

**EVALUATING PERFORMANCE OF IKUDHA IRRIGATION  
SUB-PROJECT IN GODAWARI MUNICIPALITY, LALITPUR**

A Thesis

Submitted to

Faculty of Humanities and Social Science  
Central Department of Rural Development  
University Campus, Kirtipur, Kathmandu, Nepal  
In Partial Fulfilment of the Requirements for the  
Degree of Master of Arts  
in  
Rural Development

**Submitted By**

**Aasha Khattri**

Central Department of Rural Development  
Tribhuvan University, Kathmandu  
Kirtipur, Kathmandu  
T.U. Regd. No. 6-1-311-001-96  
Exam Roll No: 282495

**February, 2025**

**EVALUATING PERFORMANCE OF IKUDHA IRRIGATION  
SUB-PROJECT IN GODAWARI MUNICIPALITY, LALITPUR**

A Thesis

Submitted to

Faculty of Humanities and Social Science  
Central Department of Rural Development  
University Campus, Kirtipur, Kathmandu, Nepal  
In Partial Fulfilment of the Requirements for the  
Degree of Master of Arts  
in  
Rural Development

**Submitted By**

**Aasha Khattri**

Central Department of Rural Development  
Tribhuvan University, Kathmandu  
Kirtipur, Kathmandu  
T.U. Regd. No. 6-1-311-001-96  
Exam Roll No: 282495

**February, 2025**

## DECLARATION

I hereby declare that the work entitled **EVALUATING PERFORMANCE OF IKUDHA IRRIGATION SUB-PROJECT IN GODAWARI MUNICIPALITY, LALITPUR** presented in this thesis is a genuine work done originally by me and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

-----

**Aasha Khattri**

Master of Arts in Rural Development

**Date:** 2081/08/10 BS

2024/11/25 AD

## RECOMMENDATION LETTER

This is certified that **Ms. Aasha Khattri** has completed the thesis entitled **EVALUATING PERFORMANCE OF IKUDHA IRRIGATION SUB-PROJECT IN GODAWARI MUNICIPALITY, LALITPUR** under my supervision and guidance. To the best of my knowledge, the study is original and carries useful information in the evaluation of Farmer Managed Irrigation Systems.

I, therefore, forward this thesis to the thesis committee for approval and acceptance.

.....

**Rajan Binayek Pasa, PhD**

Thesis Supervisor

Central Department of Rural Development

Tribhuvan University, Kirtipur, Nepal.

**Date:** 2081/08/12 BS

2024/11/27 AD

## APPROVAL LETTER

This thesis entitled **EVALUATING PERFORMANCE OF IKUDHA IRRIGATION SUB-PROJECT IN GODAWARI MUNICIPALITY; LALITPUR** accomplished by **Ms. Aasha Khattri** has been accepted for the partial fulfillment of the requirement of Master's Degree in Rural Development and Social Sciences.

### Evaluation Committee:

.....

**Associate Prof. Bishnu Bahadur Khatri**  
Head of Department

.....

**Asst. Prof. Ramesh Neupane**  
External Examiner

.....

**Asst. Prof. Rajan Binayek Pasa, PhD**  
Thesis Supervisor

**Date:** 2081/08/17 BS  
2024/12/02 AD

## ACKNOWLEDGEMENTS

The path to academic advancement is challenging for women, especially in Nepal. Balancing family responsibilities—supporting her children's education, encouraging her spouse's success, and caring for her in-laws for their health and happiness—brings immense joy but often delays a woman's personal growth and academic advancement. Yet, the courage to pursue one's dreams for academic advancement must come from within and be nurtured by the support of many. That happened to me also. Daring to join the MA Rural Development nearly fifteen years after completing my “Bachelor of Art” was all due to the support and encouragement of many people to whom I like to provide my deepest gratitude and appreciation.

First and foremost, I extend my heartfelt appreciation and sincere gratitude to the Central Department of Rural Development, Kirtipur, for granting me the opportunity to conduct this thesis. I am especially thankful to Mr. Bishnu Bahadur Khatri, Associate Professor and the Head of Department, for fostering a motivating environment. I am also deeply grateful to Dr. Rajan Binayak Pasa, my thesis supervisor, for his invaluable guidance and unwavering support throughout this study.

I am also deeply grateful to the dedicated teachers at the Central Department of Rural Development, whose guidance was instrumental in completing this research. My sincere thanks go to each of you. Throughout this research journey, I received invaluable help from several individuals. I sincerely appreciate Mr. Ramesh Maharjan and Mr. Suresh Brajracharya of the Ikudha-Rajkulo Water Users' Association for their time and support. My sincere thanks also go to Mr. Diwakar Bhattarai for preparing the GIS/RS maps of the study area.

Lastly, I am thankful to my friends for their encouragement and to my husband and children for their continuous support, which made this journey possible.

**Aasha Khattri**

Degree Candidate

**Date:** 2081/10/25

To,

**The Head of the Department  
Central Department of Rural Development  
Kirtipur, Kathmandu, Nepal**

**Subject: Self-declaration**

**Dear Sir/Madam,**

I hereby affirm that there exists no disparity in the substance of the physical print and digital version of the document specified below, which has been submitted to this establishment for the purpose of undergoing a plagiarism examination. If any dissimilarity is discovered between the physical print and digital version, I am prepared to accept any consequences as per the established regulations.

**Details:**

**Author Name** : Aasha Khattri

**Document Title** : Evaluating Performance of Ikudha Irrigation Sub-project in Godawari Municipality, Lalitpur

**Academic Level** : Masters

**Document Type** : Thesis

**Submitted To** : Central Department of Rural Development

**Mobile No.** : 9843526672

**Email** : [aasha\\_rkc@yahoo.com](mailto:aasha_rkc@yahoo.com)

**Signature** :



TRIBHUVAN UNIVERSITY

त्रिभुवन विश्वविद्यालय

CENTRAL DEPARTMENT OF RURAL DEVELOPMENT

ग्रामीण विकास केन्द्रीय विभाग



विभागीय प्रमुखको कार्यालय  
कीर्तिपुर, काठमाडौं, नेपाल ।  
Office of the Head of Department  
Kirtipur, Kathmandu, Nepal.

Ref. No. : .....

Date मिति 2081/10/25 .....

### Plagiarism Test Report

The MA thesis titled **Evaluating Performance of Ikudha Irrigation Sub project in Godawari Municipality, Lalitpur** submitted by **Aasha Khattri** for a plagiarism test on 2081/10/25 has been checked by the iThenticate plagiarism checker software. The software found an overall similarity index of 20% based on the following criteria.

Criteria:

- . Phrases : Excluded
- . Quotes : Excluded
- . Bibliography : Excluded
- . Small Sources : Percentage (< 1%)
- . Small Match : Word Count (<10 Words)
- . Abstract : Excluded
- . Methods and Materials : Included

Note: Kindly be advised that the similarity index produced by software may not comprehensively reflect the caliber and criteria of the document. Consequently, it is highly advisable for the appropriate authority to manually assess the examined file to ascertain its adherence to the essential benchmarks of being articulate, well-investigated, and upholding academic integrity.

.....

