Water Consumption Study

Nepal Water for Health (NEWAH)
Lohasal, Kathmandu
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1 Executive Summary

In May 2003 NEWAH began a *Water Consumption Study* to find out the water consumption of rural communities using gravity flow water supply schemes. Two NEWAH gravity flow projects were selected for the study, Neupanigaun and Bhadaure in Dhading district, completed in 2000 and 2002 respectively. Fifty water meters were installed on the reservoir tanks and tap stands in these communities and community members took regular meter readings for a 12 month period.

The study found average daily per capita water consumption over a twelve-month period to be 47 and 61 litres in Neupanigaun and Bhadaure respectively. In 13 of the 36 tap stands monitored (40%) average per capita water consumption was found to be in the range of 40 to 59 lpcd. Analysis of the relationship between the average distance of user households from tap stands and the average per capita daily water consumption indicates a pattern where consumption is greater at tap stands where households are located near to the tap stand. A general trend of slightly declining consumption was noted throughout the year reaching a low in January/February before rising again towards the end of the year. This is likely related to less consumption for bathing and washing in the colder months. In Bhadaure water consumption at tap stands used by Brahmins averaged 94 lpcd compared to 43 lpcd at tap stands used by Dalits. This significant variation is likely because the Dalits in the community leave their homes early in the morning to smash *gitis* on the Kahtmandu-Pokhara highway and only return in the evening and therefore do not consume much water in the community. The number of livestock owned by Brahmins is also more than in other households and Brahmins consume a lot of water in their religious practices.

A crude analysis of the revenue generated through water tariffs and the funds required to operate and maintain the schemes indicates that the schemes are not financially sustainable and that water tariffs should be increased by between 70-180%.

2 Introduction

2.1 Background

In hill areas in Nepal gravity flow schemes are the most commonly used technology. Agencies implementing these projects follow the WHO standard per capita daily consumption of 45 litres when designing schemes. When sources cannot be located near to communities with sufficient flow to provide 45 lpcd projects are not implemented. Ideally a source will provide in excess of this minimum flow so that communities can make use of the additional water supply in livelihood opportunities such as kitchen gardens and drip irrigation.

Many studies into the sustainability of gravity flow schemes, including NEWAH's Looking Back Study, show that during their lifespan projects face many challenges in to their sustainability, some of which communities themselves cannot resolve, often because of lack of financial resources. These studies show that many communities do not collect money for O&M on a regular basis and therefore maintenance funds are not available when major repairs are needed.

2.2 Objectives

1. To find out the water consumption of rural communities using gravity flow water supply schemes
2. To find out the seasonal variation of water consumption
3. To identify water consumption patterns by users from different castes
4. To identify the level of Unaccounted For Water (UFW) in a gravity flow system
5. To calculate a tariff structure to cover all operations and maintenance costs based on the amount of water used

2.3 Projects selected for study

Two NEWAH gravity flow projects were selected for the study, Bhadaure and Neupanigaun, completed in 2002 and 2000 respectively. Both projects are located in Dhading district and are easily accessible from Kathmandu facilitating regular supervision of the study. These projects were selected as they represent two distinct yet typical environments in rural Nepal. Neupanigaun is a typical rural village environment with a small gravity flow water supply scheme with11 tap stands. Bhadaure village is a rural center near to a market town, Naubise, with a large gravity flow water scheme with 30 tap stands.

Table 1: Details of projects selected for study

Project name	VDC and ward	District	Settlement type	Beneficiaries		Number of	
				People	HH	tap stands	RVTs
Bhadaure	Naubise – 2	Dhading	Settlement located next to a market town (Naubise)	1314	210	30	6
Neupanegaun	Pinda – 2	Dhading	Rural village, 30 mins walking from highway	363	63	11[1]	2

3 Methodology

3.1 Selection of water meters

Five flow meters were evaluated for use in the study. The advantages and disadvantages of the various meters are discussed below.

