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Research Article

Assessing the Operation Management: A Case of Narayani Lift Irrigation System, Nepal

Ashish Ruwali[1], Rajib Ghimire[1], Sagar Nepal[1], Shasit Gautam[1], Subin KC[1], Sudip Dhakal[1], Sandeep Parajuli[2], AK Mishra[3]

[1]Students, [2]Assistant Professor, Department of Civil Engineering, Oxford College of Engineering and Management, Gaidakot-02, Nawalpur, Nepal.
[3]Associate Professor, Madan Bhandari Memorial Academy Nepal, Urlabari, Morang, Nepal.
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I N F O

Corresponding Author:
AK Mishra, Associate Professor, Madan Bhandari Memorial Academy Nepal, Urlabari, Morang, Nepal.
E-mail Id:
anjaymishra2000@gmail.com
Orcid Id:
http://orcid.org/0000-0003-2803-4918
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A B S T R A C T

Narayani Lift Irrigation System is one of the oldest lift irrigation systems in Nepal, constructed in 1982. The machines used are as old as the project and, some were maintained and are still in operation. The study focuses on the operation assessment of the Narayani Lift Irrigation System. Field visits with a checklist, a Questionnaire survey, Key informant interviews were the main methods of data collection. The data was analysed using the Relative Importance Index and descriptive statics.

The past performance of the system indicates irrigation coverage of only 4,700 Ha of the pump scheme that too with occasional supplements to the Khageri irrigation system in the event of scarcity. Dispute during the water distribution time was frequently observed and the role of NLIWUA was effective in dispute management.

The system operation changes were observed in the socio-economic and agricultural status of the users. An increase in the economic status by 45% is noted, 55.4 % of farmers have been motivated towards agriculture. A shift of farmers from rice plantations to cash crops is noted. The operational cost and maintenance cost of components of the pump house were allocated by Government. The budget allocated was sufficient only for the temporary maintenance, but the system needs proper rehabilitation. Sediment Management is the main problem of the system; hence improvement needs to be done.

Keywords: Disputes, Distribution, Availability, Sediment, Budget, WUA

Introduction

Narayani Lift Irrigation System (NLIS) is amongst those irrigation systems which provide irrigation to the upper terraces of the Narayani River of the Bharatpur Metropolitan City. This system was initially constructed in 1982 as Chitwan Valley Development Project (CVDP) by the Department of Irrigation, which included three irrigation schemes Panchakanya, Lothar and Narayani Lift. The Narayani Lift Irrigation Project (NLIP) was studied and designed by a German Consulting Firm "Agra and Hydro Technique GMBH" in 1972 to pump water from the Narayani river and irrigate 4,700 Ha of land. The project also supplemented the Khageri Irrigation System having a command area of 3,900 Ha. The project was commissioned

in 1982 and was operational as NLIS. The NLIS has two staged pumps and two canal systems: canal-B and canal-C. Pump-A lifts water from the river to the 20 m high link canal and can pump up to 17 m^3/s, while pump-B lifts water from the link canal to 18 m to canal-C and can pump up to 7.2 m^3/s. (Narayani Lift, 2021).

The link canal, which joins pump house-A and B is 500 m in length. The main canal B is separated into two branches just upstream of pump house-B. The pump house-B lifts water to canal C. The canal-B system irrigates 2,400 ha of land in the middle terrace through a 19.50 km long main canal and 9 branch canals. The canal-C system irrigates 2,300 ha of land on the upper terrace through a 16.50 km long main canal and 7 branch canals. The system was developed up to the command area level with tertiary canals to serve an irrigation block of about 100 ha. (MOE,2076).

The past performance of the system indicates irrigation coverage of only 4,700 ha of the pump scheme only with occasional supplements to the Khageri irrigation system in the event of scarcity. The system was broken down from 1992 to 1994, rehabilitation works were carried out for the pumps in "A" and resumed operation since then. The system is operating with difficulty as frequent breaks down of the electrical and mechanical parts occur. In addition, there are various deficiencies in the electro-mechanical equipment, also problems of sediment influx into the canal system. The system is hardly operational during the rainy season only for the paddy crops when the sediment content in the river water is high. The pumps are unable to operate during low flow in the winter and spring season. (Development, M. o. (2075/2076): Mishra, A. K., & Aithal, P. S., 2022)

Objective of the Study

The objective of the study is to analyse the Waters Users Management and operation mechanism of distribution of water in the Narayani lift irrigation system.

Literature Review

a little introduction about what this section talk about and then you can demonstrate the sub titles.

Climate and Agro-Ecology

Climatic condition recorded in the year 2020 in Chitwan (station- Rampur at 256m) district is shown in Table 1.

Topography, Land use, Drainage

The altitude of the Chitwan district varies from 144 m to 1947 m from the mean sea level (MSL). It has spread over 221800 acres of land. Out of total acres of land, (46894 -21.14%), (18822 -8.49%), (142422 - 64.21%) and (13652 - 6.16%) of land are occupied by agricultural, pasture, forest and others (steep land, river, cliff, road etc.) respectively. (Metrology, D. o. (2075): District Development Committee. (2072): Rijal, E., Khatri, E., & Kharel, E. (2018). The land use pattern is shown in Table 2.

Table 2.Land Use Pattern

S. No.	Physiographic Distribution of Land	Unit	Area	Percentage by Weightage of Total
	Total Area of the District	Ha	221800	100.00
	Cultivable Land	Ha	46894	21.14
	Cultivated Land	Ha	44291	19.97 94.45 (of cultivable land)
	Non Cultivated Land	Ha	2553	1.15 5.44 (of cultivable land)
	Grazing Land	Ha	18822	8.49
	Forest	Ha	142422	64.21
	Others (Land slide, River/ Drainage, high slope, Rock, Road, Settlement etc.)	Ha	13652	6.16

Source: District Profile DDC Chitwan 2010: Gajurel, K., & K.C., T. B. (2003).

Surface Water Resources

Major surface water resources are Narayani , Rapti, Lothar, Kayar Khola, Rigdi, Khageri, Reeu rivers, Satrahajar, Bishajar, Atthais Hajar, Muntha, Devi, Lami, Tamor Ghaila, Kasara, Nanda-Bhauju, Anjura, Manjura, Gaduwa, Anjana, Parsuram Kunda, Baikuntha Lakes.

Table 1.Climatic Condition

Year	Air Temperature °C			Absolute Extreme		Relative Humidity %		Precipitation mm		No. of Rainy Days
	Max	Min	Daily	Max / Month	Min / Month	Observed at (NST)		Total	Max in 24 hrs. / Month	1:00
						08:45	17:45			
2007	30.7	18.3	24.5	40/May	4.2/Jan	87	74	2743	155/Sept	112

Source: Department of Hydrology and Metrology

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Existing Irrigation Practices

Narayani, Rapti, Lothar, Kayar, Rigdi and Rieu rivers are the main existing sources of irrigation in the area. Big irrigation canals, deep tube wells, shallow tube wells, cooperative irrigation schemes, private water pumping and wells are the existing irrigation practice in the Chitwan district (Gajurel, K, & KC, TB. (2003).). According to the DDC Chitwan profile, 44291-acre land had been utilized for agriculture purposes in the Chitwan district. Out of a total, 29499-acre lands have irrigation facilities, out of which only 15885-acre land have irrigation facilities for the whole year and 14958-acre land have partial (seasonal) irrigation facilities. About 14448-acre land have no irrigation facility. (Mishra, A. K. (2022): Dahal AK, Mishra AK,& Aithal PS. (2022): Dahal AK, Mishra AK, & Aithal PS. (2022): Mishra AK, & Dahal AK (2022).

Irrigation from Lift System

According to the annual agriculture development and statistical book, only the Narayani lift irrigation system in the Chitwan district is the main working system. It has been serving about 4700 Ha land of Bharatpur Metropolitan city.

Irrigation from Other Sources

About 15885 Ha of land was irrigated from different types/ sources of perennial irrigation systems within the district. Out of that, from east Rapti, Khagari, Panchkanya, Pithuwa irrigation canal systems 7383 Ha; Deep tube wells 374 Ha; Sallow tube wells 1704 Ha, small irrigation schemes 5545 Ha, Co-operative irrigation schemes 606 Ha and others/ private pump sets/dug wells 273 Ha lands irrigated existed (Singh, M., Liebrand, J., & Joshi, D. (2014)): Acharya, M., Poudel, R., & Bhandari, B. (1993/94): APROSC, & JMA. (1995). The details of the irrigation system are presented below in Table 3.

Socio-Economic Situation

Social Overview

As per the population census, 2001, the total population of the district is 472084 attributing to 92863. The 2010's projection shows that the total number of households in the district is 119691. Out of the total population, the composition of males and females are 235084 and 304774 respectively with a sex ratio of 99. Acharya, M., Poudel, R., & Bhandari, B. (1993/94): Bhatta, K. P., Sharma, R., & Ishida, A. (2005): Pradhan, P. (2000). The average household size is 5.08. The density of the population is 213 km2 (2010 projection- 275). The details of project-related municipality and VDCs population are presented in Table 4.

