, on an average less than one and a half buckets (each bucket of 15 litres) was being fetched per trip.

**Economic Viability of a Water Supply Scheme**

People in the hilly State of Uttarakhand collected water mostly from natural sources. Government also implemented water supply schemes for some villages. However, due to lack of proper maintenance, most of these

**Table 10 : Average Volume of Water Collected, Trips Taken per Household and Water Collected per Trip**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1. | Average volume of water per household | = | Total volume of water collected (Litres) | = | 23580 | = | 231.18 |
| | | | Number of households | | 102 | | Litres |
| 2. | Average number of trips per household | = | Total number of trips / Total number of households | = | 1227 / 102 | = | 12 Trips |
| 3. | Average volume of water fetched per trip | = | Total volume of water collected (Litres) | = | 23580 | = | 19.22 |
| | | | Total number of trips | | 1227 | | Litres |

Source : Based on primary data.

schemes remain non-functional for many months in a year. Overall water supply situation, therefore, needed to be modified as the earlier analysis of total volume of water collected per household indicated that the present level of average volume of water fetched per household was lower than the prescribed standard of water consumption. The Project Management Unit (PMU), with external funding, intended to install Water Supply Schemes (WSS) in the State in collaboration with the community and the Support Organisations (SOs). If such types of water supply schemes are installed and successfully run, households will get sufficient quality of water and their time in the arduous task of water fetching would be considerably reduced. Hence, due to the installation of PMU-Community and Support Organisations-managed water supply schemes, people will get their precious time saved which they may utilise for productive activities. Hence, implementation of these schemes may bring considerably economic benefits to the served population. But the accrual of such benefits involves substantial investment too. Investment may be viable only if the benefits derived out of it exceeded costs and when benefit-cost ratio works out to be more than one. Therefore, to know whether investment in the proposed water supply schemes (WSS) would be viable or not becomes a paramount issue in view of the substantial investment involved in the construction, operation and maintenance of these schemes. There are several measures which serve as an investment index to indicate the viability of a project. The profitability too, may be viewed from different angles. In case of investment to be made in the proposed water supply schemes, profitability has been calculated from the beneficiary's point of view. Broadly, the profitability may be classified into commercial/financial profitability and social profitability. The former is also called private profitability. The objective of this exercise is to ascertain the viability of a proposed water supply scheme by taking into account benefits that may accrue to users of the scheme as a result of proper utilisation of time involved in water collection.

**Time Saving Benefits**

Analysis in this paper is based on a sample of 102 households selected from ten villages. Average size of households worked out to be 5.45 persons. Average time taken in

collecting water per trip was calculated in case of sample households which worked out to 30.18 minutes in going, waiting, collecting and returning. This entire time will be minimised considerably when sufficient water would be made available by the water supply scheme. However, all the beneficiaries will not be using water supply scheme uniformly. It was suggested by the Project Management Unit (PMU) that 30 per cent of total beneficiaries would have private tap connections while remaining 70 per cent will depend upon public connections and would not have to spend much time in going, waiting and returning. Water collection time of a bucket of both types of households would also be reduced, because of high water pressure a bucket will be filled in 55 seconds as observed during field survey. The 70 per cent households would spend lesser time in going and waiting as public tap-stands would be installed at an average distance of 200 meters which would be far lower than the present average distance of 1065 meters of households from all available water sources. The future waiting time would also be lesser as compared to the present time required in waiting as the size of the queue would be smaller because 30 per cent households who were part of the queue earlier would be using their own private taps. In this way, average time consumed in collecting water per trip has been estimated to be 6.47 minutes in future.

Average time taken per trip at present which is referred as time before (T1) was 30.18 minutes and average time taken per trip in future which is referred as time after (T2) was estimated to be 6.47 minutes. Average volume of water collected per household before was 231.18 litres. Average volume of collected water per trip before (V) was 19.22 litres or 1.28 buckets (15 litres of one bucket) and the number of trips taken per household before (N1) was 12. After giving weights to the 'after' water consumption @40 lpcd for 70 per cent population using public tap stands and 70 lpcd for 30 per cent population using private connections, the number of trips 'after' (N2) were calculated. The number of such trips would be after (N2) i.e. (Y *50/V) = 15 trips. Where N2 was the number of trips after, Y was the average size of household (5.45 persons), 50 lpcd was weighted per capita water consumption and V was the average volume of water collected per trip before.