1. **Nepal Water Supply Corporation** - not available at time of study as the corporation was running out of stock.
2. **Kent Meters**, Kent Meters Ltd., Pondwicks Road, Luton - these meters were found to be very expensive.
3. **Neptune T- 10 Residential Meter** from Schlumberger, Albama - cost of a meter approximately NRs 18,000.
4. **Indian meters -** these meters are the most easily available ones in the market and the cost is in the range of NRs 1,000 to 1,500. The quality of data provided is not considered as good as that of the Chinese meters.
5. **Chinese Meters** - these meters are not as easily available as the Indian Meters however they are considered of better quality. The cost is around NRs 2,000 per unit. Some urban water supply systems in Nepal make use of these types of meters.

Based on cost and quality factors the study team decided to use the Chinese meters.

Picture 1: Water Meter used

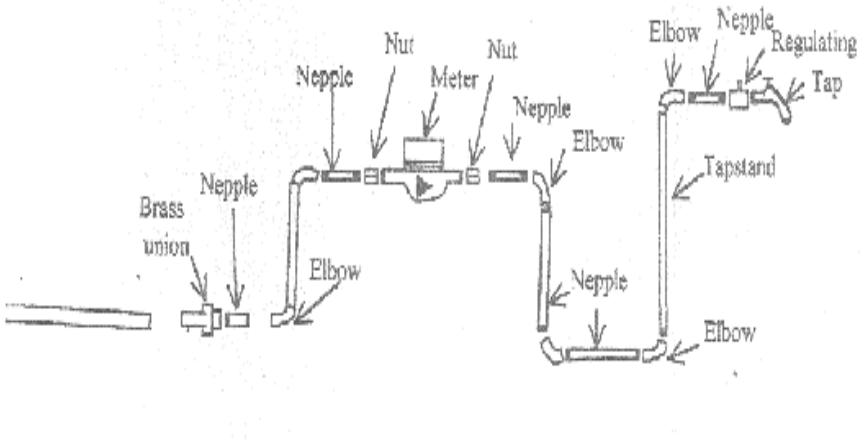
Picture 2: Location of Water Meter

[1] Meters were installed on 7 of the 11 water points in this project.

3.2 Meter fitting

The meters were installed at the back of each tap stand and reservoir tank. A total of **50** meters were installed in May 2003. A detailed drawing of the fittings used is shown below.

Figure 1 : Sketch of Meter Installation



3.3 Meter reading

NEWAH requested the Water and Sanitation User Committees in both projects to ask the maintenance caretaker or other reliable users, to take the responsibility of meter reading. The following people were appointed as meter readers.

Table 2: Meter Readers

Community	Meter Reader's Name	Position
Neupanigaun	Mr. Gokarna Neupane	WSUC Secretary
Bhadaure	Mr. Navaraj Dhakal	Maintenance Care-taker
Bhadaure	Miss. Indira Luitel	User
Bhadaure	Mr. Ishwor Rupakheti	User

Meter readers were paid NRs 1,500 per person per month. Readings were taken at the end of every day. Initially readings were taken at every water point and reservoir tank each day. After 2 months this was reduced to 5 times a month, including the first and last day of the month and once a week in between. Data collection was reduced as it was difficult to process the amount of data being collected, daily water consumption was not necessary for the analysis and meter readers were unable to take readings every day. Data was collected for a one year period from Jeth 2060 to Jeth 2061 (May 2003 to May 2004). The meter readers were instructed on how to read the meters and fill in the data forms.

3.4 Social data

Documents prepared during the detailed survey of the projects were used to provide information on the layout of the distribution systems and the number of beneficiaries. Additional information such as the number of livestock, the caste of users, the distance of households from the water point and details regarding the maintenance funds were collected by the project caretakers.

3.5 Study supervision

Field work was managed by Suriya Thapa, Senior Maintenance Social Technician of NEWAH Central Regional Office. NEWAH Engineering Section provided technical backup.

3.6 Data processing and analysis

Data was entered into Microsoft Access and exported to Excel for analysis. Data analysis was presented to the study team twice during the study. Based on this analysis changes were made to the data collection methodology and some additional data was sought.