Table 3.Details of Existing Irrigation System and it's Coverage

Project Name	Location	Command area (Ha)	Covered area
Kageri Irrigation System	Kalika Municipality, Ratnanagar Municipality Bharatpur Metropolitan city(West chitwan)	3900	5000
Narayani Lift Irrigation System	Bharatpur Metropolitan City	4700	4700
Panchakanya Irrigation System	Ratnanagar Municipality	600	1200
Ghangar Irrigation System	Madi Municipality	134	168
Khaire Khola Irrigation Project	Madi Municipality	35	45
Dehitar Irrigation Project	Rapti Municipality (Lothar)	25	30
Yangkrang Irrigation Project	Icchyakamana Rural Municipality	30	35
Chandra Khola Irrigation Project	Madi Municipality	45	65
Reoi Bagai Irrigation Project	Madi Municipality	110	185
Parut Khola Irrigation Project	Madi Municipality	93	158
Lagaura Parsa Irrigation Project	Bharatpur Metropolitan City	102	172
Ganganagar Irrigation Project	Bharatpur Metropolitan City	250	300
Maroth Khola Irrigation Project	Madi Municipality	300	450
Ajanantatal Irrigation Project	Bharatpur Metropolitan City	550	690
Patihani Parsa Irrigation Project	Bharatpur Metropolitan City	665	1050
Uppalo Reoi Irrigation Project	Madi Municipality	100	225
Gopalnagar/Harinagar/Gaurinagar/ Irrigation Project	Madi Municipality	162	327
Lothar Irrigation System	Rapti Municipality	1000	1600

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Purbi Rapti Irrigation Project (90 canal)	Rapti Municipality, Khairahani Municipality	10235	24387
Different 25 Irrigation Projects		825	1250
Ground Irrigation Project		678	
Total		24539	42037

Source: District Profile DDC Chitwan 2010: Gajurel, K., & K.C., T. B. (2003)

Table 4.Distribution of Households and Population and Family Size

S.No	Name of VDCs & Municipality	2001 Census					2010 Projection			
		AVG H/H Size	Total no of HHs	Total Population	Male	Female	Total no of HHs	Total Population	Male	Female
1	Bharatpur N.P	4.48	19922	89323	45858	43465	24677	115128	59106	56022
2	Fulbari VDC	5.08	674	3426	1696	1730	869	4416	2186	2230
3	Gitanagar	4.75	2550	12106	5888	6218	3287	15603	7589	8014
4	Mangalpur	4.92	2951	14508	7126	7382	3804	18699	9185	9515
5	Saradanagar	4.83	1983	9584	4587	4997	2556	12353	5912	6441
6	Shivanagar	4.8	1436	6891	3369	3522	1851	8882	4342	4540
Total		4.60	29516	135838	68524	67314	37044	175081	88320	86762

Source: CBS, 2011

The main market centre of the area are Narayangad, Mungling, Bharatpur, Ratnanagar & Other market centres are Parsadhap, Rampur, Jagatpur, Shivanagar, Bhandara, Kuringhat, Basantapur (Madi), Bandarjhula, Parbatipur, Meghauli, Chanauli, Mangalpur, Gitanagar, Parsa (Khairahani), Gardi (Madi), Kalyanpur (Madi), Patihani, Saradanagar. (Statistical Year Book of Nepal. (2003): Sharma K R (1996) Singh M, Liebrand J, & Joshi D. (2014).

Economic Activities

As per CBS, 2001, about 57.51% of all persons were engaged in economic activities, while the remaining 42.49% were taking care of the household, student, retired or economically inactive for other reasons. The data is mentioned in Table 5.

Approximately, the highest 45.04% of the economic active population was involved in farm fishing/ forestry works. About 13.76% were engaged as service workers and shop, market sales workers (CBS,2011). The category of workers accounted for 11.51% engaged as craft and trade workers. About 6.33% were found professional/ semi-professional/ technical workers. 2.98% depend upon administrative and clerical work. About 2.78% of people were engaged in production labour worker. 0.91% and 16.68% economically active people were found engaged in legislators/ senior officials/ manager and other and not stated works respectively.

Methodology

Study Process

In order to meet objectives of the study, different literatures related to Narayani Lift Irrigation System, social parameter, climatic condition, irrigation and agricultural condition of command area as well as whole district, water demand in these area, Plans, policies, rules and regulations related to the irrigation, user committee, water resource use in context of Nepal have been collected and studied, which provided the secondary data relevant to this study. After the collection of the information and data required for the case study, field survey is done around the command area and office to study the present operating condition and maintenance status of the system. Also interview is done with governmental officers, members of user committee and local farmers to obtain ground reality of system and

Table 5.Economically Active and Inactive Male Female Population

Status	2001 Census			2010 Projection		
	Total	Male	Female	Total	Male	Female
Economically Active	208515 (57.51%)	119723 (66.81%)	88792 (48.42%)	268755 (57.51%)	154311 (66.81%)	114444 (48.42%)
Economically Inactive	154059 (42.49%)	59489 (33.19%)	94570 (51.58%)	198566 (42.49%)	76675 (33.19%)	121891 (51.58%)
Total	362574	179212	183362	467321	230986	236335

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obtain a brief of role of user committee. On the collection of both primary and secondary data, a comprehensive analysis was done. Post analysis, the different dimensions and alternative ways for the solutions had been identified. The whole process of the methodology for this study is schematically demonstrated through Figure 1.

Study Area

Chitwan is amongst those districts of the Narayani zone that lie in the Central Development Region of Nepal. It covers an area of 2218 square kilometres. It has extended between 270º 15 '-270 º 45' N latitudes and 840 º 27'-850 º 85' E longitudes. It covers altogether 1 Rural Municipality-Icchyaamana Rural Municipality, 1 metropolitan city-Bharatpur and 4 municipalities – Ratnanagar, Khaireni, Rapti, Madi. Narayani Lift Irrigation system has been serving about 4700 Ha land of Bharatpur Metropolitan City (Narayani Lift (2021): Gajurel K, & KC, TB (2003)) About 15,885 Ha of land has been irrigated from different types/ sources of perennial irrigation systems within the district (Gajurel K, KC, TB (2003)). The map below shows the topography and the command area of the Narayani Lift Irrigation System (Figure 2).

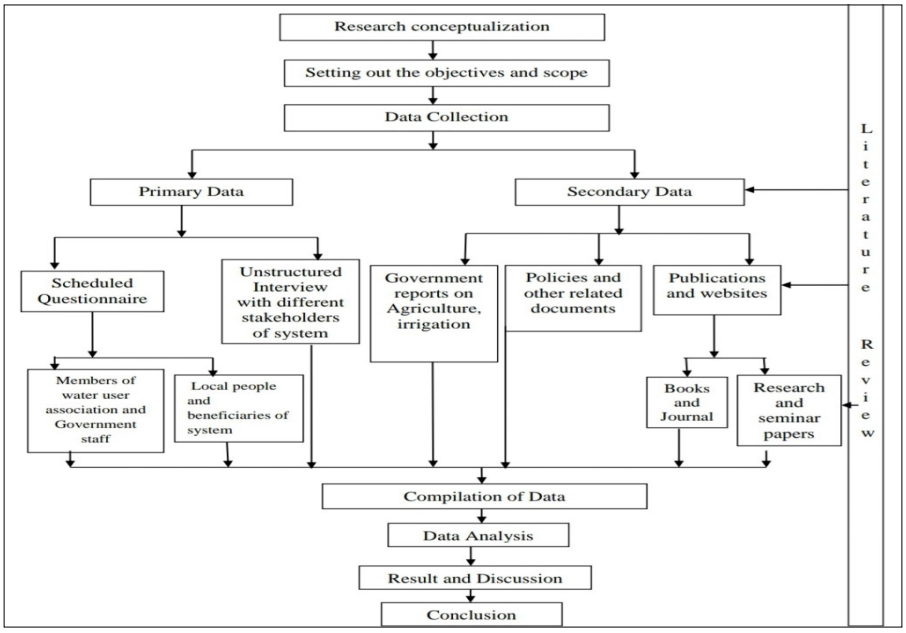

Figure 1.General Methodology

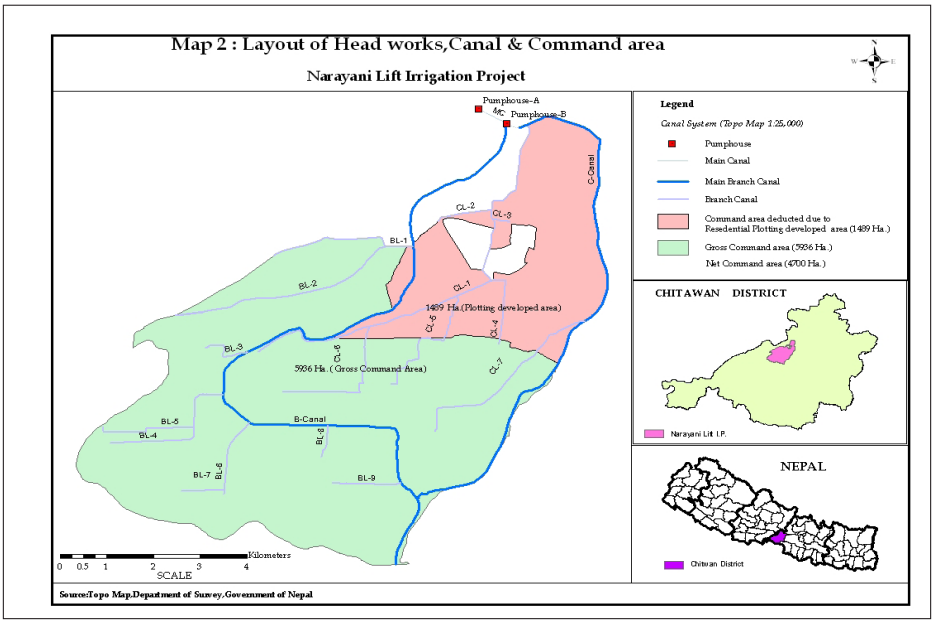

Figure 2.Topographic Map of Narayani lift Irrigation Project

Source: Department of Survey, Government of Nepal

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Population Selection and Sampling

Respondents from diverse backgrounds were selected. The respondents would be governmental officials of the Narayani Lift Irrigation System, members of the user committee responsible for the overall management of the system and local farmers using the service. The distribution of the respondent is shown in Table 6.

Table 6.Respondents of Primary Data for the Questionnaire Survey

S.No	Category of Respondents	Number	Percentage
1	Government officials	5	8.33
2	Member of user committee	15	25
3	Local farmers	40	66.67
	Total	60	100

Data Analysis

Data analysis was been done at different stages using statistical tools and the data is presented in tables and tools like bar charts and pie-chart.

Relative Importance Index

The hierarchy of the causes of disputes and problems and threats of the system were identified using the Relative Importance Index (RII). The participating respondents have provided numerical scoring expressing their opinions on the degree of importance of each Indicator. The collected data was analyzed using various statistical methods.

$$RII = \sum \frac{Wi}{Xi} \frac{\text{Average Importance}}{5} \text{ x } 100\% \text{ (Mishra, A.K., 2019)}$$

Where,

Wi = the weight given to the ith response: i=1, 2, 3, 4,5,
Xi = frequency of the ith response,
A = the highest weight (5 in this study),
n = the number of respondents.

Analytical Research

The descriptive research was also carried out, the analytical research was mainly focused on the first objectives of the study. The analytical research was helpful to find out the opinion of farmers, member of WUA and governmental officials about the system and also to find whether the roles of WUA was effective and the opinion of farmers and government officials about WUA. An analytical questionnaire survey was done (Mishra, Anjay Kumar, Prakash Yadav, & Aithal, P. S., (2021)).