Authorized Signature

## ABSTRACT

Nepal is an agrarian country where agriculture is vital to rural livelihoods, employment, and the national economy. Irrigation is essential among other inputs to boost agricultural development and productivity. Only about 40 percent of Nepal's agricultural land is irrigated at present, underscoring the need for further investment in building new irrigation infrastructure and maintaining existing systems. The Ikudha Irrigation Sub-project (IISP), with a history spanning over a century, has been traditionally established and operated by local farmers. It is situated in wards 3, 4, and 14 of Godawari municipality. The IISP provides irrigation facilities to 70 hectares of farmland and benefits to over 500 families. Its water source is the perennial, spring-fed Godawari River, originating from the nearby Godawari hill range. The government of Nepal and the Asian Development Bank have periodically invested in modernizing and improving its operating mechanism and management.

This study aims to evaluate the relevancy, efficiency, effectiveness, impact, and sustainability of IISP and its role in agricultural development. This study used a case study research design in which required data were collected from 69 households (out of a total of 268 households of ward no.14) by using the household survey. The study also used Focus Group Discussions (n=3) and Key Informant Interview (n=7) techniques for collecting narrative information from the participants. Besides, the changes in the watershed and irrigation command areas were mapped using Arc GIS software through an analysis of Google Earth imagery.

The study found that IISP becoming relevant to increasing agricultural production. The operating mechanism also has been performing efficiently and effectively in increasing agriculture production and productivity. The irrigation facility also impacted positively in increasing family income, health, and hygiene as well as education life span and other amenities. However, due to the diversification of family income sources, the overall positive impact on farm-based livelihood has decreased to date compared to the past. The study also found that land use changes have occurred across the municipality, including the Godawari watershed and IISP command areas. With the significant increase in land prices, the conversion rate of agricultural land to built-up areas has increased dramatically. The flow of sewage and waste into the canals, sedimentation, and encroachment activities have challenged the sustainability of the irrigation system. Maintaining the head works, main canal, branch canals, and field channels is critical to ensuring efficient water flow and minimizing seepage.

Finally, the study concludes that the operating mechanism of the IISP is performing satisfactorily. It has used both traditional and modern practices to maintain its relevancy and provide efficient services which is becoming effective and impactful for promoting agriculture production. However, from the sustainability point of view, there is a disconnect between protecting agricultural land and expanding irrigation facilities. Therefore, the provincial government and local government need to provide technical and financial support to develop and implement standard norms and regulations for the sustainability of IISP.

## TABLE OF CONTENTS

<b>DECLARATION</b>	<b><i>i</i></b>
<b>RECOMMENDATION LETTER</b>	<b><i>ii</i></b>
<b>APPROVAL LETTER</b>	<b><i>iii</i></b>
<b>ACKNOWLEDGEMENTS</b>	<b><i>iv</i></b>
<b>ABSTRACT</b>	<b><i>vii</i></b>
<b>TABLE OF CONTENTS</b>	<b><i>viii</i></b>
<b>LIST OF THE TABLES</b>	<b><i>xi</i></b>
<b>LIST OF FIGURES</b>	<b><i>xii</i></b>
<b>ACRONYMS/ABBREVIATIONS</b>	<b><i>xiii</i></b>
<b>CHAPTER I</b>	<b><i>1</i></b>
<b>INTRODUCTION</b>	<b><i>1</i></b>
1.1 Background of Study	<b><i>1</i></b>
1.2 Problem Statement	<b><i>4</i></b>
1.3 Objectives of the Study	<b><i>6</i></b>
1.4 Significance of the Study	<b><i>6</i></b>
1.5 Limitations and Delimitations of the Study	<b><i>7</i></b>
1.6 Organization of the Study	<b><i>8</i></b>
<b>CHAPTER II</b>	<b><i>9</i></b>
<b>LITERATURE REVIEW</b>	<b><i>9</i></b>
2.1 Conceptual Review	<b><i>9</i></b>
2.1.1 Agriculture as the Backbone of the Nation's Economy	<b><i>9</i></b>
2.1.2 Irrigation and Agricultural Productivity	<b><i>10</i></b>
2.1.3 Historical Development of Irrigation System	<b><i>11</i></b>
2.2 Theoretical Bases	<b><i>15</i></b>
2.2.1 Theory of Agriculture Modernization	<b><i>15</i></b>
2.2.2 Irrigation System as Common Pool Resource	<b><i>15</i></b>
2.3 Policy Practices	<b><i>16</i></b>
2.4 Empirical Studies	<b><i>22</i></b>
2.5 Conceptual Framework of the Study	<b><i>25</i></b>
<b>CHAPTER III</b>	<b><i>26</i></b>

<b>RESEARCH METHODS AND METHODOLOGY</b>	<b>26</b>
3.1 Research Philosophy	26
3.2 Research Paradigm	26
3.3 Research Design	26
3.4 Selection of the Study Area and Rationale	27
3.5 Nature and Sources of Data	28
3.6 Population, Sampling, and Sample Size Distributions	29
3.7 Data Collection Techniques and Tools	29
3.7.1 Household Survey	29
3.7.2 Focus Group Discussion	29
3.7.3 Key Informant Interview	29
3.8 Data Analysis and Interpretation	30
3.9 Ethical Consideration	30
<b>CHAPTER IV</b>	<b>31</b>
<b>INTRODUCTION OF THE STUDY AREA</b>	<b>31</b>
4.1 Godawari Municipality	31
4.2 Irrigation Systems in Godawari	33
4.3 History of Ikudha Irrigation Canal	34
4.4 Ikudha Water User's Association	37
<b>CHAPTER V</b>	<b>39</b>
<b>DATA ANALYSIS AND INTERPRETATION</b>	<b>39</b>
5.1 Socio-economic Information	39
5.1.1 Profile of the Respondents	39
5.1.2 Land Holding Status of the Farmers	39
5.1.3 Economic Status of the Farmers	40
5.2 Operating Mechanism and Management of Irrigation Sub-project	40
5.2.1 Formation of Water User Association	40
5.2.2 Maintenance of the Irrigation Canals	41
5.2.3 Distribution and Availability of Water	41
5.2.4 Governance Challenges and Issues	42
5.3 Evaluation of the Ikudha ISP	43
5.3.1 Perceived Relevancy	43
5.3.2 Perceived Efficiency	44

5.3.3 Perceived Effectiveness _____	46
5.3.4 Perceived Impact _____	47
5.3.5 Perceived Sustainability _____	49
<b>5.4 Role of Irrigation Sub-project in Agricultural Development _____</b>	<b>51</b>
5.4.1 Irrigation and Agricultural Development _____	51
5.4.2 Food Sufficiency/Adequacy _____	53
5.4.3 Functions of Performance Indicators for Agriculture Development _____	54
5.4.4 GIS Map Change Detection _____	55
5.4.5 Changes in Land Use _____	57
<b>CHAPTER VI _____</b>	<b>59</b>
<b>SUMMARY OF FINDINGS, CONCLUSIONS AND IMPLICATIONS _____</b>	<b>59</b>
<b>6.1 Summary of Findings _____</b>	<b>59</b>
<b>6.2 Conclusions _____</b>	<b>61</b>
<b>6.3 Implications _____</b>	<b>62</b>
6.3.1 Theoretical Level Implication _____	62
6.3.2 Policy Level Implication _____	63
6.3.3 Managerial Level Implication _____	64
<b>6.4 Areas for Further Research _____</b>	<b>64</b>
<b>REFERENCES _____</b>	<b>66</b>
<b>APPENDICES _____</b>	<b>70</b>
Appendix A: Household Survey Questionnaires _____	70
Annex B: FGD and KII Guidelines _____	76
Annex C: Members of Ikudha Rajkulo Water User Association's _____	77
Appendix D: Land Use Changes in the Godawari Watershed & Command Areas _____	78
Appendix E: Glimpses of the Field Study _____	79