3.7 Limitations of the study

The data recorded by the meter readers was not always accurate and complete. On some days data was not recorded, on some days the meter reading recorded was lower than on the previous day and often the digits written by the meter readers were hard to decipher. This made data processing difficult.

The meter readers doubted the quality of the meters and reported that at times the meters moved backwards. This raises some questions regarding the validity of the data.

Due to the large size of Bhadaure project, 30 taps and 6 reservoir tanks, the meter readers could not take readings at all meters at the same time. This meant that by the time some readings had been taken a large volume of water may have flowed through other meters. This resulted in problems with data analysis as discussed later in the report.

4 Findings

4.1 Water consumption by users

Table 3: Water consumption in Neupanigaun over a 12 month period

Tap Number	Reading on 01/02/2060	Reading on 31/01/2061	Total flow (litres)	Flow per day (litres)	Number of users	lpcd
2	46,760	785,993	739,232	2,025	31	65
4	117,706	1,571,865	1,454,160	3,984	118	34
5	42,360	920,022	877,662	2,405	35	69
7	52,098	622,681	570,583	1,563	40	39
8	45,235	584,226	538,990	1,477	32	46
9	92,142	979,674	887,532	2,432	37	66
Total			**5,068,158**	**13,885**	**293**	**47**

In Neupanigaun the average per capita consumption over the year is estimated at 47 lpcd and ranges from 34 lpcd at tap no. 4 (school tap) to 69 lpcd at tap no. 5.

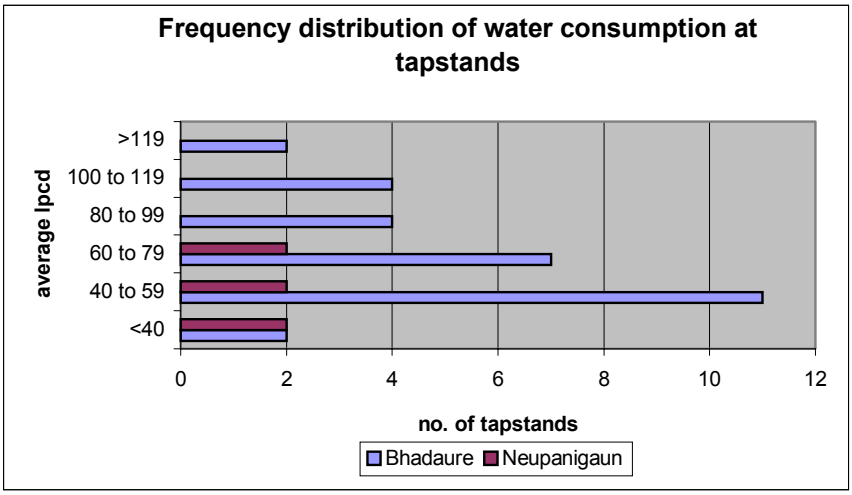
Table 4: Water consumption in Bhadaure over a 12 month period

Tap number	reading on 29/02/2060	reading on 28/02/2061	Total flow (litres)	Flow per day (litres)	No of users	Consumption (lpcd)
1	191,651	1,384,777	1,193,127	3,269	61	54
2	171,342	1,488,350	1,317,008	3,608	40	90
3	95,704	652,402	556,699	1,525	38	40
4	125,175	1,212,466	1,087,291	2,979	35	85
5	58,440	443,758	385,318	1,056	21	50
6	116,083	911,195	795,112	2,178	42	52
7	149,241	1,185,929	1,036,688	2,840	50	57
8	160,020	1,440,132	1,280,112	3,507	57	62
9	127,461	945,213	817,753	2,240	55	41
10	57,478	505,932	448,454	1,229	45	27
11	88,253	942,225	853,971	2,340	45	52
12	105,959	923,142	817,184	2,239	36	62
13	136,384	723,643	587,259	1,609	182	9
14	94,077	765,794	671,717	1,840	27	68
15	105,877	886,902	781,025	2,140	38	56
16	246,317	2,271,372	2,025,055	5,548	55	101
17	38,197	355,485	317,288	869	12	72
18	172,552	1,510,254	1,337,702	3,665	29	126
19	151,084	1,044,532	893,448	2,448	34	72
20	100,787	897,960	797,173	2,184	20	109
21	140,582	1,290,980	1,150,398	3,152	31	102
22	181,294	2,128,375	1,947,081	5,334	28	191
23	30,582	297,559	266,977	731	16	46
24	121,863	1,337,221	1,215,357	3,330	37	90
25	86,017	773,247	687,230	1,883	37	51
26	256,514	1,822,421	1,565,907	4,290	63	68
27	52,931	676,324	623,392	1,708	26	66
28	96,450	663,245	566,795	1,553	32	49
29	60,799	1,160,915	1,100,116	3,014	31	97
30	62,516	624,914	562,398	1,541	13	119
Total			**27,685,034**	**75,849**	**1,236**	**61**