Result and Discussion

Source and Supply

The source of the irrigation system is the Narayani River located at the Narayanghat, Chitwan district, the irrigation water directly intakes from the Narayani River through the gabion wall constructed on the left bank without weirs. Because of the seasonal fluctuation of the water level, a range of five meters ordinarily (average minimum water height of 92.5 m and maximum 98.0 m), pipe inlets with four different elevations were installed on the wall. During monsson, the lower inlet pipes were closed by a gate and the surface water is intake through the upper ones.

In 2020 water pumping scenario is 7 m^3/ s water lift from pump house A is distributed 6.2 m^3/ s to canal B system and 0.8m^3/ s to canal C system. Irrigation peak water demand of canal B system for remaining agricultural command area for agriculture 2267.90 ha with peak period crop water requirement 2.0 ltr/ sec/ ha is 4.54m^3/sec. Similarly irrigation peak water demand of Canal C system for remaining command area for agriculture 945 ha with peak period crop water requirement 2.0 ltr/ sec/ ha is 1.89m^3/ sec.

Source of Irrigation Water Before NLIS

Irrigation has been done in Chitwan as inhabitants increased with the migration of people from different districts. The location of Chitwan in Terai is considered the bread basket of Nepal. Around the command area, the traditional source of irrigation such as groundwater, rainwater and surface water was used, also groundwater source such as tube well was commonly found. The result of the survey on the source of irrigation when the Narayani Lift Irrigation System is not operating shows that the majority of farmers i.e 55% in the command area are dependent on groundwater sources such as tube wells and Bore well. During the survey also many bore wells were seen and in every house, there was a tube well in the command area.

Around 25% of farmers wait for rainwater for irrigation. Generally, those farmers who have cultivable land far from residents such people are found to depend on rainwater and 20% of them used surface water from nearby lakes during the monsoon when lakes got flooded.

Water Availability Status

NLIS withdraw water from snow feed perennial Narayani river. Narayani River flows throughout the year and during monsoon season high intensity discharge is recorded. Only during the monsoon season water enters the intake of the system and feed the system. Generally, the system is operated in July and feeds the canal for up to 3-5 months. The water from the source operated only for some months may not be abundant. On asked sufficiency status of water in the system to local farmers and water user, association members result obtained is illustrated in Figure 3.

Farmers and members of the water user association have somewhat similar thoughts on the sufficiency of water. Both completely deny that water from the source is fully

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sufficient for irrigation, 20% of them find water partially sufficient and in the same context, 46.67% of the members of the water user association agree. The majority of farmers' i.e 57.5% agrees that water from the system is sufficient for one crop season and 40% of the member of the water user association agree with this context. It is found that 22.5% of the farmer and 13.33% of the members of the user association accept that water is not sufficient for irrigation.

Since the majority of the beneficiaries of the system agrees on partial sufficiency of water and used only for one crop season, also water is fed in intake of the system only during monsoon study team thought to study for the necessity of secondary source for sufficient intake of water and result is presented in Figure 4.

All stakeholders i.e local farmers, member of WUA and government officials strongly disagree with denying of necessity of secondary sources for intake of water in the system and also, 52.5% of farmers, 40% of the member of WUA and 60% of government officials suggest it is most necessary of a secondary source to increase the abundance of water in the system.

Pumping Stations

Two pumping stations are Pump station "A" constructed at the intake point and "B" which is 500 m upstream of the "A" station connected with the Link canal. The pumps are vertical turbine flow type of Indian made. The capacity of Pump station "A" is shown in Table 4 and of Pump station, "B" is shown in Table 7.

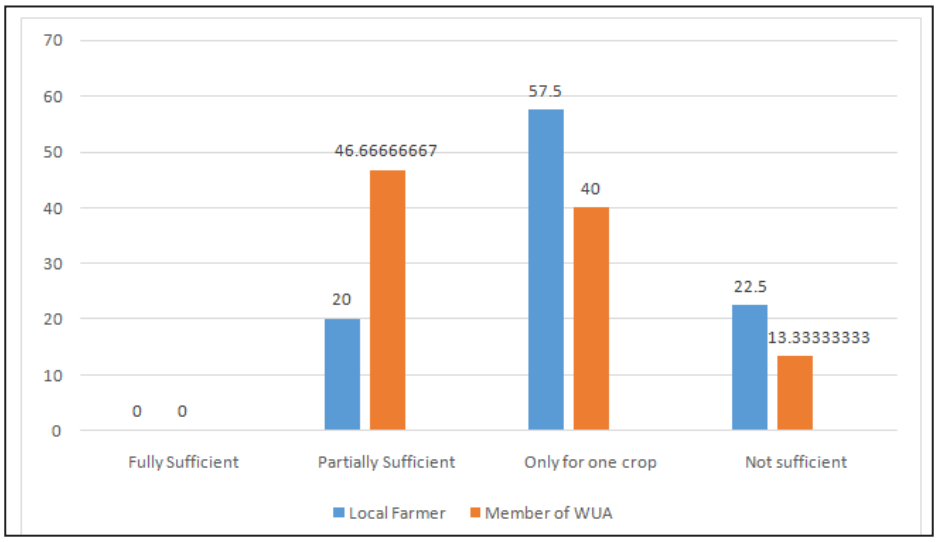

Figure 3.Sufficiency status of water in system

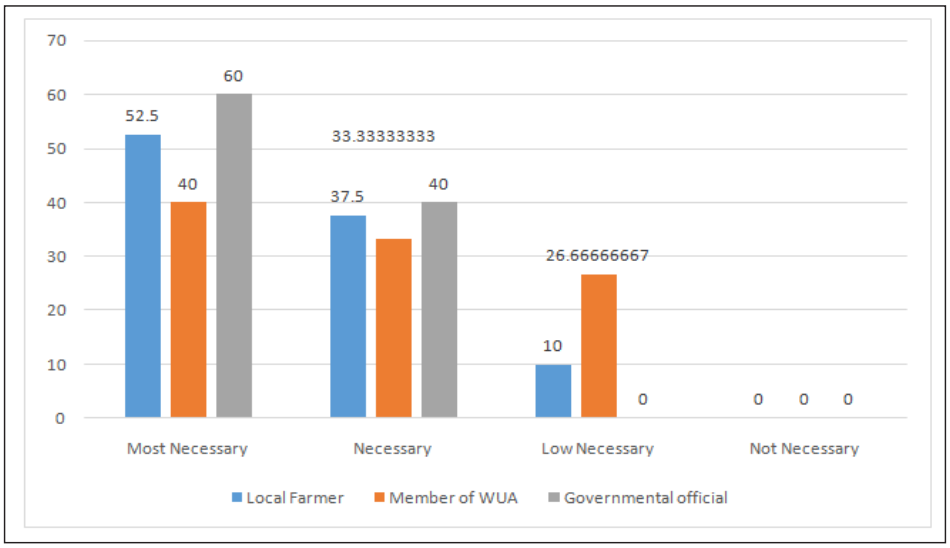

Figure 4.Necessity of Secondary Source for Sufficient Intake of Water in System

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Table 7.Pump Installed at Pump House "A"

Discharge (m^3/sec)	Capacity	Number	Remarks
4.00 m^3/sec	1200 KW	2 Nos	Both pumps are operated with frequent maintenance
2.00 m^3/sec	750 KW	2 Nos	Both pumps are operated with frequent maintenance
1.00 m^3/sec	330 KW	1 Nos.	Damaged/motor winding was burst.
Total Nos.		5.00	

Table 8.Pump Installed at Pump House "B"

Discharge (m3/sec)	Capacity	Number	Remarks
1.6 m^3/sec	500 KW	1 Nos	Motor winding is burst
0.8 m^3/sec	250 KW	3 Nos.	2 nos. pumps are operated with frequent maintenance where as one pump is not working completely.
Total Nos.		4.00	

Of the 5 motors installed at Pump House "A", one motor of 330 kW capacity is damaged completely and the remaining 4 motors (2 motors of 1200 kW and 2 motors of 750 kW) are operated with frequent maintenance. Every after the pump operation, maintenance of the pump is been done for the operation of the pump for next year.

There are a total of 4 pumps installed at Pump House "B", of which motor winding of one motor of 500 kW capacity is completely burst, of 3 pumps of 250 kW, 1 pump is completely not working and 2 pumps are operated with frequent maintenance.

Link Canal

The distance of 500 m length (Lining Canal) links the pump stations "A" and "B" with 1/10,000 of canal slope, 3.5m of bottom width, 3.3m of depth and 1:1.1 of canal inside slope. Silt deposit on the bed of canal up to the 1m depth while surveying.

Distribution System

Canal "B" System

Main Canal

Main Canal "B" is diverted from the link canal and jointed the Khageri Canal at the end in order to supply excess water to Khageri System. It is 17.6 km of wet masonry lining canal with a conveyance capacity of 7.8 m^3/s and average slope of 1/ 6,500, located middle elevation area between Main Canal "C" and Khageri Canal. Division weirs are installed on main canal at some divergent points to secondary, slide gates are constructed at the beginning point of secondary canals. These gates are operated by the project staff, but there is no check and water measurement structures.

Secondary Canals

There are nine secondary canals and the total length is 15.5 km with the same lining structure as main canal.

Tertiary Canals

Tertiaries are earth canals with brick masonry lining at the inlet points. Round-shaped sluice gates are installed at the point's directory to intake water from the main canal to the tertiary. From secondary canals, the round-shaped slice gates and stop logs are located at the inlet of tertiaries. Drop structures are mainly made of stone masonry and some part of brick masonry. Main Canal "B" is not damaged so much, but soil sedimentation is observed all along the canal and it reduces the canal's water conveying capacity. After the monsoon season, huge amount of settled soil was removed from the canal.

Canal "C" System

Main Canal

Main Canal "C" is 10.2 km of wet masonry lining canal after the pump station "B", flowing from north to south on the border of the project area and Mahendra Reserved Forest; the area with high elevation in the project area. Division structures are in the same condition as the "B" system.

Secondary Canals

There are six secondary canals of 20.5 km total length, also have no check and water measurement structures.

Tertiary Canals

There are 52 tertiaries of 61.5 km in total length, the structures are the same as the "B" system. The soil sedimentation is only observed from the beginning point up to the duckbill weir of 771 m points.

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Figure 5

Figure 6

In most of the lower parts the soil is not settled, because of the high flow velocity, the canal is eroded and broken at many points. From this part, considerable water is leaked to the ponds in the reserved forest.

The canal "B" system contains two secondary canals No. 2 (BL2) and No. 6 (BL6). "C" system consists of Major canal CL1, which in the preset state is not functioning and most of its stretches are encroached, chocked and filled. The majority length of the canal passes through the urban area other secondary canals CL-2, CL-3, CL-4, CL-5, CL-6 are the branch of CL-1 hence all are not functioning. Whereas, CL-7 secondary canal lies at Gauriganj has still important for its command area useful for farming, but this area has a deficit of the irrigation water.