Thus, the resultant time savings per household (TSHH) are calculated as :

$$TSSH = \{(N2 * T2 - N1 * T1) / 60\} = 4.43 \text{ hours}$$

The total time savings (TSVL) in the sample is :

$$TSVL = \{(TSHH * \text{Number of Households})\} = 452.22 \text{ hours}$$

**Benefit Estimate**

Total benefits in value terms can simply be calculated by multiplying total time savings in the sample by the prevalent average wage rate in sample villages. However, it is impossible that the total time savings in the sample that would result on account of proposed water supply scheme will be used totally for work purpose. It is natural that some of the time saved by the households may be used in household activities or leisure. Frank Michel has used in his analysis that 52 per cent of the total time saved in water fetching will be utilised for different work purposes. Hence, we have also adopted the same 52 per cent of total time saved to be used in working. The average wage rate of ₹ 47 per day in the sample which has been arrived at from the sample data was divided by the 8 hours and multiplied by the 52 per cent of the total time saved. The resultant figures provided ₹ 3.03 which was the value of time savings per hour (VLTS). The value of time saved per day in the sample was = VLTS * TSVL, which came to

₹ 1368. This value of time saved per day in the sample has been multiplied by the 365 days to arrive at the value of time saved per year in the sample which worked out to ₹ 49, 9,412. According to the results of our sample data, 25 per cent of whole day time was devoted for work, 35 per cent of total time was devoted for household activities and 40 per cent of total time was given to leisure activities. According to these figures, 53 per cent of total time saved was utilised and BC ratio worked out to be 2.06 (net benefit) and 2.24 (net benefit hardware only). Detailed results are presented in Table 11.

**Table 11 : Outcome of Short Term Economic Criteria Study**

**Calculation of BC Ratio**

| Total population in sample | Total households in sample | Average persons per household (y) |
|---|---|---|
| 556 | 102 | 5.45 |

**Average distances involved and time taken in collecting water per trip**

| | Distance (mtrs) | Time (In Minutes) | | | | |
|---|---|---|---|---|---|---|
| | | Going | Waiting | Collecting | Returning | Total |
| Present | 1065 | 10.35 | 4.76 | 2.82 | 12.25 | 30.18 |
| Future | | | | | | |
| Public | 200 | 1.94 | 3.33 | 1.17 | 2.30 | 8.74 |
| Pvt. Conn. | 0 | 0.00 | 0.00 | 1.17 | 0.00 | 1.17 |
| Average | 140 | 1.36 | 2.33 | 1.17 | 1.61 | 6.47 |

Average time taken per trip before (T1) 30.18 Min

Average time taken per trip after (T2) 6.47 Min

Consumption levels

| Avg. Vol. of water collected per household before | Average volume fetched per trip before (v) | Number of trips taken per household before (N1) |
|---|---|---|
| 231.18 Litres | 19.22 Litres (1.28 buckets) | 12 |

**Weighted consumption 'after'**

| | |
|---|---|
| From public stand posts (@ 40 lpcd for 70 per cent population) | 28 lpcd |
| From private connections (@ 70 lpcd for 30 per cent population) | 21 lpcd |
| Total | 49 lpcd |
| Say | 50 lpcd |

**Explanatory Notes**

* These figures are based on a sample of 102 households in 10 villages of the Hill region.

* Present distances and time taken are based on the empirical data taken from the above sample. Collection at present is from more than one type of source.

* It has been assumed that in future no tapstand shall be more than 200 mts from any household. It has also been assumed that there will be 30 per cent private connections.

Formulae for future times taken are as follows

$$\text{Going/ returning time} = \frac{\text{(Actual time in going/ returning at present)} * 200}{\text{Actual distance covered at present}}$$

Waiting time = Actual time in waiting at present * 0.70

Collecting time = Time taken to fill 1.28 buckets from a tap

(A tap fills a bucket in 55 seconds).

* Avg.Vol. of water collected per household/ number of trips before are based on empirical data taken from above sample.

**Investment Costs**

Investment costs comprise hardware costs (HC), software costs (SC) and operation and maintenance costs (O&M). Hardware costs are to be incurred on pipes and plant and machinery etc. Software cost denotes the cost to be incurred on training and orientation programmes. It has been proposed by Project Management Unit (PMU) that the entire hardware costs would be incurred within three years from the initiation of the project. The PMU further suggested that no hardware costs are required in year-1 while 30 per cent and 70 per cent hardware costs would be spent in year-2 and year-3.The per capita software costs would be ₹ 267 in year-1 which was the planning phase cost and ₹ 146 in year-2 which is the implementation and post-implementation cost. No software cost was required in third year. In case of hardware costs, it was not required in year-1 while it will be ₹ 590 in year-2 and ₹ 1378 in year-3. In this way, total per capita capital costs estimate at market price of a scheme for the same worked out to be ₹ 267 in year-1, ₹ 736 in year-2 and ₹1524 in year-3.The per capita capital costs have been multiplied by the sample population. The resultant figures were the cost of a scheme. These costs figures were ₹ 1,48,452 for hardware and ₹ 1,48,452 the total in year-1. In the year-2, ₹ 81,176 and ₹ 32,826 and ₹ 4, 09,438 were software, hardware and total costs of a scheme respectively. In the year-3, ₹ 7, 65,946 and ₹ 7,65,946 were the software and total costs, respectively (Table 12).