Note - the data in the tables actually shows flow and not consumption. The assumption is that all water leaving the tap is consumed - i.e. tap is never left open and water not wasted.

Average water consumption in Bhadaure is 61 litres per capita per day. The lowest consumption is at tap no. 13 (school tap) where consumption is 9 lpcd. The tap stand used by households only with the lowest consumption is tap no. 3 with 40 lpcd. The tap with the highest consumption is tap no. 22 with 191 lpcd. This tap is located on the road, near to a shop and has no regulating valve. Consumption is higher in Bhadaure than Neupanigaun. This may be because Bhadaure is a semi urban community while Neupanigaun is a rural community.

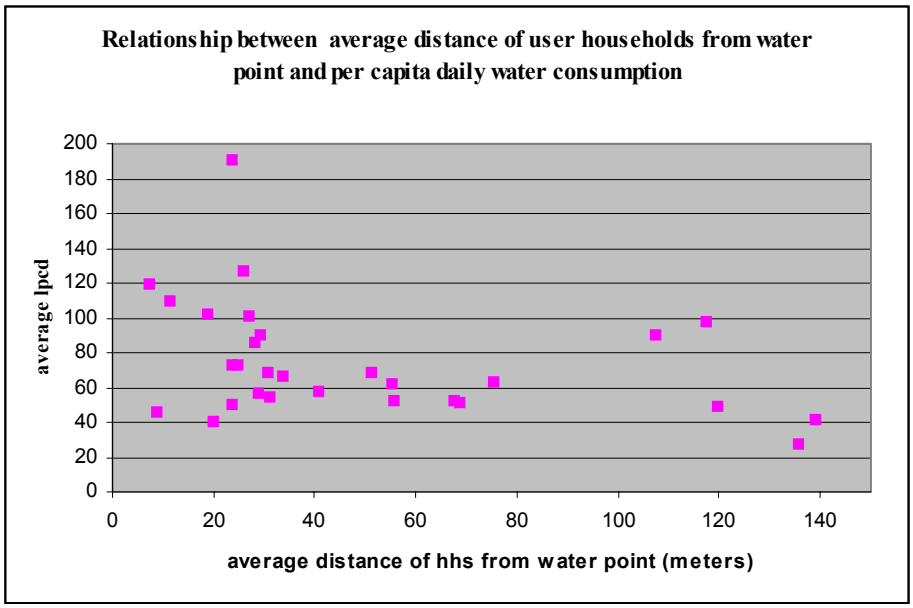
Fig 2: Frequency distribution of average water consumption at tap stands in Neupanigaun and Bhadaure



In 13 of the 36 tap stands monitored (40%) average per capita water consumption was found to be in the range of 40 to 59 lpcd.

4.2 Water consumption and distance from the water point

Fig 3: Relationship between average distance of user households from water point and per capita daily water consumption



The figure above presents the relationship between the average distance of user households from tap stands and the average per capita daily water consumption. A pattern emerges where consumption is greater at tap stands where households are located near to the tap stand and consumption is less where households are located further away from tap stands.

4.3 Reasons for greater or lesser water consumption on certain days

Meter readers noted the reasons for more or less water consumption on certain days. The reasons are presented below.