## LIST OF THE TABLES

Table 3.1. <i>Philosophical Assumptions of the Study</i> _____	26
Table 4.1. <i>Demographic Characteristics of the Households</i> _____	32
Table 4.2. <i>Descriptions of the key features of Ikudha Irrigation System</i> _____	36
Table 5.1. <i>Average land size of the Ikudha Irrigation Command Area</i> _____	39
Table 5.2. <i>Cost Sharing by the User Group in the Construction and Maintenance</i> ____	41
Table 5.3. <i>Perceived Perception the Respondents on Water Availability</i> _____	42
Table 5.4. <i>Perceived Relevancy of the Ikudha Irrigation Project</i> _____	43
Table 5.5. <i>Perceived Efficiency of Ikudha Irrigation Project</i> _____	45
Table 5.6. <i>Perceived Effectiveness of the Ikudha Irrigation Project</i> _____	46
Table 5.7. <i>Perceived Impacts of the Ikudha Irrigation Project</i> _____	48
Table 5.8. <i>Perceived Sustainability of the Ikudha Irrigation Project</i> _____	50
Table 5.9. <i>Agriculture Development after Irrigation Facilities</i> _____	53
Table 5.10. <i>Family Food Sufficiency from Own Production</i> _____	53
Table 5.11. <i>Functions of Agriculture Development</i> _____	54
Table 5.12. <i>Data Types &amp; Layers Used for Preparing GIS Map of Study area</i> _____	56
Table 5.13. <i>Changes in the Land Cover from 2000 to 2019 in Godawari Area</i> _____	58

## LIST OF FIGURES

<i>Figure 2.1.</i> Conceptual Framework of the Study _____	25
<i>Figure 3.1:</i> Map of the Godawari Municipality _____	28
<i>Figure 4.1.</i> Map Showing the Study Area and Adjoining Municipalities _____	31
<i>Figure 4.2</i> Forest Cover Map of Godawari Municipality _____	33
<i>Figure 4.3:</i> Location Map of Ikudha Irrigation Sub-project _____	34
<i>Figure 4.5:</i> Ethnic Composition of Ikudha Water User Group _____	37
<i>Figure 5.1.</i> Methodology for Map Layout _____	57

## ACRONYMS/ABBREVIATIONS

AD	:	Anno Domini
ADB	:	Asian Development Bank
ADS	:	Agriculture Development Strategy
AMIS	:	Agency Managed Irrigation Systems
APP	:	Agricultural Perspective Plan
BCM	:	Billion Cubic Meter
B.S.	:	Bikram Sambat
CBS	:	Central Bureau of Statistics
CPR	:	Common Pool Resources
DoI	:	Department of Irrigation
DoWRI:		Department of Water Resources and Irrigation
FAO	:	Food and Agriculture Organization
FGD	:	Focus Group Discussion
FMIS	:	Farmer Managed Irrigation System
FRTC	:	Forest Research and Training Centre
FY	:	Fiscal Year
GDP	:	Gross Domestic Product
GIS	:	Geographic Information System
GON	:	Government of Nepal
Ha	:	Hectare
HH	:	Household
HMG	:	His Majesty's Government
ICID	:	International Commission on Irrigation and Drainage
IMP	:	Irrigation Master Plan
IISP	:	Ikudha Irrigation Sub-Project
IS	:	Irrigation System
ISF	:	Irrigation Service Fee
ISP	:	Irrigation Support Programme
JMIS	:	Jointly Managed Irrigation Systems
LDC	:	Least Developed Countries
LPG	:	Liquefied Petroleum Gas
MoALD:		Ministry of Agriculture and Livestock Development
MoF	:	Ministry of Finance
MoH	:	Ministry of Health
MoEWRI:		Ministry of Energy, Water Resources and Irrigation
NEC	:	Nepal Eastern Canal
NISP	:	Nepal Irrigation Sector Project
NPC	:	National Planning Commission
NPHC	:	National Population and Housing Census
NRB	:	Nepal Rastra Bank
RoR	:	Run-off-River
SDG	:	Sustainable Development Goal
SSI	:	Semi-structured Interview
TEPC	:	Trade Export Promotion Centre
USAID:		United States Assistance for International Development
WECS	:	Water Energy Commission
WUA	:	Water User Association
WUG	:	Water Users' Group

# CHAPTER I

## INTRODUCTION

### 1.1 Background of Study

The irrigation system and water resources are considered common-pool resources. Common-pool resources are systems that produce a limited amount of resource units, meaning that when one person uses them, it reduces the amount available to others (Ostrom et al., 1994). Common-pool resources are either natural or human-made resources characterized by two key aspects: (i) it is particularly challenging and costly to exclude potential beneficiaries through physical or institutional means, and (ii) exploitation by one user decreases the availability of the resource for others. Thereby, irrigation systems are among the most important types of common-pool resources for organizing and coordinating irrigational activities (Ostrom, 1992a). Overutilization of resources without their maintenance and wise use leads to resource degradation or scarcity. That ultimately becomes the failure or collapse of the systems and resources.

Water resources and community-managed irrigation systems are among the good examples of Common Pool Resources in Nepal. The efforts of a single farmer in the maintenance and repair of the irrigation canal do not limit the utilization of the water to him and herself only. The collective actions in the maintenance and management of the irrigation facilities may become cheaper and more effective. However, the collective management of the common pool resources faces many challenges and requires special attention.

It is easier to measure three performance measures: (1) the physical condition of irrigation systems, (2) the quantity of water available to farmers at different seasons of the year, and (3) the agricultural productivity of the systems. Lam (1998) reported that irrigation systems governed by the farmers themselves perform significantly better on all three performance measures provided other variables are constant.

Nepal is an agrarian country with limited land and a relatively large population of 29,192,480, growing at a rate of 0.93 percent (NSO, 2021). Agriculture plays a crucial role in rural livelihoods, employment, and the national economy. Approximately 25.8 percent of Nepal's Gross Domestic Product is

derived from the agricultural sector (NSO, 2021; MoF, 2021). Despite this, the sector's contribution to the economy is declining (MoF, 2021). Nonetheless, agriculture remains the largest source of employment in Nepal, engaging over 70 percent of the population.

Nepal is a country rich in water resources, with an abundance of water in the form of snow covers, rivers, springs, lakes, and groundwater. Annual rainfall varies widely across the country, ranging from 250 mm to 5,000 mm, with an average of 1,500 mm (WECS, 2011). Nepal is home to large rivers such as the Mechi, Koshi, Karnali, Mahakali, and Narayani, as well as numerous smaller rivers. There are 33 rivers in Nepal with drainage areas exceeding 1,000 km<sup>2</sup>, contributing significantly to the country's water supply (WECS, 2011). In total, Nepal has over 6,000 rivers, collectively draining about 225 billion cubic meters (BCM) of water annually, equivalent to an average flow of 7,125 m<sup>3</sup>/s. However, only 29.3 BCM of this water is utilized each year (WECS, 2011; MoEWRI, 2018; DoWRI, 2019). Of the utilized water, approximately 98.2 percent (28.8 BCM) is used for agriculture, while only about 1.7 percent is allocated to industry (WECS, 2011; MoEWRI, 2018). Despite the abundant water resources, their utilization for economic and social development in Nepal remains low.