**Table12 : Outcome of Short-Term Economic Criteria Study**

| | |
|---|---|
| Number of trips after {N2} ie {y*50/v} | 15 |
| Time savings per household {TSHH={(N2*T2-N1*T1)/60}} | 4.43 (hrs) |
| Total time savings in the sample {TSVL={TSHH*Number of Households}} | 452.22 (hrs) |

**Benefit Estimates**

| Use of Time | Work | Housewok | Leisure | Total |
|---|---|---|---|---|
| (a) Percentage of Time by Use | 30% | 16% | 54% | 100% |
| (b) Valuation of Time in that Use (% of wage) | 100% | 50% | 25% | |
| (c) Weight to apply to wage rate (a)*(b) | 30% | 8% | 14% | 52% |
| (d) Wage Rate (R./day)= | | | | 47.00 |
| (e) Value of Time Savings per hour, {VLTS} | | (Rs./hour) (d)*(c)/8 hrs | | 3.03 |
| Value of time saved per day in the sample = {VLTS*TSVL} | | | | ₹ 1368 |
| Value of time saved per year in the sample = | | | | ₹ 499412 |

Per capita investments costs

| | Hardware | Software | O&M |
|---|---|---|---|
| Year 1 | 0 | 267 | 0 |
| Year 2 | 590 | 146 | 0 |
| Year 3 | 1378 | 0 | @3% of total Hardware costs |
| Total | 1968 | 413 | 59 |

**Capital cost estimate at market prices of a scheme for the sample (₹)**

| Per capita costs | Year 1 | Year 2 | Year 3 |
|---|---|---|---|
| Software | 267 | 146 | |
| Hardware | | 590 | 1378 |
| Total | 267 | 736 | 1378 |
| Cost of a scheme for the sample (per capita cost sample) population | | | |
| Software | 148452 | 81176 | |
| Hardware | | 328262 | 765946 |
| Total | 148452 | 409438 | 765946 |

* The number of trips after have been calculated on the basis of 'weighted consumption' after.

* Distribution of use and valuation of time has been assumed.

* These cost figures at market prices have been worked out from the project cost tables used by the Dec. 1995 Mission. The following assumptions have been made.

**Hardware**

- No hardware in year 1

- 30 per cent and 70 per cent costs in year 2 and 3, respectively.

**Software**

- Planning phase cost in year 1

- Implementation and post-implementation cost in year 2.

**O & M**

From year 3 onwards

**Benefit- Cost Flows**

Year-wise costs to be incurred on hardware, software and operation and maintenance of a water supply scheme for the sample are shown in Table 13.

It has been assumed that the population of sample would increase by 2 per cent annually. The values of the time saved per year in case of sample have also been depicted in the same table. The benefit-cost flows (₹) have been calculated year-wise up to 24 years as suggested by the PMU. The net benefits have been arrived at by deducting the total capital costs of a scheme from the value of time saved per year in the sample. It is evident from the values of the net benefits and the net benefits of hardware that the net gains would be negative in the first, second and third years after the implementation of the scheme as the beneficiaries would not get any time savings up to the three years which shall be the planning and implementation years. Since fourth year onwards, the net benefits and benefits on hardware would accrue and go on increasing up to 15 years, serving the population with the 2 per cent increase each year. The scheme would be unable to meet the requirements of the water of growing population after 15 years and hence benefits will stagnate. The value of benefit-cost ratio for the entire period works out to be 2 in case of net benefits and 2.18 in respect of net benefits of hardware only which implied that the scheme is economically viable to be implemented in the State. A discount rate of 11 per cent in the net present values has been given to take into account the impact of the inflation, changes in the interest rates and the risk factor. The basis of 11 per cent discount factor is also based on Frank Michel's estimation.