Table 5: Reasons for less/more water consumption

SN	Reasons for less consumption
Technical	
1	less flow from tap
2	tap closed
3	pipeline blocked/damaged
4	brass union damaged
5	no water in source
Climatic	
1	cold weather
2	winter
3	rainy day
4	foggy day
5	old tap repaired and now used
Social	
1	use of other sources
2	less consumers
3	less bathing on cold day
4	school closed
5	less people in house
6	decrease in cattle
7	people busy in farm work
8	someone died
9	only used for drinking
10	Dalits left village to work
11	one house migrated
12	farmers left village to work
13	people went to market
14	Saturday - no interest in cleaning
15	stream used for bathing
16	guests returned home
17	end of construction
18	women went to mother's house
19	people sick

SN	Reasons for less consumption

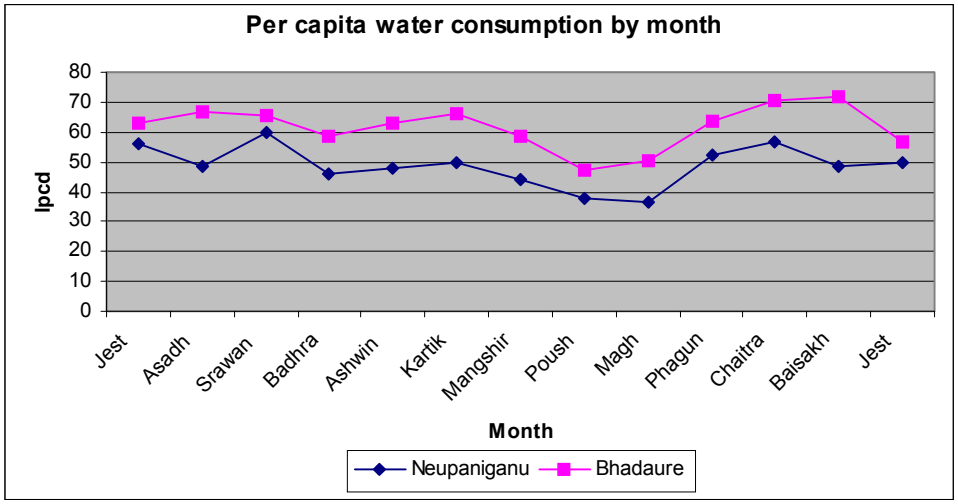
SN	Reasons for more consumption
Technical	
1	pipe connected to tap
2	tap leaking due to washer damage
3	no water in old tap
Social	
1	house cleaning
2	clothes washing
3	water used in kitchen garden
4	bathing
5	construction (school, house, Chautara)
6	Saturday
7	labourers staying in village for construction work
8	visitors/guests
9	population increase
10	more users due to bandh
11	party
12	house taking water from overflow
13	all people at home
14	more free time
15	no water last week
16	more cattle
17	tap left open at night
18	children playing with tap
19	water used in plantation
20	users from other tap use the tap
21	making alcohol
22	farmers working nearby
23	maize crop season
24	cattle watering
25	water misuse
26	school started
27	job holder returned home
28	rice planting
29	Janai Purnima bathing

SN	Reasons for more consumption
30	Monday prayers
31	Mahadev jatra
32	rice feeding ceremony
33	Bratabanda
34	Ahadasi
35	marriage ceremony
36	pooja
37	someone died
38	Sakranti/Teej/Dasshain/Krishna Asthami/Tihar
39	Nagapanchami
Climatic	
1	sunny day

Out of 29 reasons given for less consumption 19 (66%) are related to social causes and the other reasons are either technical or climatic. 43 different reasons were given for greater consumption of which 39 (91%) were social the remainder either technical or climatic.

4.4 Seasonal variation of water consumption

Fig 4: Per capita water consumption in Neupanigaun and Bhadaure by month



A general trend of slightly declining consumption was noted throughout the year reaching a low in Poush and Magh before rising again towards the end of the year. This is due to less use of water for bathing, livestock watering and irrigation in the cold winter months.