Proper management and utilization of water are crucial for achieving a sustainable green revolution. Globally, the green revolution in agriculture began in the 1940s in Mexico and spread worldwide during the 1950s and 1960s. The green revolution refers to the adoption of modern agricultural methods and technologies, such as high-yielding variety seeds, tractors, fertilizers, pesticides, and irrigation facilities, to boost productivity. In Nepal, efforts toward a green revolution began at the policy level after the 1950s. However, due to the lack of modern technology, equipment, agricultural inputs, irrigation facilities, and investment, the green revolution in Nepal remains in its very early stages.

In this context, irrigation is a critical factor for the development and productivity of the agricultural sector. Currently, only about 40 percent of agricultural land in Nepal has some form of irrigation (DoWRI, 2019), and just one-third of this irrigated land benefits from year-round irrigation facilities (MoEWRI, 2018). Much of the agricultural land remains unirrigated, is cultivated only during the rainy season, and has lower productivity compared to its potential. To address this, the Government of Nepal has been implementing large-scale

irrigation projects, primarily targeting the arable lands of the Terai lowlands. Examples include the Bagmati Irrigation Project, Narayani Irrigation Project, Sikta Irrigation, Bheri-Babai Diversion Multipurpose Project, Sunkoshi-Marin Diversion Project and Ranijamara-Kularia Irrigation Project etc. These are predominantly government-led joint-managed irrigation systems.

Out of Nepal's 2,641,000 hectares of agricultural land, approximately 1,766,000 hectares are suitable for irrigation (MoEWRI, 2018). Currently, irrigation facilities are available on 1,433,287 hectares, including 443,365 hectares with underground irrigation, 167,925 hectares of farmer-managed irrigation, and 813,067 hectares of surface irrigation (MoEWRI, 2018).

Nepal has implemented medium-sized irrigation infrastructures that support between 100 and 2,000 hectares of agricultural land in the Terai, and between 10 and 500 hectares in the hills and mountains. The country has completed 445 such medium-sized irrigation projects, providing consistent and reliable irrigation to 58,403 hectares of land (MoEWRI, 2018). Most of these irrigation systems are based on the run-of-the-river (RoR) concept, which results in reduced water availability during the winter months.

In FY 2018/19, only 33 percent of irrigable land in Nepal had year-round access to irrigation, with a goal to increase this to 50 percent by the end of FY 2023/24 (NPC, 2020). However, this target set by the 15th periodic development plan of the Government of Nepal has not been achieved. The area of agricultural land with irrigation is gradually expanding through the maintenance of traditional systems and the implementation of new technologies. Of the total 2,641,000 hectares of arable land, 2,265,000 hectares are considered irrigable. By the end of FY 2018/19, infrastructures were developed to irrigate 1.473 million hectares land (NPC, 2018).

Owing to this research, several indigenous irrigation canals exist in Lalitpur district, where traditional irrigation practices have been in place for a long time. Examples include the Tapau-Dha Irrigation Project, Godawari Irrigation Project, Godamchaur Rajkulo Irrigation Project, Tikabhairav Rajkulo, Tileshwor Irrigation Project, and Ikudha Irrigation Sub-Project. Farmers from various wards in Lalitpur district benefit from these small-scale irrigation systems, which were established by local communities.

Numerous surface irrigation projects in Lalitpur district have been initiated and maintained by local farmers and communities to irrigate their lands. These community-led projects are primarily small-scale Farmer Managed Irrigation Systems (FMIS). One such project, the Ikudha Irrigation Sub-project, is an FMIS located in Godawari municipality, ward number 14. It has been in operation for many years, with the residents of Badegaun and Thaiba utilizing water from the Godawari River to irrigate their fields. The source of water is spring fed perennial source. The irrigation area is situated at the left bank of the Godawari river and located in between latitudes 27°22'11"N and 27°22'28"N, and longitudes 85°20'38"E and 85°21'30"E, at an elevation of approximately 1425 - 1450 meters above sea level.

"Iku Dha" is a Newari term, with "Dha" meaning "Kulo" (irrigation canal). This canal has been operating by the collective efforts of the local farmers, with significant support from the Department of Irrigation for upgrades and rehabilitation in 1981 (DoI, 2009). The Ikudha Irrigation Project has a command area of approximately 75 hectares, benefiting the residents of Godawari Ward Nos. 4 and 13. The project area includes 331 households, with a population of 1,800 (ADB, 2009) and has increased rampantly afterward. The Godawari River, a spring-fed perennial river, serves as the water source for the Ikudha system, with a winter discharge measured at 124 liters per second (DoI, 2009). The Ikudha irrigation sub-project has common property governance, scarcity of water resources, equitable distributions of water resources and conflict resolution related issues. Therefore, this study aimed to evaluate performance of Ikudha irrigation sub-project by using five evaluation indicators: relevancy, efficiency, effectiveness, impact and sustainability.

## **1.2 Problem Statement**

The global population is projected to reach 9.7 billion by 2050 and could peak at nearly 11 billion around 2100 (UN, 2022). In Nepal, the average population growth rate has slowed from 1.35 percent to 0.93 percent (CBS 2011, NSO, 2021). The population in Nepal, as well as globally, has been steadily rising (NSO, 2021). Despite this, the country still faces the challenge of feeding a large population. Approximately 4.6 million people in Nepal are food insecure, with 20 percent of households experiencing mild food insecurity, 22 percent moderate,

and 10 percent severe food insecurity, according to the Nepal Demographic and Health Survey 2016 (MoH, 2017). Food insecurity is particularly prevalent in rural areas where subsistence farming relies on low-yield, rain-fed agriculture. In rural areas, 12 percent of the population is severely food insecure, compared to 9 percent in urban areas (MoH, 2017).

Agriculture remains the largest employer and a significant contributor to the national economy, yet crop production falls short of meeting the growing food demand. Although 70 percent of Nepal's population is engaged in agriculture, production levels are insufficient to feed everyone. The demand for food continues to rise due to various factors such as changing food habits, increased purchasing power, urbanization, population growth, and modernization.

Nepal aims to transition from a Least Developed Country (LDC) to Developing Country status by 2026. Achieving "Zero Hunger," one of the United Nations' Sustainable Development Goals (SDG 2), is also a national priority, and the Government of Nepal is working towards this goal. Furthermore, the Constitution of Nepal (2072) protects the "Right to Food" as a fundamental right of the people. Beyond doubt, expanding and promoting effective and sustainable irrigation facilities is crucial for achieving these Sustainable Development Goals and upholding the constitutional rights of the population.

The nation's development aspirations cannot be realized without a significant transformation in the agricultural sector in Nepal. Agriculture is a key driver for industrial development, as there is a positive correlation between the two in an agrarian country. The agricultural sector supplies essential raw materials for industries, making its development crucial for industrial growth. To achieve the goal of transitioning from a Least Developed Country to Developing Country status by 2022, and further to a middle-income country by 2035 and a Developed Country by 2050 (NPC, 2015), it is essential to build a self-reliant economy with sufficient and surplus production.