**Summary and Conclusions**

The State of Uttarakhand, which was part of the U.P. State earlier, is largely a mountainous region in the lap of Great Himalaya. In the State, availability of safe drinking water has been a serious problem because of larger availability and dependency on natural sources of water like Dhara, Naula and river for various water needs. But due to their natural open flows, water gets contaminated and becomes unsafe for human consumption. To make available the safe water to the people, State government had installed many water supply schemes in the past which could not be successful because of lack of community participation in thier operation and maintenance. Few years back, State government, with financial support from the World Bank, decided to install Water Supply and Sanitation Projects with the help of NGOs and community. The idea was that with the installation of such projects,

**Table 13 : Outcome of Short Term Economic Criteria Study**

(in ₹)

| Project Year | Costs | | | | Benefits | Net Benefits | Net Benefit Hardware only | Population Served |
|---|---|---|---|---|---|---|---|---|
| | Hardware | Software | O&M | Total | Time savings | | | |
| 1 | 2 | 3 | 4 | 5=(2+3+4) | 6 | 7=(6-5) | 8=(6-5-3) | 9 |
| 1 | 0 | 148452 | 0 | 148,452 | 0 | (148,452) | (148,452) | 0 |
| 2 | 328262 | 81176 | 0 | 409,438 | 0 | (409,438) | (409,438) | 0 |
| 3 | 765946 | | 32,826 | 798,772 | 499,412 | (299,360) | (266,533) | 578 |
| 4 | | | 32,826 | 32,826 | 509,400 | 476,574 | 509,400 | 590 |
| 5 | | | 32,826 | 32,826 | 519,588 | 486,762 | 519,588 | 602 |
| 6 | | | 32,826 | 32,826 | 529,980 | 497,154 | 529,980 | 614 |
| 7 | | | 32,826 | 32,826 | 540,580 | 507,754 | 540,580 | 626 |
| 8 | | | 32,826 | 32,826 | 551,391 | 518,565 | 551,391 | 639 |
| 9 | | | 32,826 | 32,826 | 562,419 | 529,593 | 562,419 | 651 |
| 10 | | | 32,826 | 32,826 | 573,668 | 540,841 | 573,668 | 664 |
| 11 | | | 32,826 | 32,826 | 585,141 | 522,315 | 585,141 | 678 |
| 12 | | | 32,826 | 32,826 | 596,844 | 564,018 | 596,844 | 691 |
| 13 | | | 32,826 | 32,826 | 608,781 | 575,954 | 608,781 | 705 |
| 14 | | | 32,826 | 32,826 | 620,956 | 588,130 | 620,956 | 719 |
| 15 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 16 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 17 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 18 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 19 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 20 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 21 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 22 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 23 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| 24 | | | 32,826 | 32,826 | 633,375 | 600,549 | 633,375 | 734 |
| NPV at Disc. Rate of | | | | | | | | |
| 0.11 | 826,478 | 199,625 | 217,822 | 1,243,925 | 3,736,411 | 2,492,486 | 2,710,308 | |
| | | | | | BC Ratio | 2.00 | 2.18 | |

* An annual increase of 2 per cent in population has been assumed.

substantial time of the people used in water fetching would be saved considerably which people can use in economic activities to earn additional income. Thus, the water supply projects would give time savings in water collection whose total returns would be higher than the costs to be incurred on the schemes for a longer time period of 15 years. The paper has examined these hypotheses to ascertain as to what extent the assumptions turn into reality. To study it, primary data were collected from the sample households relating to their size, water fetching practices, sources of water, quantity of water fetched by the households, time involved and time savings that would result due to easy and adequate availability of safe water from the new scheme. The average family size in State was found to be 5.45 persons. The village community was found to be dependent upon four types of water sources, namely, Dhara, tap, Naula and river. The most important water source was Dhara from which 51.30 per cent of total quantity of water was fetched by the sample households. Only 12.80 per cent of total water procurement was made by tap, which was the only source of potable water. The river has been reported to be the water source from which only 3.70 per cent of total water was obtained. The Naula was also one of the major natural water sources which provided 32.70 per cent of total water used by sample population. An average quantity of water collected per household per day was found to be 15.41 buckets in the sample. It worked out to around 42 litres per capita per day. For drinking water purpose, 11 litres per capita was the water volume fetched. The figure of 11 lpcd was calculated from average volume of water collected per household for different uses. The per household water use for drinking purpose was found to be 61.82 litres. When this figure was divided by the average household size of 4.45 persons, we got the 11 lpcd for drinking purpose. The sample households required 30.18 minutes to reach the water source in each trip. Average distance of sample households from the existing water sources worked out to be 10365 metres. Average distance of natural water sources like Dhara, Naula and River was found to be 1 km. and more. Average number of trips taken to fetch water per person by gender and age-group revealed that 5 trips per person engaged in water collection were undertaken. The average time taken per person to fetch water by gender and age-group showed that 30 minutes were required. On the whole, average volume of water collected per household worked out to be 231 litres. The average number of trips per household were 12 and the average volume of water collected per trip was estimated to be 19 litres.

Financial viability of the proposed water supply scheme was analysed for sample population. The value of the benefit-cost ratio worked out to be 2 in case of net-benefits and 2.18 in respect of net-benefits of hardware only which implied that the scheme was financially viable for implementation in the State of Uttarakhand. It also indicated that such type of water supply schemes have viable replicability in other parts of the country.

## References

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