4.5 Water consumption patterns by different castes

Table 6: Water consumption by users of differents castes in Neuapanigaun

Tap number	Caste of majority of users	Consumption (lpcd)
4	Janajati/school	34
7	Dalit	39
8	Dalit	46
9	Brahmin/Dalit	48
2	Dalit	65
5	Dalit	69

In Neupanigaun the majority of users (81%) are Dalits. It is not possible to discern any difference in water consumption patterns between different castes.

In Bhadaure approximately one third of beneficiaries are Brahmin, one third are Chhetri and one tenth each are Dalit and Janajati. The caste of users is presented in the table below.

Table 7: Caste of beneficiaries in Bhadaure

Caste	Users	%
Dalit	106	9%
Janajati	132	11%
School	173	14%
Chhetri	378	31%
Brahmin	447	36%
Total	**1,236**	**100%**

Estimates of the water consumption by various castes were made by calculating the average per capita consumption at water points used by different castes. The results are presented in the table below.

Table 8: Average daily per capita water consumption by different castes of users

Users	Average Consumption (lpcd)
School	9
Dalit	43
Chhetri	56
Janajati	64
Chhetri&janajati	65
Janajati&Brahmin	73
Brahmin	94

The results indicate that Brahmins use significantly more water than all other castes - on average Brahmins use more than twice as mush water as Dalits. This is likely because Dalits in the community leave early in the morning to smash *gitis* on the Kahtmandu-Pokhara highway and only return in the evening and therefore do not consume much water in the community. The number of livestock owned by Brahmins is also likely to be more than in other households and Brahmins consume a lot of water in their religious activities.

4.6 Unaccounted For Water (UFW) in the gravity flow systems

Table 9: Neuepanigaun RVT versus Tap stand flow – Unaccounted for Water

		For period 1/2/2060 to 31/5/2060			
RVT number	**Taps supplied**	**RVT outflow**	**Tap outflow**	**UFW (litres)**	**UFW (%)**
1	2,4,5,6	1,778,548	1,488,170	290,378	16.3%
2	8,9	602,896	607,010	-4,114	-0.7%

During a 4 month period the meter on reservoir tank number 1 recorded a flow of 1,778,548 litres. This tank feeds taps no. 2, 4, 5 and 6 and the combined flow from these taps over the same period was 1,488,170 litres. This indicates that approximately 290,000 litres (16% of flow) left the tank but did not reach the taps, possibly due to leakage in the system, or that there was a significant gap between taking the readings at the tank and tap stands.

In the case of reservoir tank no. 2 the results are the opposite, indicating that approximately 4,000 litres more water flowed from the taps than left the tank, however at 0.7% of flow this is not significant.

Table 10: Bhadaure RVT versus Tap stand outflow – Unaccounted for Water

		For period 03/02/2060 to 31/01/2061			
RVT number	**Taps supplied**	**RVT outflow**	**Tap outflow**	**UFW (litres)**	**UFW (%)**
1	1,2,3,4,5	4,771,760	4,503,721	268,040	5.6%
2	6,7,8	3,064,762	3,065,064	-302	0.0%
4	14,15,16,24	4,616,662	4,686,623	-69,961	-1.5%
4a	17,18,19	2,541,101	2,542,645	-1,544	-0.1%
5	25,26,29	3,369,683	3,388,960	-19,277	-0.6%
5a	27,28	1,180,833	1,187,125	-6,291	-0.5%
6	20,21,22,23,30	4,454,880	4,630,447	-175,567	-3.9%
Total		**23,999,681**	**24,004,584**	**-4,903**	**0.0%**

***Note** – data for reservoir tank no. 3 feeding taps 9 to 13 not available.*

Overall there is little UFW in the full Bhadaure system. In 4 branches the UFW is insignificant (less than 1%), in 2 branches there is some negative UFW and in one branch water appears to be escaping from the system.

Positive UFW could be due to leaks in the system. However negative UFW i.e. more water flows from taps than tanks, can not be due to leaks. One explanation is that the meter reader first read the meter on the tank and by the time s/he reached the meter on the tap a certain volume of water had flowed past the tap meter, accounting for the difference. Likewise reading the tap meter before the tank meter could give the appearance of a leak.