Farm/ Service Road

A total length of 150 km was constructed as farm road and service road for canal maintenance, which has some 3 m width and gravel pavement.

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Main Canal Structures

Main Canal "B" is 17.681 km out of which a total of 2.5 km is masonry lining separated at different places and the rest are wet masonry lining canals with a conveyance capacity of 7.8 m^3/ sec and an average slope of 1/6,500, located in middle elevation area between Main Canal "C" and Khageri Canal. Division weirs are installed on the main canal at some divergent points to the secondary, slide gates are constructed at the beginning point of secondary canals. These gates are operated by the project staff, but there are no check and water measurement structures.

Main Canal "C" starts from the 165 m of long at the beginning from pump house "B" is underground with HDP main pressure pipe and 10.2 km open canal out of which total 3.5 km lining separated at different places of wet masonry lining canal after the pump station "B", flowing from north to south on the border of the project area and Reserved Forest; the area with high elevation in the project area. Division structures are in the same condition as in the "B" system.

Command Area

NLIS was designed and operated to irrigate 4,700 Ha of land. The project was also made operational to supplement the Khageri Irrigation System having a command area of 3,900 Ha. The total area under the NLIS designed irrigation is found to be reduced from 2488.90 to 2267.90 Ha among canal "B" and 2262.35 to 944.075 Ha in the "C" system. The land use plan of the project for study year i.e 2020 is shown in Table 9.

Table 9. Land Use Plan of Project

S. No.		Tertiary Canal	Area (Ha)			Canal Link
			Total	Irrigated	Unirrigated	
1	i	B1-T1	32.50	32.50	0.00	B
	ii	BL1	71.60	35.30	36.30	B
	iii	B1-T2	8.40	6.20	2.20	BL2
	iv	B1-T3	27.60	22.60	5.00	BL2
	v	B1-T4	17.80	15.80	2.00	BL2
	vi	B1-T5	10.10	0.00	10.10	BL1
	Sub-total "B1"	168.00	112.40	55.60		BL2
2	i	B2-T1	10.60	5.70	4.90	BL2
	ii	B2-T2	17.10	13.00	4.10	BL2
	iii	B2-T3	17.40	17.40	0.00	BL2
	iv	B2-T4	57.30	44.90	12.40	BL2
	v	B2-T5	17.10	7.80	9.30	BL2
	vi	B2-T6	21.00	12.60	8.40	BL2
	vii	B2-T7	21.40	7.20	14.20	BL2
	Sub-total "B2"	161.90	108.60	53.30		
3	i	B3-T1	25.80	23.40	2.40	BL2
	ii	B3-T2	15.00	8.00	7.00	BL2
	iii	B3-T3	52.80	11.90	40.90	BL2
	iv	B3-T4	24.00	11.30	12.70	BL2
	Sub-total "B3"	117.60	54.60	63.00		
4	i	B4-T1	25.30	14.20	11.10	B
	ii	B4-T2	12.00	10.40	1.60	B
	iii	B4-T3	66.00	38.70	27.30	B
	iv	B4-T4	56.30	47.40	8.90	B
	Sub-total "B4"	159.60	110.70	48.90		
5	i	B5-T1	14.00	14.00	0.00	B

ISSN: 2455-3190
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	ii	B5-T2	10.20	9.50	0.70	B
	iii	B5-T3	7.70	5.80	1.90	B
	iv	B5-T4 (BL2)	79.70	53.80	25.90	BL2
	Sub-total "B5"	111.60	83.10	28.50		
6	i	B6-T1	36.30	33.30	3.00	B
	ii	B6-T2	9.20	7.00	2.20	B
	iii	B6-T3	5.10	4.10	1.00	B
	iv	BL3	28.00	23.90	4.10	B
	v	B6-T4	9.30	8.60	0.70	B
	vi	B6-T5 (BL4)	47.20	43.20	4.00	BL4
	vii	BL5	33.30	5.80	27.50	BL4
	Sub-total "B6"	168.40	125.90	42.50		
7	i	B7-T1	32.00	30.20	1.80	B
	ii	B7-T2	12.20	11.80	0.40	B
	iii	B7-T3	50.40	47.40	3.00	B
	Sub-total "B7"	94.60	89.40	5.20		
8	i	B8-T1	30.50	30.50	0.00	BL4
	ii	B8-T2	28.90	28.90	0.00	BL4
	iii	B8-T3	13.00	13.00	0.00	BL4
	iv	BL5	16.90	16.90	0.00	BL5
	v	B8-T4	37.20	37.20	0.00	BL4
	Sub-total "B8"	126.50	126.50	0.00		
9	i	B9-T1	23.10	21.80	1.30	BL4
	ii	B9-T2	42.80	39.80	3.00	BL4
	iii	B9-T3	31.40	30.30	1.10	BL4
	Sub-total "B9"	97.30	91.90	5.40		
10	i	B10-T1	43.00	31.30	11.70	BL4
	ii	B10-T2	27.00	20.50	6.50	BL4
	iii	B10-T3	35.60	28.30	7.30	BL4
	Sub-total "B10"	105.60	80.10	25.50		
11	i	B11-T1	3.80	3.70	0.10	BL6
	ii	B11-T2	67.50	65.70	1.80	BL6
	iii	B11-T3	47.20	45.50	1.70	BL6
	iv	B11-T4	13.50	12.40	1.10	BL6
	v	B11-T5	11.90	11.50	0.40	BL6
	Sub-total "B11"	143.90	138.80	5.10		
12	i	B12-T1 (BL6)	13.50	12.90	0.60	BL6
	ii	B12-T2 (BL6)	33.70	32.20	1.50	BL6
	iii	B12-T3 (BL6)	21.30	20.50	0.80	CL6
	iv	B12-T4 (BL7)	14.30	13.40	0.90	CL6
	v	B12-T5 (BL7)	19.00	18.50	0.50	CL7
	Sub-total "B12"	101.80	97.50	4.30		

ISSN: 2455-3190
DOI: https://doi.org/10.24321/2455.3190.202201

13	i	B13-T1	23.90	22.30	1.60	CL7
	ii	B13-T2	17.70	16.80	0.90	CL7
	Sub-total "B13"	41.60	39.10	2.50		
14	i	B14-T1	38.20	37.80	0.40	B
	ii	B14-T2	26.90	25.50	1.40	B
	iii	B14-T3	8.40	7.80	0.60	B
	iv	B14-T4	6.80	6.60	0.20	BL8
	v	B14-O1 & O2	4.80	4.60	0.20	B
	Sub-total "B14"	85.10	82.30	2.80		
15	i	B15-T1 (BL8)	34.50	29.90	4.60	BL8
	ii	B15-T2 (BL8)	17.30	16.50	0.80	BL8
	iii	B15-T3 (BL8)	26.00	19.90	6.10	BL8
	iv	B15-T4 (BL8)	18.10	15.10	3.00	BL8
	v	B15-T5 (BL8)	11.70	10.30	1.40	BL8
	vi	B15-T6 (BL8)	19.70	16.40	3.30	BL8
	Sub-total "B15"	127.30	108.10	19.20		
16	i	B16-T1	30.70	27.90	2.80	B
	ii	B16-T2	30.00	21.50	8.50	B
	iii	B16-T3	15.80	12.10	3.70	B
	iv	B16-T4	49.40	36.90	12.50	B
	v	B16-T5	42.90	12.00	30.90	B
	Sub-total "B16"	168.80	110.40	58.40		
17	i	B17-T1	10.90	7.70	3.20	B
	ii	B17-T2	17.90	14.90	3.00	B
	iii	B17-T3	13.30	10.40	2.90	B
	iv	B17-T4	17.80	15.00	2.80	B
	v	B17-T5	26.60	23.00	3.60	B
	Sub-total "B17"	86.50	71.00	15.50		
18	i	B18-T1	5.80	5.00	0.80	B
	ii	B18-T2	21.30	18.80	2.50	BL9
	iii	B18-T3	35.20	25.20	10.00	BL10
	iv	B18-O1	14.50	12.80	1.70	BL11
	v	B18-T4	29.10	26.70	2.40	BL12
	vi	B18-T5	29.50	24.70	4.80	BL13
	vii	B18-T6	29.30	0.00	29.30	BL14
	viii	T	73.90	73.90	0.00	BL15
	Sub-total "B18"	238.60	187.10	51.50		
19	i	B19-T1	31.40	17.40	14.00	B
	ii	B19-T2	28.40	23.70	4.70	B
	iii	B19-T3	47.10	25.40	21.70	B
	iv	B19-T4	22.30	22.30	0.00	B
	Sub-total "B19"	129.20	88.80	40.40		

ISSN: 2455-3190
DOI: https://doi.org/10.24321/2455.3190.202201

20	i	B20-O1	17.30	1.00	16.30	B
	ii	B20-O2	18.10	10.80	7.30	B
	iii	B20-O3	19.60	11.60	8.00	B
	Sub-total "B20"	55.00	23.40	31.60		
Sub Total of B-System	2488.90	1929.70	559.20			
1	i	C1-T1	38.30	25.70	12.60	C
	ii	C1-T2	32.50	26.70	5.80	C
	iii	C1-T3	14.20	1.20	13.00	C
	iv	C1-T4	5.40	0.50	4.90	C
	v	C1-T5	12.70	0.00	12.70	C
	vi	C1-T6	13.60	0.00	13.60	C
	Sub-total "C1"	116.70	54.10	62.60		
2	i	C2-T1	51.20	51.20	0.00	CL1
	ii	C2-T2	64.30	64.30	0.00	CL1
	Sub-total "C2"	115.50	115.50	0.00		
3	i	C5-T1	11.50	11.00	0.50	C
	ii	C5-T2	5.70	5.50	0.20	C
	iii	C5-T3	4.50	4.20	0.30	C
	iv	C5-T4	29.50	26.80	2.70	C
	v	T	129.20	129.20	0.00	C
	Sub-total "C5"	180.40	176.70	3.70		
4	i	C6-T1 (CL7)	17.00	17.00	0.00	CL7
	ii	C6-T2 (CL7)	19.80	19.80	0.00	CL7
	Sub-total "C6"	36.80	36.80	0.00		
5	i	C7-O1 (CL7)	18.90	18.90	0.00	CL7
	ii	C7-O2 (CL7)	10.50	10.50	0.00	CL7
	iii	C7-O3 (CL7)	23.20	22.10	1.10	CL7
	Sub-total "C7"	52.60	51.50	1.10		
6	i	C8-T1 (CL7)	11.90	11.90	0.00	CL7
	ii	C8-T2 (CL7)	14.20	12.30	1.90	CL7
	iii	C8-T3 (CL7)	25.90	21.20	4.70	CL7
	iv	C8-T4 (CL7)	16.60	13.20	3.40	CL7
	v	C8-T5 (CL7)	32.00	15.10	16.90	CL7
	vi	C8-T6 (CL7)	69.90	66.50	3.40	CL7
	vii	C8-T	29.60	29.10	0.50	CL7
	Sub-total "C8"	200.10	169.30	30.80		
7	i	C9-T1 (CL4)	126.70	0.00	126.70	CL1
	ii	C9-T2	57.70	22.60	35.10	CL1
	iii	C9-T3	19.70	10.90	8.80	CL1
	Sub-total "C9"	204.10	33.50	170.60		
8	i	C10-T1	22.70	18.20	4.50	CL1