Adequate water and irrigation facilities are essential for advancing Nepal's agricultural sector, but irrigation remains a limiting factor. Despite significant efforts by the Government of Nepal, irrigation facilities across the country are still insufficient. FMIS has a longstanding role in meeting irrigation needs, which reduces the government's financial burden and labor. Therefore, FMIS should be encouraged and prioritized, with increased technical support provided through

training and exposure visits. All three levels of government (federal, provincial, and local) should support these systems. Rapid conversion of irrigated farmland to urban areas, as seen in the Ikudha irrigation command area, threatens agricultural sustainability. To address this, the government should strictly enforce Nepal's land-use policy to prevent agricultural land from being repurposed. Local governments should not permit the conversion of irrigated farmland into urban developments, helping to ensure that agricultural land remains dedicated to farming.

In Nepal, key challenges in irrigation include outdated infrastructure and the poor performance of existing systems, low system efficiency, and underutilization of canal water. Additional issues are weak participation from (WUAs), limited institutional capacity, insufficient integration between agriculture and irrigation, and the persistence of subsistence farming practices in command areas (Gajmer, 2014). Therefore, effective irrigation systems and their proper management are crucial for enhancing agricultural productivity and ensuring food security by ensuring adequate availability, accessibility, utilization, and stability of food resources.

### **1.3 Objectives of the Study**

The general objective of this study is to evaluate the performance of the Ikudha irrigation sub-project for agriculture development in the command areas. The specific objectives are as follows:

- i) To examine the operating mechanism of the Ikudha irrigation sub-project.
- ii) To evaluate the relevancy, efficiency, effectiveness, impact, and sustainability of irrigation sub-project mechanisms in promoting agriculture and its functionality.
- iii) To assess the role of the Ikudha irrigation sub-project in agricultural development.

### **1.4 Significance of the Study**

The proper management of the irrigation system is very crucial in fulfilling the water needs throughout the year. To overcome the uncertainty of the rainwater available and water shortage for different crops, the Government of Nepal and farmer communities have established and operated different irrigation systems in

Nepal. Nepal has tremendous water resources. However, agriculture is mostly dependent on rain. Due to the lack of water, the average productivity of land is very low. Irrigation is important to increase land's productivity. Applications of water to the plants increase their productivity. Despite the different needs of the plant according to its species requirement, water is the most important element for the growth and production of the crops. Some plants especially paddy need plenty of water during the cultivation period and the availability of the water in different stages of the plants and seasons determines the growth and production of the crops. Dependence on rainwater for cultivation increases the insecurity of crop production. To overcome the uncertainty of water availability during cultivation, irrigation is an important element. In this context, this study also analyzed the role of the Ikudha irrigation sub-project in agriculture development.

This study focuses on the role of Water User Groups (WUGs) as well as other responsible stakeholders in the management of the Ikudha, irrigation system. People's participation in canal maintenance along with equitable water distribution among users is inevitable for the sustainability of the irrigation system. The local governance systems and patterns are also the areas of the study that support the sustainability of this irrigation sub-project. This study attempts to evaluate the relevancy, efficiency, effectiveness, impact, and sustainability of the Ikudha Irrigation subproject. The findings will be valuable for the local level Government and the respective Water User Groups to identify strengths and weaknesses in the project's management. Timely identification of resources needed for rehabilitation and maintenance helps address any ongoing issues and facilitates updates and improvements to the canal's physical structure and organizational operations.

Additionally, the study also analyzed the involvement of user groups in the project's management. Therefore, this study offers reflections on similar community-managed irrigation projects and provides guidance for developing better management systems throughout the country.

### **1.5 Limitations and Delimitations of the Study**

This study focused on operating and management performances of the Ikudha irrigation sub-project and its role in agriculture development. The study is conducted in the Badegaun and Thaiba areas of the Ikudha community

Irrigation sub-project located in Godawari municipality of Lalitpur district. Most of the project beneficiaries' members belong to Newar communities. The required data are collected from 69 beneficiaries' households by using household survey questionnaires. The measurement indicators such as relevancy, efficiency, effectiveness, impact, and sustainability have been used to analyze the operating and management performance of the Ikudha irrigation sub-project. The socio-economic and biophysical changes in the irrigation command areas and their adjoining geography also have been discussed.

## **1.6 Organization of the Study**

This study is divided into six chapters. The first chapter deals with the background information of the study, problem statement, objectives of the study, significance of the study, and delimitation of the study. The second chapter reviews existing literature, covering previous research on irrigation development in Nepal, management practices of irrigation systems, and the contribution of FMISs to the national irrigation framework. The third chapter outlines the research methodology, guiding the research design, techniques of data collection, and interpretation process. The fourth chapter highlights the introduction of the study area. The fifth chapter focuses on data analysis and interpretation. Finally, the sixth chapter presents the summary of findings, conclusion, and implications.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Conceptual Review**

##### **2.1.1 Agriculture as the Backbone of the Nation's Economy**

The agricultural sector serves as a driving force for economic growth and plays a central role in national and global economies (UN, 2015). Agriculture serves as a primary source of food, employment, and income for 40 percent of the world's population (UN, 2015). According to the Food and Agriculture Organization, approximately 67 percent of the world's population resides in agricultural areas (FAO, 2021). Advancements in agriculture contribute not only to economic growth but also create self-employment and job opportunities for young people. In Nepal, agricultural products account for an estimated 35 percent of total exports (WB, 2022). The value of global agricultural exports in 2020 was 3.7 times higher than in 2000, with agriculture's share in total merchandise trade rising from 6.3 percent in 2000 to 8.5 percent in 2020 (FAO, 2021).

Nepal is an agricultural country. It has an area of 147,516,000 ha (FRTC, 2024). Among which 2,641,000 ha of land is cultivable. The crop productivity of the agricultural land of Nepal is 3.21 Metric Tons per hectare (MoALD, 2022). The Agriculture Sector Contribution to the nation's GDP has been constantly decreasing for many years reaching 23.95 percent in 2021/22 (NRB, 2022). Besides a huge population involved in agriculture, 55 districts are food deficit districts. Less than 54 percent of people are living in subsistence farming and 21.6 percent are people with rampant poverty and hunger (MoALD, 2022).

The agriculture sector has huge potential in the Nepalese economy as it provides employment to over 70 percent of the country's population (MoALD, 2022) and it is a part of their livelihood. However, subsistence production of agricultural products leads countries to food insecurity and trade deficits. Despite commercialization in agriculture farming, production has failed to cope with growing food demand. In fiscal year 2021/22, the imports of agricultural products have risen to Rs. 325 billion which was Rs. 250 billion in 2019/20 (TEPC, 2021). Increasing agricultural productivity increases farm incomes, increases food supply, lowers food prices, and creates more job opportunities (DFID, 2017).

Investment in increasing agriculture productivity is necessary to become a country self-sufficient in food and economically independent. Although agriculture is a major sector of Nepal's economy, production and productivity have not increased due to various reasons such as land fragmentation, unavailability of modern inputs, lack of proper irrigation systems, lack of access to credit to the small farmers, dependency on monsoon, and so on.