4.7 Current status of maintenance funds

Table 11 : Current status of Bhadaure maintenance fund 2 years after project completion

	Income	Expenditure	Remark
Initial maintenance fund	12,000		
Tariff from users & interest	44,020		163 hh each paid NRs 15 per month for 24 months
Caretaker salary		33,600	NRs 1,400 per month for 24 months
Repairs and maintenance		2,673	potas, talcha, tools, washers, kerosene
Sub total	**56,020**	**36,273**	
Balance	**19,747**		

Two years after the end of the project there is NRs 19,747 in the maintenance fund in Bhadaure, a 65% increase since the end of the project. Each households pays NRs 15 per month. If all users had paid regularly NRs 59,000 would have been collected however only NRs 44,000 has been collected, a difference of 15,000, equivalent to 1,000 missed payments, around a quarter of payments. The fund is kept in the local bank and is used for paying the caretaker only and is not put to any other productive use.

Table 12 : Current status of Neupanegaon maintenance fund 3 years after project completion

	Income	Expenditure	Remark
Initial maintenance fund	7,000		
Tariff from users & Interest	40,833		63 hh each paid NRs 10 per month for 36 months
Caretaker salary		18,000	NRs 500 per month for 36 months
Repairs and maintenance		3,315	potas, talcha, tools, washers, kerosene
Sub total	**47,833**	**21,315**	
Balance	**26,518**		

In Neupanegaun, three years after the end of the project there is NRs 26,518 in the maintenance fund, an increase of around 3 times since the end of the project. Each household pays NRs 10 per month. If all users had made regular monthly payments, NRs 22,680 would have been raised however 40,833 had been collected, a difference of NRs 18,000.

4.8 Proposed tariff structure to cover all operations and maintenance costs based on the amount of water used

Table 13: Proposed tariff for Bhadaure to cover all maintenance costs

Tariff to cover all maintenance	Cubic meters	NRs
annual system flow	27,700.0	
annual amount needed to maintain system		50,000.0
estimated cost per cubic meter		1.8
average annual consumption per hh	170.0	
average annual tariff per hh to cover maintenance costs		306.9
current annual tariff per hh		180.0
increase required in tariff to cover maintenance costs		70%

Table 14: Proposed tariff for Neupanegaun to cover all maintenance costs

Tariff to cover all maintenance	Cubic meters	NRs
annual system flow	5,000.0	
annual amount needed to maintain system		20,000.0
estimated cost per cubic meter		4.0
average annual consumption per hh	86.0	
average annual tariff per hh to cover maintenance costs		344.0
current annual tariff per hh		120.0
increase required in tariff to cover maintenance costs		187%

On the assumption that NRs 50,000 is needed each year to maintain the Bhadaure system in perfect condition and using the average annual water flow, it is estimated that the price of water should be fixes at NRs 1.8 per cubic meter to cover full O&M. On average a household in Bhadaure was found to consume 170 cubic meters per year which mean that the average annual tariff required to cover O&M costs would be NRs 307 per year. This represents a 70% increase on the current tariff of NRs 180 per year. Making the same rough calculation for Neupanigaun it is estimated that the tariff would increase by 187% to NRs 344 per hh per year.

5. Conclusion

The insights gained through the study have provided NEWAH with evidence of water consumption patterns which can be used in designing future projects taking into consideration the occupation and caste of the users and the location of the community (peri-urban or rural community, warm of cold location).

Based on the analysis of maintenance funds it is evident that current tariffs will not cover the full costs of O&M that will arise during the life of the project. This will lead to poor sustainability if major repairs are required in the future.

Annex A Map showing study area
Annex B Data collection forms
Annex C Layouts of projects
Annex D People involved in the study

Name	Position
Gokarna Neupane	WSUC Secretary
Navaraj Dhakal	Maintenance Care-taker
Indira Luitel	User
Ishwor Rupakheti	User
Anil Pokhrel	Technical Division Head
Santosh Basnet	Engineering Section Head
Dipendra Shahi	Data Entry
Suriya Thapa	Senior Social Technician
James Wicken	Consultant