ISSN: 2455-3190
DOI: https://doi.org/10.24321/2455.3190.202201

	ii	C10-T2	4.50	4.10	0.40	CL1
	iii	C10-T3	14.50	7.70	6.80	CL1
	iv	C10-T4 (CL5)	82.40	8.00	74.40	CL5
	Sub-total "C10"	124.10	38.00	86.10		
9	i	C11-T1 (CL5)	140.00	1.50	138.50	CL1
	ii	C11-T2	9.60	3.20	6.40	CL1
	iii	C11-T3	13.70	12.60	1.10	CL1
	iv	C11-T4	6.30	6.20	0.10	CL1
	Sub-total "C11"	169.60	23.50	146.10		
10	i	C12-T1	90.80	90.80	0.00	CL1
	ii	C12-T2	30.50	29.50	1.00	CL1
	iii	C12-T3	14.50	13.70	0.80	CL1
	Sub-total "C12"	135.80	134.00	1.80		
11	i	C13-T1	43.60	18.10	25.50	CL6
	ii	C13-T2	59.80	26.30	33.50	CL6
	iii	C13-T3	41.50	4.00	37.50	CL6
	iv	C13-T4	46.50	20.90	25.60	CL6
	Sub-total "C13"	191.40	69.30	122.10		
12	i	C14-T1	13.30	0.00	13.30	CL1
	ii	C14-T2	19.30	0.00	19.30	CL1
	iii	C14-T3	38.70	0.00	38.70	CL1
	iv	C14-T4	64.80	0.00	64.80	CL1
	Sub-total "C14"	136.10	0.00	136.10		
13	i	C15-T1	62.20	48.90	13.30	CL1
	ii	C15-T2	33.00	25.50	7.50	CL1
	Sub-total "C15"	95.20	74.40	20.80		
Total	1758.40	976.60	781.80			
14	i	C3 & C4	375.15	375.15	0.00	
	ii	CL2	128.80	0.00	128.80	
	Sub-total	503.95	375.15	128.80		
Sub Total of C-System	2262.35	1351.75	910.60			
Grand Total (B+C)	4751.25	3281.45	1469.80			

Source: Narayani Lift-Khageri Management Division Office, Bharatpur

System Operation and Cost of Electricity

As for operation, the project office is in charge of intake up to the main canal, and the total operating expenses for the system in the year 2020 are Rs 9,659,018.00 out of which Rs 5,159,018.00 for staff expenses and Rs 4,500,000.00 for electricity.

Government Budget for Operation and Maintenance

Total Staffs working for System operation is Pump Operator (3 people), Electric Lineman (2 people), Mechanical Helper (2 people), Watchman (4 people) and Seasonal Helper (5 people) per month (during pump operation). This information is illustrated in Table 10.

From Table 10, the graph, it was observed that in recent years the cost incurred in electricity of the system is decreasing and hence, operation cost per hectare is decreasing. As Nepal is moving forward to the electricity self-independent, the operation days of the pump can be increased so that fields receive more water see Figure 5.

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Table 10.Expenses of Narayani Lift Irrigation System of Past 8 Years

S.No	Fiscal Year	Operation and Maintenance Cost NRS	Electricity Bill NRS	Total Cost (Excluding Staff Expenses) NRS	Pump Operation Days/ year	Operation & Maintenance Cost/ ha
1	2068/69	40596188.00	2,67,80,000.00	38046188.00	98	8543.00
2	2069/7sss0	5,159,018.00	45,00,000.00	9,659,018.00	93	2,032.73
3	2070/71	9,030,227.50	60,00,000.00	15,030,227.50	98	3,163.09
4	2071/72	9,370,245.00	1,15,00,000.00	20,870,245.00	107	4,392.12
5	2072/73	17,496,621.00	1,00,00,000.00	27,496,621.00	97	5,786.63
6	2073/74	8,263,328.02	1,60,70,000.00	24,333,328.02	90	5,120.92
7	2074/75	9,308,137.71	2,77,32,460.19	37,040,597.90	90	7,795.15
8	2075/76	2,465,364.69	1,25,00,000.00	14,965,364.69	90	3,149.44
9	2076/77	5,799,577.70	20,00,000.00	7,799,577.70	90	1,641.41

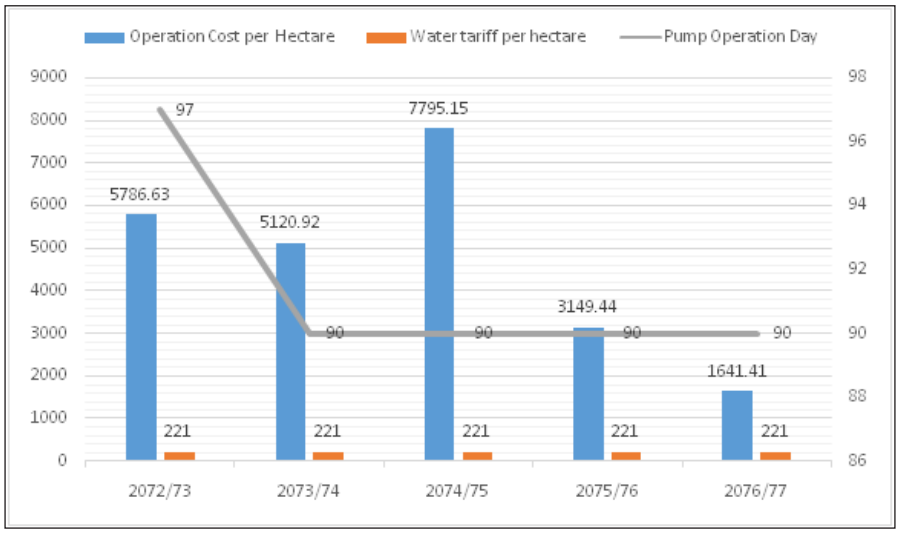

Figure 5.Budget Status of NLIS

Also, it is found that, there is huge gap between the water tariff collected per hectare from the operation cost per hectare and the difference in budget is sanctioned by the Ministry of Energy, Water resources and Irrigation. (MOE, 2076).

Water User Tariff Collection

The basis for collection of service charges from farmers is the charge on irrigation area. The secondary and tertiary canal is maintained by the user's association. The farmer's necessity for effective water distribution among themselves was the motive, and the associations have been formed getting advice from the project office.

The major activity of the association is to remove settled soil and clean canals, and materials like concrete and gravel are provided by the project office in case of need. The state of maintenance depends, but it is still low level on the whole.

An irrigation fee of 221 Rs/Ha is imposed on beneficiary farmers by the users association, but the tariff collection is not satisfactory for most rejects to pay. According to (Bhatta, Matsuoka, &Shrestha, Vol.14/No.1), The reason is supposed that many farmers have not got enough water as they expected, as in some other projects the fee is paid to a certain extent.

It is not that farmers don't pay the tax, during the survey it is found that every farmer pays the water user tariff but the majority of farmers i.e 55% of farmer pay only when they are reminded and the minority of them i.e 17% usually forgets to pay the tariff and there were 28% of them who regularly pays water user tariff on time.

It is found that maximum farmers are willing to pay when reminded. Both the local farmers and water user association were interviewed for are farmers comfortable with the tariff that they have to pay. The result of study is as below:

Majority of members of water user association i.e 40%,

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say that farmer are fully comfortable on the water user's tariff but on same context only 17.5% agreed. Majority of the farmers'i.e 37.5% agreed that they are paying only because of compulsion only, 33.33% of members of WUA agreedwith this context. While member of WUA doesn't think that farmers are not willing to pay tariff and it is found that 20% of the farmer doesn't will to pay tariff. Also, a balanced population of farmer and member (i.e 25% of farmer and 26% of member of WUA) agreed that people are not comfortable on water tariff (Figure 6).

Water Users Association

Narayani Lift Irrigation is a joint managed system in which, Narayani lift-Khageri Management Division under the Department of Irrigation as an agency is managing and separate organizational structure of Water User Association is functioning.

For the proper management of Narayani Lift Irrigation System in an effective and well-coordinated manner, a Narayani lift irrigation water users association (NLIWUA) has been formed as per the Water Resource Act 2049 comprising 23 members in 2051 BS. This central committee, chaired by Mr. PurnaBahadurRanabhat has been working for the system. Further, 2 branch committees comprising 47 members, 35 sub branch committees with 315 members, 1 constituent assembly committee with 105 members and 12 regional members have been directly involved in smooth sailing and functioning of NLIS. An outline of the existing organizational structure of WUA of NLIS is presented in Table 11.