### **2.1.2 Irrigation and Agricultural Productivity**

Irrigation has positive consequences in agriculture production. Water is one of the most important inputs along with others for farming. One hectare of irrigated cropland is worth multiple acres of rain-fed cropland. Globally, 40 percent of food is produced on irrigated land, which makes up only 17 percent of the land being cultivated. FAO estimates that agriculture currently accounts for 70 percent of global freshwater withdrawals (FAO, 2012).

Improvements and optimum irrigation management increase agricultural production and reduce the water demand (Perry et al., 2009). Irrigated yields are more stable than unirrigated or rainfed cultivation. An extensive study by Vaidyanathan et al. (1994) found that one hectare of irrigated land produced 150 percent higher values than unirrigated land in South India. This is mainly due to the diversification of cropping patterns, intensity of cultivation, the introduction of high-yielding variety, and individual crop yields.

Irrigation development provides growth in primary agricultural production. Irrigation impacts farm production in three important ways. It is found that after irrigation facilities, the yields of conventional crops increased by two to three-fold in drier regions of Alberta, USA. There is also the possibility to increase crop diversity by cultivating high-value special crops that give greater returns than in unirrigated areas. Further, irrigated crop yields are more stable and have greater income stability compared to unirrigated crops. It allows the farmers to meet the production targets and fulfill the marketing contracts. In some dry areas, irrigation may serve as the only water source for cultivation as seen in the desert. Also, in prolonged drought cases, it provides water as per the requirements of the crops.

### 2.1.3 Historical Development of Irrigation System

The history of irrigation is traced back to ancient times. However, institutional, and organizational development evolved globally since the 1950s. As per the International Commission on Irrigation and Drainage (ICID, 2016), perennial irrigation was in practice in the Mesopotamian plain by diverting water from small channels formed in the field. The oldest known irrigation method known as Qanats developed in Persia in 800 BC, and is still in use today.

Human civilizations had begun near the banks of the large rivers. The reason behind this could be the availability of water as the prominent factor for livelihood. The deposition of the fertile soils in the lowland banks of the large river and availability of the water for the irrigation of crops are the main reasons for the human civilizations in the riverbank such as Nile, Brahmaputra, Mesopotamia, etc. Irrigation is the most essential element for the maximum use of land throughout the year by producing two or three crops and by cultivating long-duration commercially important crops. It facilitates the most intensive use of scarce land resources, and it is also essential for increasing the use of yield-increasing inputs and enhancing the cropping intensity and crop productivity (Narayanmoorhty, 1997).

In Nepal, the primary goal of the irrigation system is to develop controlled and year-round irrigation sustainably through optimum utilization of available water resources for increasing agricultural productivity (HMG, 2002). The government of Nepal (GoN) prioritized the construction of irrigation infrastructure since the first planned development. The Government of Nepal used internal and foreign resources to build small, medium, and large-scale irrigation systems. The irrigation development phase of Nepal can be categorized into six periods which are as follows:

**Early Development Phase (Before 1956).** There is a long history of irrigation development in Nepal. There was community involvement in irrigation construction, management, and operation in the initial days, and in a few cases, there was financial and technical support from the Government in this phase. The Civil Code, namely the National Statute of 1854 has this provision for the operation and management of irrigation systems. Traditional Rajkulos constructed during the 17<sup>th</sup> and 18<sup>th</sup> centuries in Kathmandu valley (Pradhan & Yoder, 1990)

demonstrated excellent irrigation culture. Some of the Rajkulos are still in operation in Kathmandu. Argheli Irrigation System was constructed in Palpa during the 17<sup>th</sup> century by Mani Mukunda Sen, the first king of Palpa. Chandra Nahar, the first public sector canal, with a net command area of 10,000 ha was constructed in 1922 and is still in operation (Pradhan & Yoder, 1990; FAO, 2009). Similarly, Judha Nahar 1946 and Phewa Lake Dam are examples of the early development phase of the irrigation system in Nepal.

**Infrastructure Development Phase (1957-1970).** The government initiated and expanded irrigation infrastructure during this phase with support from bilateral and multilateral agencies such as the World Bank, ADB, and India, etc. The focus was on developing essential irrigation infrastructure and supplementary irrigation facilities. Examples of infrastructure projects constructed during this period include the Chandra Nahar, West Koshi, West Gandak, Narayani, Banganga, Kamala, and Mahakali irrigation projects.

**Intensive Development Phase (1971-1985).** The government began to invest a huge amount with support from foreign aid in irrigation infrastructure between 1971 and 1985. There was a strong focus on command area development (CAD) up to 25-40 hectares and intensive irrigation in this phase. Sunsari-Morang Irrigation Project (SMIP), Narayani Zone Irrigation Project (NZIP), Manusmara Irrigation Project, West Gandak, and Kankai are some examples of the projects developed in this period. Similarly, there was groundwater development in the Bhairahawa-Lumbini, Kailali, and Kanchanpur districts of Nepal.

Then HMGN received US\$ 14.00 million from the World Bank for Narayani Zone Irrigation and Development Project stage 2 in 1978 to upgrade and increase the capacity of the existing Nepal Eastern Canal (NEC) irrigation system and extend the development of its command area. The project included the improvement of NEC's remaining length (52 km) beyond that restored (27 km) under Stage I; protection of NEC against flood damage; further development of the NEC command's irrigation distribution system; drainage network and canal service roads in 12,700 ha, and improvement of those constructed in 16,000 ha in Stage I.

**Integrated Development Phase (1986-1990).** There was a focus on hill irrigation in this phase. There were several integrated development projects conducted in this period such Resource Conservation and Utilization Project

(RCUP) in the Dhaulagiri zone, the Koshi Hills Area Rural Development Programme (KHARDEP) and the Koshi Hill Development Project of the UK Government and Rapti Development Project of USAID. The irrigation project was integrated with the agriculture and forestry projects during this phase. There were several projects conducted in the hills of Rasuwa-Nuwakot, Sagarmatha, Koshi Hill, Mahakali, Karnali-Bheri, Seti, Mechi, and Rapti regions of Nepal.

**Participatory Development Phase (1991-2012).** With the government's priority of decentralization in Nepal, the Government devised the Irrigation Policy and regulation giving space for the involvement of the WUA. The government initiated the formation and handed over the small to medium-sized irrigation projects to the WUA for their operation, management, and maintenance. The management rights transferred to the WUA have been proven successful in the sustainable utilization of water resources cheaply and cost-effectively. Some irrigation sector projects such as Nepal Irrigation Sector Project (NISP) and Irrigation Sector Project (ISP) were developed to strengthen WUA for the management and maintenance of irrigation projects.

**Modern Irrigation (2013-todate).** This phase is known for the focus and priority of the government to introduce and implement the most modern technology in irrigation development projects. The GoN has devised and implemented megaprojects such as river diversion projects with a focus of year-round irrigation to large areas. The GoN has inaugurated the Sunkoshi Marin Diversion Multipurpose Project, Sindhuli to irrigate an additional 122,000 ha of land in Dhanusha, Mahotari, Sarlahi, Rautahat and Bara. Similarly, the Bheri Babai Diversion Multipurpose Project is the first of its kind of inter-basin water transfer project conceptualized to provide a round-the-year irrigation facility to 51,000 ha of land of Banke and Bardia district. Similarly, the Sikta Irrigation Project has been developed to provide water for reliable irrigation in 42,766 hectares of land at Banke, Nepal.