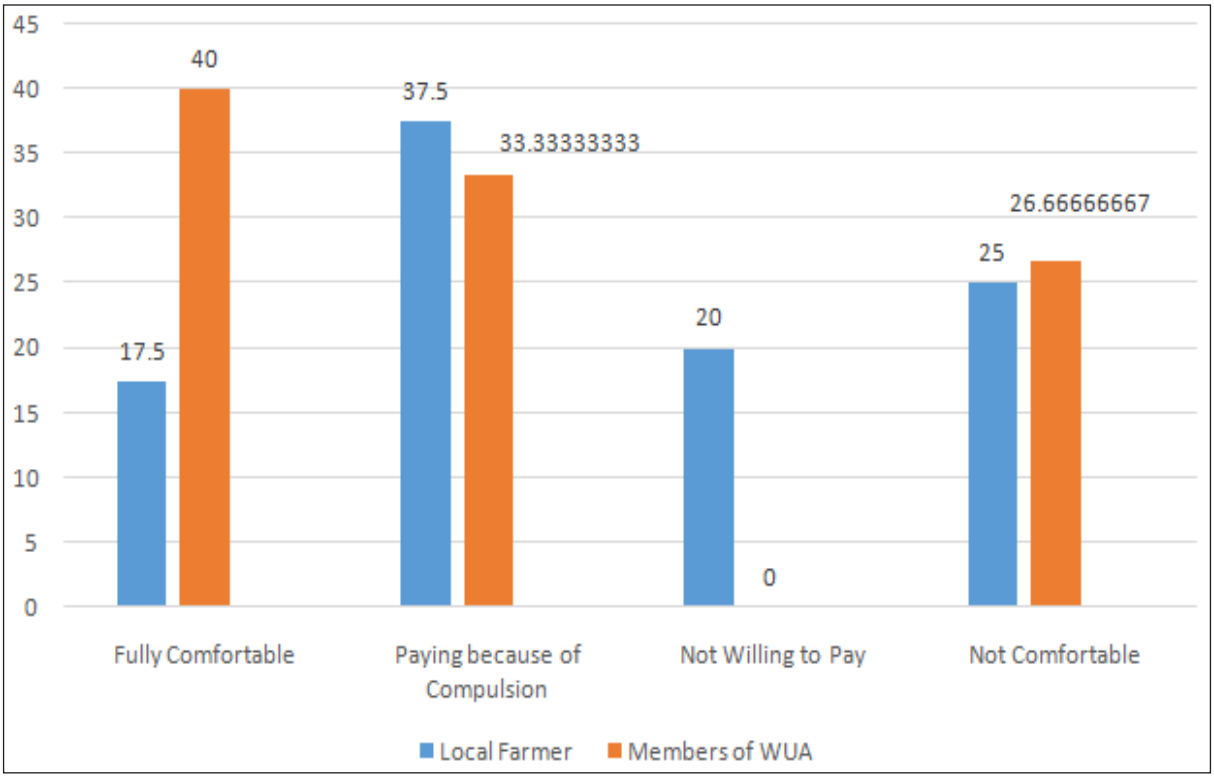

Figure 6.Status of Farmers and Member of WUA on comfort for water tariff

Table 11.Outline of the existing organizational structure of WUA of NLIS

Types of Committee	Number of committee	Number of member
Central committee	1	23
Branch committee	2	47
Sub-branch committee	35	315(35*9)
Constituent Assembly Committee	1	105(35*3)
Regional member		12

Source: Narayani Lift Irrigation Water User Association

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The NLIWUA has been collecting water tariff with users regularly. The WUA used to collect Rs.100/Ha/Year since 2051 BS(KC, M, &Gautam, DR (2006)):International Water Management Institute.(2004). But from the fiscal year 2057/58, the collection amount has increased to Rs.150/Ha/Year. Now, the collection amount has increased to Rs.221/Ha/Year.

Roles of Water User's Association

In Joint management irrigation system, Water User's Association is the main executive body for the management of system. There are various roles of WUA in proper management of system. The main roles of Narayani Lift Irrigation water users association (NLIWUA) are as follows :

1. Reliable delivery of water after pump operation.
2. Clear decision making and taking account of user's interest.
3. Dispute Management.
4. Maintenance of secondary and tertiary canal.
5. To aware farmers for proper use of system.
6. Call for regular meetings for management and maintenance of system.

To understand how the user's and government officials find the roles played for NLIWUA a study was done and all the government officials finds the roles of water user's association is very effective and the response of local people is presented in Figure 7.

During the study, majority of the local farmers'i.e 58% find the role played by NLIWUA is effective and 17% agreed that it is very effective. While 20% of them said somehow effective role had been played, there are 5% according to whom the role played is not effective similar toKattel, S. (2007).

The general study of the roles played by the WUA is not sufficient for the overall study of roles played by the WUA. Hence, to understand the roles played by the Water User association in detail, the Relative Importance Index is also applied. The result of the Relative Importance Index is as in Table 12:

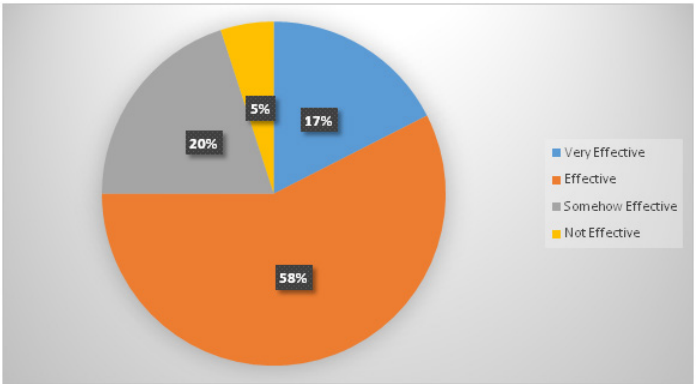

Figure 7.Effectiveness on Roles played by NLIWUA

Table 12.Ranking of Roles Played by NLIWUA

S. No.	Roles	Local Farmers		Member of WUA		Average Importance	
		RII (in %)	Rank	RII (in %)	Rank	RII (in %)	Rank
a.	Reliable delivery of water after pump operation.	65	5th	82.67	3rd	75.6	3rd
b.	Clear decision making and taking account of user's interest.	68.5	3rd	76	4th	73	4th
c.	Dispute Management.	73	2nd	92	1st	84.4	2nd
d.	Maintenance of secondary and tertiary canal.	85	1st	90.67	2nd	88.4	1st
e.	To aware farmers for proper use of system.	54	6th	59	6th	62.4	6th
f.	Call for regular meetings for management and maintenance of system.	69	4nd	68	5th	68.4	5th

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The result of RII based on the roles played by the NLIWUA giving preference 60% to the response of members of WUA and 40% to views of local farmers shows that NLIWUA played its role very satisfactory in the maintenance of the secondary and tertiary canal. Also, more emphasis should be given to aware the farmer for proper use of the system, since the role played to aware the farmers were not satisfactory. More awareness plans and campaigns should be launched by the WUA to motivate and educate the locals to use the water system.

Dispute Management

A dispute is very common in the jointly managed irrigation system. There are certain rules and regulations to manage these disputes. Since disputes are very common, therefore, the resolution mechanism must be strong enough so that it does not get converted into conflict. Hence, dispute management is a must which needs to be utilized in the full phase. It is one of the most important roles that NLIWUA is playing. The NLIWUA is responsible for dispute management within the system. To understand the status of the dispute during the use of water from the system, the study was done whose result is presented in Figure 8.

During the study it was found that about 42.5% of respondents agreed that always dispute is encountered during the use of water in Main Canal B, similarly, 20% of respondents agreed on always dispute is encountered during the use of water in Manal Canal C. In both canals, very few said that there is no dispute, i.e 2.5% of the respondent of Main canal B and 6.67% of them of Main canal C. 32.5% of them of main canal B and 46.67% of them of the Main canal C agreed there is dispute frequently encountered.

Causes of Dispute

There may be many more causes of the dispute based on geography and nature of the system, there are some the dispute noted in the system during the study and a Relative Importance Index Analysis is done (Figure 9).

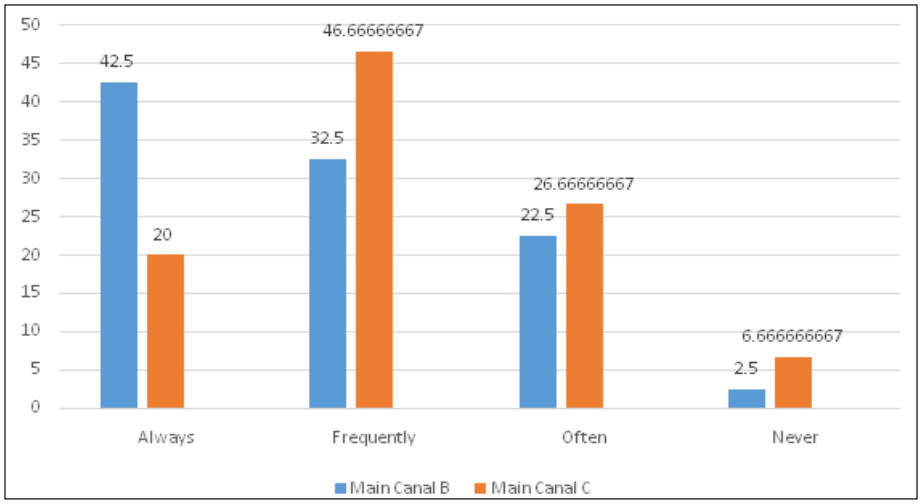

Figure 8.Frequency of Dispute in Main Canal

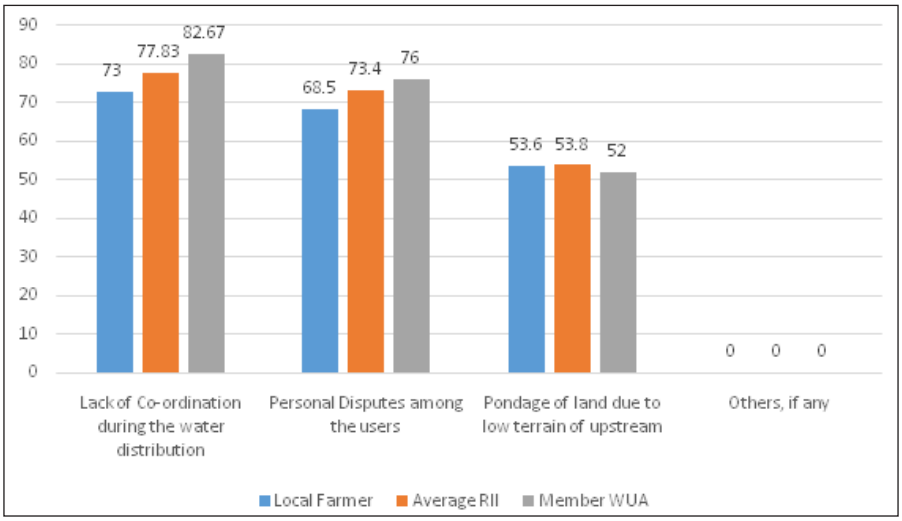

Figure 9.RII on Causes of Disputes

ISSN: 2455-3190
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Awareness, Trainings and Meetings

One of the main roles of WUA is to organize different campaigns to aware the farmers' proper use of water and the conservation of canals and other components such as gates. Similar pieces of training and meetings are organized so that there is easier management of the system.

During the study, it was found that the participation of 48% of the farmers in the meeting and training is very less whereas 32% take part frequently and 17% of farmers are regular attendees. Also, 3% of the farmers have never taken part in the meeting and the training that had been organized by the WUA.

Opinion and Importance of NLIS

The most important awareness about the project among the farmers as observed during the study period is the value of irrigation water without which their income level decreased by 50%.

It is known that by using the water from the system beneficiaries highly benefited. During the study it is found that 100% of government officials consider the system as only secondary source and the result of views of local farmers and members of WUA on opinion about the system is shown in Figure 8.

27.5% of local farmers and 33.33% of members of WUA find the system very beneficial similarly 52.2% of the farmers, 46.67% of member of WUA and 100% government officials find NLIS as secondary source. For 12.5% farmers and 13.33% member of WUA they found system partially beneficial. There were 7.5 % of the farmers and 6.67% of the member of WUA who doesn't find NLIS beneficial (Figure 10).

Agricultural Benefits

TheNarayani Lift Irrigation Systems through management of existing irrigation system, expansion of irrigated area and expansion of year round irrigation area can enhance the agricultural benefits as stated below.

- Reliable irrigation water supply increase crop yields and subsequent increase in production and farm income.
- Water supply can initiate crop diversification with more cash crops with high return value like vegetable, fruits, cash crops etc.
- Potential for high value agricultural commodities based markets are available as Bharatpur is the entry point to Pokhara and Kathmandu where there are ever increasing demands.
- All the command areas of canal are accessible with road, so transportation of agricultural products could be brought to market easily.
- The command area is very fertile and mildly sloping towards south-west direction. If the farmers could be motivated for crop diversification, this area is suitable for upland crops and of conventional irrigation practice of farrow, graded irrigation practice could be implemented.

The response of farmers and member of WUA on agricultural status after the Narayani lift irrigation system comes on operation. 30% of famers and 13.33% of member of WUA says, agricultural status is increased rapidly and also 2.5% of farmer and 6.67 % member of WUA deny this and say agricultural status is decreased than that of before. 22.5% farmer and 20 % of member of WUA say the agricultural status is same as before.

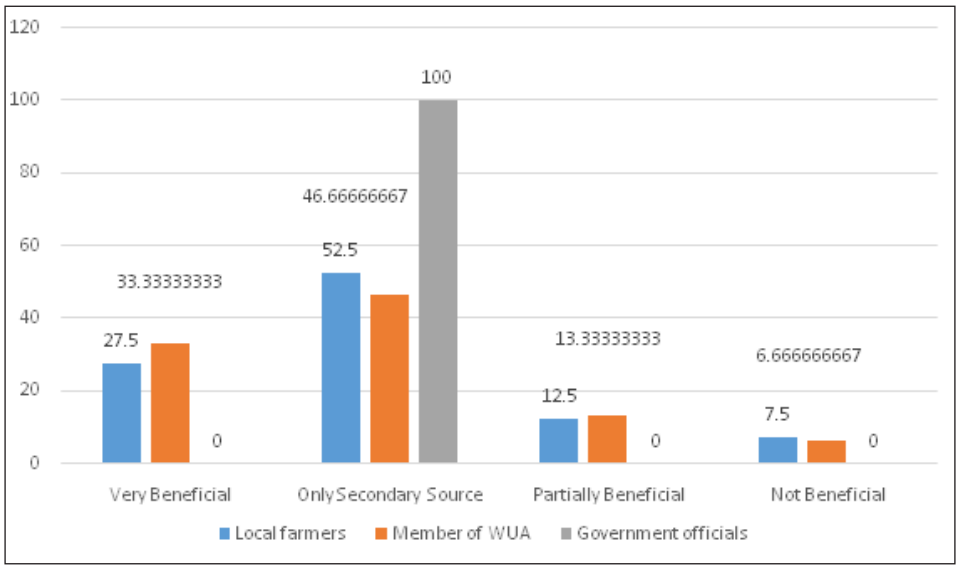

Figure 10.Opinions on NLIS

ISSN: 2455-3190
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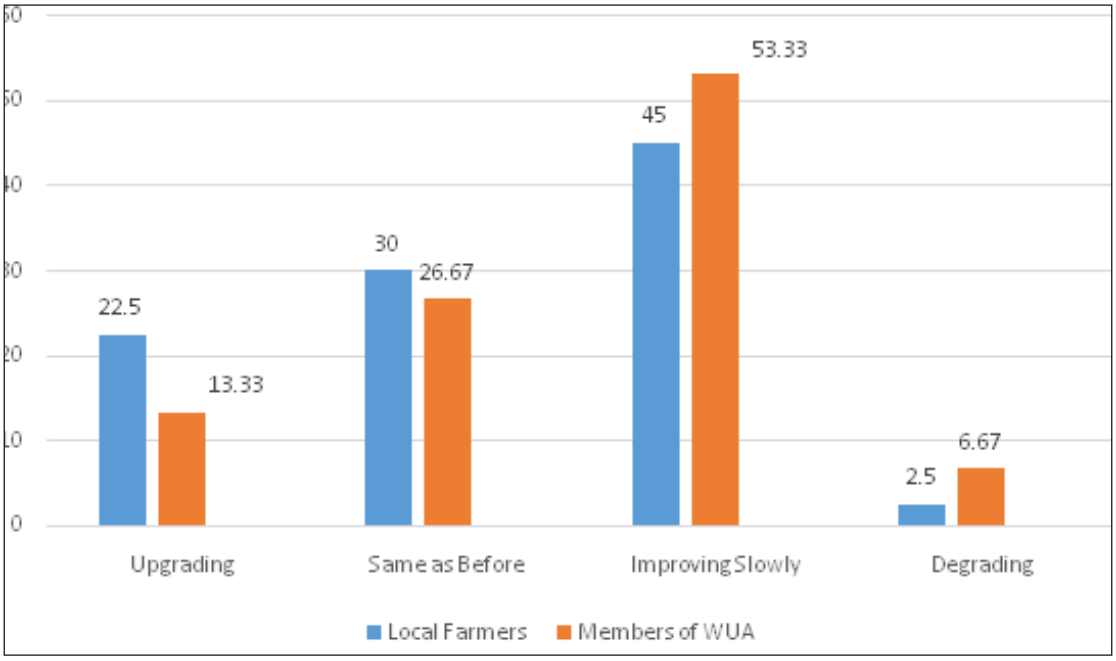

Figure 10.Opinions on NLIS

45% of the farmers and 60% of the member of WUA agree that they are more motivated on agriculture as the system comes in operation.

Socio-Economic Benefit

By the operation of system, it is found that more farmers are motivated on agriculture then it is sure that this will upgrade the socio-economic condition of the overall area. Though most of the area is urban significant involvement of women is there, not only in urban area but in village area also women are engaged in system management.

Not only the involvement of women the economic condition of the farmers are also changed than that of before. Result of study on economic status of society after the system is presented Figure 11.

Wide variety of respondantsi.e 45% of farmers and 53.33% of the member of WUA agree on economic status is improving slowly. And 22.5% of farmers and 13.33% of member of WUA agree that the economic status of the society is upgrading. 30% of local farmers and 26.67% of member of WUA says the economic status of society is same as before. And minority of farmers i.e 2.5% and member of WUA i.e 6.67% says the econimic status is degrading.

Irrigation Parameters

Effective Rainfall

The 60% of monthly rainfall, which exceeds 100 mm/ month, was counted as effective rainfall. The site data was the average monthly rainfall at Rampur Agricultural Station (See table 13).

Table 13.Effective Rainfall data

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm/day)	0	0	0	0	0	6	7	7	3	0	0	0

Table 14.Peak Water Requirement

Crop	Peak Water Requirement (Liter / Sec / ha)	Period
Rice (normal)	1.2	September
Rice (early)	1.8	April
Wheat	0.5	June – February
Corn	0.5	May
Mustard	0.45	November – December
Mung Bean	0.7	May
Vegetables	0.9	April
Grass (Fodder)	1.7	May

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Water Requirement

The peak water requirement of each crop is shown in table 14. Based on these figures, the peak water requirement for Narayani Scheme was estimated at 2.00 liter per sec per Ha.

Generally the water of the system is used to irrigate the land in which rice, wheat and vegetable are grown. The following Table 15, shows the water requirement up to a crop growing stage. (liter / sec / Ha.)

Table 15.Water requirement upto a crop growing stage. (liter / sec / Ha.)

Growth Stage (%)	Rice	Wheat	Vegetables
0	1.05	0.30	0.10
10	1.05	0.30	0.22
20	1.10	0.50	0.40
30	1.15	0.73	0.53
40	1.25	0.93	0.59
50	1.33	1.00	0.61
60	1.40	0.95	0.59
70	1.45	0.78	0.54
80	1.45	0.54	0.45
90	1.40	0.32	0.35
100	1.30	0.22	0.31

Data in the Tables 13 and 14 are derived from theStatistical Information on Nepalese Agriculture (2075/ 76).

Here, the effective rain cannot solely fulfill the water requirement of the crops in the field around the command area. Hence, to increase the water availability to the crop the peak water requirement for Narayani Scheme was estimated at 2.00 liter per sec per Ha.

Irrigation Efficiency

Irrigation efficiency is a percentage of retained water in an effective soil layer against the total volume of intake water. It is calculated by the conveyance efficiency (CE) multiplied by the application efficiency (AE), and they are defined as follows:

CE (%) = 100 – volume of conveyance loss / volume of intake water

AE (%) = 100 – volume of application loss / volume of inlet water

Where;

Conveyance Loss: evaporation and/or leakage loss during conveyance

Application loss: surface run-off and / or percolation out of the effective layer after inlet to a field. The irrigation efficiency according to crops is shown in Table 16.

Table 16.Irrigation Efficiency

	Rice	dry-season crops
Conveyance efficiency (%)	80	80
Application efficiency (%)	90	60
Irrigation efficiency (%)	72	48

Problem and Threats of Narayani Lift Irrigation System

Frequent Damage of Electro-Mechanical Components

The electromechanical components which are too old and the accessories are not easily available in the local market.