After the restructuring of Nepal into federal systems, three tiers of government have different roles and responsibilities in the development and maintenance of irrigation systems in their respective jurisdictions. It is necessary to mobilize investment from the federal government for large irrigation facilities with strategic importance; from the provinces for medium-scale irrigation facilities; and from the local level for small irrigation projects which has been the

priority implementation of all tiers of Government in Nepal at present. There are several irrigation management systems in Nepal broadly categorized into two groups those operated and managed by FMIS and those operated either fully by the government or jointly by the government and users called agency-managed irrigation systems.

Irrigation development in the country remained in the hands of people for many years giving birth to the FMIS (Pradhan, 1989). Almost 70 percent of all irrigated land in Nepal is under farmer-managed irrigation systems (Pradhan, 2000). FMIS is a democratic institution and is considered as a national heritage due to its inherent democratic and indigenous characteristics (Pradhan, 2000). FMIS are usually simple traditional systems created by farmers to divert water from both seasonal and permanent streams and rivers. The government began a program of assisting selected FMIS to upgrade their primary infrastructure.

Government intervention has focused on constructing permanent diversions and upgrading primary canals. FMIS renovation was also identified as an opportunity to strengthen WUAs with a proven track record of self-sustained operation and maintenance. Mostly small and medium in size, FMIS has good scope for enhancing productivity and expanding command areas. Further, the FMIS is found effective in managing the water resources to achieve improved agricultural production as they are capable of a) timely delivery of water; b) allocation and distribution of the water; c) labor mobilization for maintenance; d) raising cash to pay for the maintenance of the system; e) supervising and carrying out construction; and f) identifying the most serious problems in physical structure and finding solutions.

The irrigation system is categorized under the basis of development, coverage of command area and management. Based on development, there are traditional farmer irrigation systems developed, owned and managed by communities, traditional farmer irrigation systems supported by the government, government-developed surface irrigation systems, government-developed tube well irrigation schemes, and individual farmer-owned and operated tube wells and pumps.

Based on management, there are Farmer Managed Irrigation Systems (FMISs), Agency Managed Irrigation Systems (AMISs), Jointly Managed Irrigation Systems (JMISs) and Private Irrigation Systems (PISs). Based on the

coverage of command area, ISs can be categorized into major irrigation system having more than 5,000 ha in Terai and 1,000 ha in the Hills, large irrigation system greater than 2,000 ha and less than 5,000 ha in Terai and greater than 500 ha and less than 1000 ha in Hills, medium ISs greater than 200 ha and less than 2000 ha in Terai and greater than 25 ha and less than 500 ha in Hills and small irrigation system less than 200 ha in Terai and less than 25 ha in Hills.

## **2.2 Theoretical Bases**

The theoretical review helps to understand research issues from the viewpoints of existing theories. This study has brought theoretical insights from agriculture modernization theory, and common pool resource management theory.

### **2.2.1 Theory of Agriculture Modernization**

Nobel Laureate economist Theodore William Schultz (1964) stressed the need for an “agrarian revolution” or higher productivity through technical change in agriculture. T.W. Schultz emphasized that the key to agricultural transformation lies in emphasizing technological change in agriculture. According to T.W. Schultz, there are two key areas to make agricultural transformation. First, it is critical to make modern technologies available. Secondly, agricultural transformation is possible with the adoption of modern technologies.

Schultz model of traditional agriculture theory is based on under developing country whose economy basically relies on agriculture. For the transformation to modern agriculture, the traditional factors of production should be changed. There should be a balance between demand and supply side. Education, technology, skill, investment, and marketing are the additional factors which help to transform subsistence farming to commercial one.

According to T.W. Schultz, the ability and skills of farmers, their access to credit capital, crop insurance to protect the risk, expansion of marketing facilities, and stable price policy are the keys to agriculture transformation.

### **2.2.2 Irrigation System as Common Pool Resource**

Common-pool resources are natural or man-made resources shared among different users, a condition that produces unhealthy competition for their utilization often leading (although not necessarily) to their degradation or even to

their destruction (Marelli, 2008). For human life to persist and flourish into the indefinite future, technological practice must sustainably utilize resources.

Ostrom's Eight Principles of Common Pool Resource (CPR) management is relevant here in assessing the impacts of the Ikudha irrigation project. Ostrom's work suggests that CPR users can work together to reverse environmental degradation and sustainably govern their commons. She provides a potential framework for all successful cases of common self-governance with common eight principles:

- i) The CPR has clearly defined boundaries (effective exclusion of external unentitled parties),
- ii) There is congruence between the resource environment and its governance structure or rules,
- iii) Decisions are made through collective-choice arrangements that allow most resource appropriators to participate,
- iv) Rules are enforced through effective monitoring by monitors, who are part of or accountable to the appropriators,
- v) Violations are punished with graduated sanctions,
- vi) Conflicts and issues are addressed with low-cost and easy-to-access conflict resolution mechanisms,
- vii) Higher-level authorities recognize the right of the resource appropriators to self-govern,
- viii) In the case of larger common-pool resources: rules are organized and enforced through multiple layers of nested enterprises.

### **2.3 Policy Practices**

Nepal has long history of undocumented and documented irrigation policy and program implementation. As the country is land scarce agrarian economy, the rulers of the country had prioritized the provision of irrigation facilities to farmers from the time immemorial. Different traditional forms of water management systems such as irrigation canals, Rajkulos, terracing, gully controls have been implemented for many centuries.

Farmers managed irrigation systems have longest history in Nepal. Thousands of FMIS are prevalent scattered in the mountains, river valleys and Terai. Many farmers managed irrigation systems were rehabilitated in Kathmandu

valley during 1950s (Pradhan & Belbase, 2018). Farmer managed irrigation systems have been traditionally governed by social norms and collective community decisions. The government recognized FMISs only in 1980s (Pradhan & Belbase, 2018). The responsibility of aiding and technical support to farmer-managed irrigation systems also came within the jurisdiction of the Government.

Public sector irrigation development in Nepal took place only in 1950s (Pradhan & Belbase, 2018). Only two public sector irrigation systems namely Chandra Nahar (Canal) and Judha Nahar were constructed before 1950. Realizing the importance of the irrigation, the Government of Nepal had established Department of Irrigation (DoI) established with the mandate of irrigation development all over the country in 1952. Before the restructuring of the department in 2075 BS, Irrigation units at then all 75 Districts were established under the Department of Irrigation. After restructuring, many field-level working units have been transferred under the jurisdiction of the provincial governments.

Many of the irrigation systems were constructed after the establishment of the Department of Irrigation (DoI) in Nepal. Even the rehabilitated farmer managed systems were converted into agency-managed systems (Pradhan & Belbase, 2018). Nepal initiated construction of large-scale surface irrigation systems in Terai with the loans from the World Bank and Asian Development Bank since 1970s.

Irrigation policies and regulations emphasized farmers' participation from planning to implementation of small and medium irrigation schemes. Necessary amendments to the Irrigation Rules were made, with emphasis on the management improvement of the already completed irrigation systems. The following are the major policy interventions of the Government of Nepal.