High Sediment in Water/ Sediment Management

NLIS usually pump water during monsoon season having high sediment content in the river, whereas during winter and spring season low water level of the Narayani river causes extreme vibration of the pumps as such pumping of water con not be continued. So pumping during the monsoon season has caused sediment problems in the canal system, inlet channel, and also damages the pump parts frequently. Previous studies on the sedimentation issues of NLIS indicated that the gabion dam in front of the inlet channel should be improved to abstract skimmed top water level of Narayani River, monitoring its concentration regularly, and pumping operation should be restricted during flood period. In addition, the lowest conduit of the gabion dam should be closed during monsoon season; neither of the above recommendations is generally followed. In order to address these problems sediment control measures should be adopted at the entry point to minimize the influx of higher order sediments, and a sediment basin provision at the link canal for removing substantial sediments probably larger than 0.06 mm size particles. The present note will explore the possible solutions for such measures and will recommend appropriate solution. Suspended sediment concentration in the river varies largely due to geological phenomenon occurring in its catchment; it varies from 8000 -15000 mg/l in common and might go up to 30000 mg/l during high flood. The hydrological station No. 450 of DHM has some data on sediment content of the river and its discharge variations. The previous studies have found some relationship of the sediment concentration. It has indicated that the average sediment concentration during June to August months varies from 1894 to 6000 mg/l as shown in Table 17.

It is certain that the sediment concentrations in the Narayani River are very high during July and August. Therefore, the gabion dam should be made as filter block to check the high concentrated sediment influx into the system.

ISSN: 2455-3190
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Table 17.Mean Monthly Discharge and Sediment Concentration of Narayani River

Mean Data of the years 2010 to 2020	June	July	August
Mean Monthly discharge m3/sec	1548	3576	4231
Mean Sediment Concentration mg/l	1894	5007	5978

Source: Narayani Lift-Khageri Management Division Office, Bharatpur

It is learnt that the system is designed for 6000 ppm concentration of sediment, however during monsoon season it varies from 2000 to 30,000 ppm, which cause frequent breakdown of the impeller blades and other accessories of the pumps at A.

Urbanization and Reduction of Irrigation Area

The existing irrigation system is located nearbyBharatpur Metropolitan city where there is regular influx of migrated population so that the urban areas are increasing by construction of physical infrastructures like buildings, roads, and others. By which there is reduced the irrigation command area. The total area under the NLIS designed irrigation is found to be reduced from the 2488.90 to 2267.90Ha among the canal "B" and 2262.35 to 944.075Ha in "C" system. The systems which will have agriculture practices in next 10 to 15 years are assumed approximately to be 2000 Ha in B System and 600 Ha in C-System.

Water Leakage from Canals

The NLIS is suffering from high leakage of the irrigation water from the main canal. Only two km length of canal B system from the beginning (especially urban area) is masonry lining and some for few other sections partly to prevent the seepage losses. About 3.5 km length of main canal C is lined and the branch canal CL-1 is lined within the urban area. The loss due to seepage in earthen channels is much more than loss by evaporation. The percentage loss in earthen canal is 15 to 20%, transit loss is 2.5%, evaporation losses is 1.5 to 2.0% of seepage loss, loss in cultivation over field 8 to 9%(Indian Practical Civil Engineer's Handbook 17/72, 2005). Based on the data, leakage assessment is shown in Table 18.

Change in Agriculture Pattern

Difference in farming program between original plan and actual situation most of farmers choose only paddy as a monsoon crop.

Over Loading in Some Tertiary Canals

In the cause there has been growing demand for outlet directly from a reliable canal, the total water management come to be quite complicated, and some quarrel arise among farmers on water distribution. Table 19, shows the percentage of land getting full irrigation water in the project.

Generally, the pump operation time is during the sowing period of rice which is mid monsoon and early winter, as field also experiences rainfall during that period and tertiary canal is verysmall and sometime due to rainfall and water from system, overloading of tertiary is seen and due to such overloading, bursting of tertiary is observed.

Regular Maintenance and Question of Sustainability

WUA and beneficiary farmers need to made more responsibilityin regular maintenance of the system. The user farmers will also be made responsive in paying regular water tariff. It is conceptualized to be responsible for local ownership and longer run sustainability of the lift irrigation system. Relative Importance index for Problem and Threats of the System shown in Table 20.

Table 18.Leakage Assessment

Main Canal	Peak Demand (m3/sec)	Supply (m3/sec)	Supply of Irrigation Water through lined and unlinned canal					
			Supply	Seepage Loss @ 20%	Loss in cultivation over fields @ 8.5%	Evaporation Loss @ 2%	Total Loss	Net Irrigation Supply
B	4.54	6.20	6.20	1.24	0.53	0.12	1.89	4.31
C	1.89	0.80	0.79	0.16	0.07	0.02	0.24	0.55

Table 19.Percentage of Land Getting Full Irrigation Water in the Project

Canal	Spring	Monsoon	Winter
"B" System	0.00 %	68.06 %	5.00 %
"C" System	0.00%	42.83%	2.50%

ISSN: 2455-3190
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Table 20.RII on Problems and Threats of NLIS

S. No.	Factors	Local Level		Member of WUA		Governmental Officials		Average Importance	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
A	Frequent Damage of Electro-Mechanical Components	59.333	3rd	76.2	2nd	58.22	3rd	63.947	3rd
B	High Sediment in Water/ Sediment Management	78.333	1st	83.6	1st	86.4	1st	83.139	1st
C	Urbanization and Reduction of Irrigation Area	60.333	2nd	71.6	3rd	73.06	2nd	68.803	2nd
D	Water leakage from canals	33.667	6th	59.8	5th	42	4th	44.838	4th
E	Change in Agriculture Pattern	40	5th	62.2	4th	32.4	5th	43.62	5th
F	Over loading in some tertiary canals	56.667	4th	33.6	7th	30.5	6th	39.281	6th
G	Regular Maintenance and Question of Sustainability	20	7th	42.2	6th	22.56	7th	27.684	7th

In this RII analysis, giving 40% preference to response of Governmental officials, 30% to response of members of WUA and 30% to views of local farmers, it is found that, Sedimentation Management is principle threat of the system.Similarly, urbanization and reduction in command area is also the threat that system has to care. Frequent damage in the components is also one of the problem and updated components should be replaced. In study water leakage is not found in high scale. This seems that, concerned authority has been doing well for maintenance, but also maintenance is a problem and should be mitigated as possible. Proper Agriculture pattern should be set and overloading of tertiary should be mitigated.

Conclusions

From the study, following conclusions are made:

The roles of NLIWUA was found to be effective,and among the different roles, NLIWUA was seen very satisfactory in Maintenance of the secondary and tertiary canal. Each year before the pump operation time maintenance work is completed.

Therole of NLIWUA was found to be not satisfactory to organize meetings and aware farmers to use the system effectively. Though meetings were called very less, only 17% of farmers regularly attended the meetings.

Dispute during the water distribution time was frequently observed and role of NLIWUA was effective in dispute management. The main reason for dispute i.e 77.3% of cases of dispute was found due to lack of co-ordiantion among the farmers regarding water allocation. Since, very less farmers attend meetings and frequently awareness and meeting was not organized this may had happened.

After the system came in operation changes was observed in socio-economic and agricultural status of the users. Women Participation in public/social works had increased, increase in economic status by 45% is noted also 55.4 % of farmers had been motivated in agriculture and shift of farmers from rice plantation to cash crop.

The water user tariff collected (Rs.221/Ha) was used only to maintain the canal. The operational cost and maintenance cost of components of pump house was allocated by Government. The budget allocated was sufficient only for temporary maintenance but system is in need of proper rehabilitation. Due to temporary repair and maintenance efficiency of the system is reduced.

Narayani Lift Irrigation System was operated around 3 to 4 months in a year and majority farmersi.e 57.5% said the water was sufficient only for one crop, hence 52.5% of farmers consider NLIS as secondary source. During the remaining 8 to 9 months majority of farmers depend on ground water sources like tube well,as well as rain water.

To provide sufficient water round the year, any kind of secondary sources should be connected to the system In this context, 60% government officials 59.3 % Member of WUA and 74% of farmers agreed. As the tail end of this

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system was on Khageri System, command area of Khageri System could also be increased and irrigation status of West Chitwan would be improved.

Among the pumps in system (i.e 5 nos in Pump house A and 4 nos in Pump house B) without frequent maintenance no pump would be in operating condition. Also one pump was completely damaged and was not operating completely. Due to this, cost of the system was increasing and on other hand water pumping volume was decreasing. Although due to rapid urbanization the command area was decreasing and with decreased water volume system was performing satisfactory.

Sediment Management was principle threat to the system. Due to silting in intake, pumps are also damaged and require frequent maintenance and decreased efficiency of pumps is noted along with increase in cost was found. Sand deposit of up to 1m in Link canal and around 0.6m in main canals, up to 0.3m in secondary and tertiary canals were found. In some places, blockage of tertiary due to sand deposits was also found.

Bharatpur Metropolitan City being a developing city in country, unplanned urbanization was rapid and due to this the command area of NLIS was continuously decreasing. The designed command area was 4700 Ha in study year command area reduced to 3282 Ha. Reduction of 1469 Ha was found.

Water leakage assessment was done based on (Indian Practical Civil Engineer's Handbook 17/72, 2005), and found that, to the demand of 6.3 m^3/sec, supply of 7 m^3/sec was done and total loss of 2.13 m^3/sec was found and which results net irrigation of 4.87 m^3/sec.

Length of Main Canal 'B' is 17.681 km with 2.5km concrete lining and in many places lining work is going on, and rest is wet masonry. Length of Main Canal 'C' is 10.2 km with 3.5km concrete lining and rest is wet masonry.Length of secondary canal is 15.5 km and all are wet masonry lining. Tertiary canal is earth canal with brick masonry in inlet points.

Recommendations

According to the results and discussion of the study, we can recommend that:

This seems, the water intake from source is insufficient for farmers, so it is recommended to add the water to intake. As, 52.5% of farmers, 40% of the member of WUA and 60% of governmental officials suggest it is most necessary of secondary source to increase abundance of water in system. Detailed Feasibility Study to add secondary source is highly recommended.

Replacement of the old worn pumps by new ones toimprove performance as old pumps isbeyond economic repair. Proper rehabilitation plan for the pump house is needed so that water supply would be increased with decreased budget for operation and maintenance.

Proper Urban Planning norms and directives should be adopted by the metropolitan city or government in order to balance and check the transformation of agricultural land to urban area. Due to unplanned and rapid urbanization service to downstream level are effected.

Either the services of irrigation system should be increased or water user tariff should be updated, since many farmers don't will to pay water user tariff. Hence new method of tariff collection could be introduced to address the condition of both NLIWUAand farmers.

Sediment Management is main problem of the system hence improvement should be done. The improvement works has to be defined in two sections; one should be around gabion dam or on the river front of the intake channel to prevent the entry of high sediment from river, second to settle the pumped sediment content in the link canal by providing settling basin with hydraulic flushing arrangement towards the river back.

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