**National Statute (Muluki Ain 1854).** Nepal enacted the National Statute (Muluki Ain 1854) to provide the legal foundation for the overall functioning of the society. National Statute of Nepal, 1854 Muluki Ain (National Statute of 1854, Land Cultivation Section) was the only governing law at that time that provisions maintenance and priority of receiving water, etc (Pradhan & Belbase, 2018). According to the National Statute (1854), priority of receiving water should be given to the farmer who constructed the canal. It also mentions the priority of the water to upstream lands compared to lower reach and farmers should rehabilitate

the canal by themselves to the extent possible if it is damaged by natural calamities.

The government of Nepal constructed the Chandra Nahar Irrigation Project with the support of the Government of India by applying modern engineering techniques in 1923 which is considered as the official involvement of the Government in the irrigation sector in a real sense. The Rana dynasty issued various legal instruments such as 'Sanad', 'Sawal' etc. to regulate the operation and maintenance of state-built and operated irrigation systems.

**Irrigation Act (1962).** Nepal introduced the Irrigation Act in 1962 with provisions for Costs of construction and maintenance of field channels, construction of higher-order canals, permission to use irrigation water, transfer of water rights, penalizing of the misuse of water, etc. Canal and Electricity and Related Water Resources Act, 1968: The Irrigation Act, 1962 was later replaced by the Canal and Electricity & Related Water Resources Act, 1968. It has provisions about obtaining the license for water use for commercial purposes, including for irrigation, and the right to collect irrigation service fees from private agencies. It provisions restricting any activity, which results in an adverse impact on the environment.

**Irrigation Working Policy (1988).** Nepal initiated several people-focused development policies during the 1980s such as Community Forestry Program. Following this, the GoN has made a major policy shift in irrigation development and management approach. The government introduced an Irrigation Working Policy that emphasized participatory planning, development, and management of the irrigation systems. Irrigation Regulation, 1988, and Irrigation Directives were also brought out by the government.

**Irrigation Directives (1988).** Directives provided detailed procedures for the formation of the WUA. It has provisioned the necessary involvement and participation of the Water Users Group in the construction, operation, and maintenance of tertiary canals, field channels, and drainages of large Agency Management Irrigation Systems. In addition, it has made it necessary to coordinate with the WUA on Water allocation and distribution by the agency in an irrigation system. As in Community Forestry User Groups, it has also the provision for the formulation of the Constitution of WUA defining its roles and responsibilities. Irrigation service fees set by regulation must be paid by the users.

**National Water Plan (2002–2027).** Water and Energy Commission of Nepal has prepared and promulgated the National Water Plan (2002–2027). It was approved by the His Majesty's Government of Nepal in January 2002. This plan includes programs in all strategically identified output activities so that all these programs, in consonance with each other, will contribute to maximizing the sustainable benefits of water use. The broad objective of the plan is to contribute in a balanced manner to the overall national goals of economic development, poverty alleviation, food security, public health and safety, decent standards of living for the people, and protection of the natural environment (WECS, 2002). It is a framework to guide, in an integrated and comprehensive manner, all stakeholders in developing and managing water resources and water services. It has developed a set of specific short-, medium- and long-term action plans for the water sector, including program and project activities, investments, and institutional aspects.

**Water Resources Act, 2049 B.S. (1992 AD).** The government of Nepal has promulgated the Water Resource Act, 1992 to make legal arrangements for the rational utilization, conservation, management, and development of the water resources that are available in Nepal in the form of surface water, underground water, or in whatsoever form. It aims to determine the beneficial uses of water resources, preventing environmental and other hazardous effects thereof, and keeping water resources free from pollution. It provisions the issuance of the license for the use of water with few exceptions. It made the priority order on the Utilization of Water Resources in order of (a) Drinking water and domestic users; (b) Irrigation; (c) Agricultural uses such as animal husbandry and fisheries; (d) Hydroelectricity; (e) Cottage Industry, industrial enterprises, and mining uses, (f) Navigation; (g) Recreational uses; (h) Other uses. The act also provisions the formation of the Water Users Association.

**Irrigation Regulation, 2056 B.S. (2000 AD).** The government of Nepal has formulated and implemented irrigation regulations under the Water Resources Act, 2049 (1992). The regulations define "Irrigation" as the act of supplying water through the Structure on the field for agricultural use. The regulation had provisioned the registration and functions of the Water Users' Association. The collection of Irrigation Service Fees (ISF) is the major responsibility of the WUA

besides others such as repair and maintenance, distribution of water, record keeping, mobilizing people's participation etc.

**Irrigation Policy (1992).** The government of Nepal first time promulgated the detailed Irrigation policy in 1992 and made several subsequent amendments then after. It has set six major objectives including providing continuity to the Nepali farmers' traditions and managing their irrigation systems as autonomous entities. The policy had categorized the irrigation systems into four groups namely a) Irrigation systems operated by water users, b) Government irrigation systems to be turned over to the Water Users' Associations, c) Irrigation systems under the Joint Management of the government and WUAs and d) Private irrigation systems.

This irrigation policy was subsequently amended in 1997 and 2003. Further, it was promulgated into the newest Irrigation Policy in 2013 (2070). It has the long-term vision to provide year-round sustainable and reliable irrigation facilities to all agricultural lands to increase agriculture productivity. It focuses on multipurpose irrigation projects and extension, promotion, and development of surface, and subsurface irrigation based on new technology including lift irrigation. It is based on inter-basin water transfer, reservoir-based irrigation, conjunctive use of surface and underground irrigation as well as making more responsible and accountable to WUA.

**Agricultural Perspective Plan (1995).** The government of Nepal adopted a 20-year Agricultural Perspective Plan (APP) in 1995 to accelerate national growth through diversification and commercialization of agriculture. It emphasizes realigning investments, particularly in (i) shallow tube-well for irrigation in the Terai (ii) agricultural roads (iii) fertilizer, and (iv) research and extension. The plan has also directed new investments to priority outputs, especially rice, citrus, apple, vegetables, livestock, forestry products, and agribusiness. However, the results of the APP were not satisfactory mainly due to ambitious targets, huge gaps in investments, and organizational weaknesses. Further, inadequate growth of year-round irrigated areas, use of prioritized inputs, and political instability also caused the poor growth of the agricultural sector.

**Agriculture Development Strategy (2015-2035).** The Agriculture Development Strategy (ADS) was formulated in 2013. The ADS is the long-term strategy of the agricultural sector with twenty years of vision and ten years of

action plan and strategy focusing on governance, productivity, profitable commercialization, and competitiveness. The vision of the ADS has been stated as a self-reliant, sustainable, competitive, and inclusive agriculture sector that contributes to economic growth, improved livelihood, and food and nutrition security. ADS emphasizes promoting self-sufficiency in food grains and import substitution in several commodities where the country has the potential to grow. It also emphasizes expanding reliable and year-round irrigation systems to increase agriculture productivity.

The ADS has targeted enhancing the average annual growth rate to 5 percent from 3 percent for the agricultural sector, increasing land productivity to USD 5,000 per hectare from the baseline's USD 1,600, and reducing rural poverty from 27 percent to 10 percent by the year 2035.

**Irrigation Master Plan (IMP) (2019).** Nepal's first irrigation master plan was implemented in 1990. Over twelve major irrigation development projects in Nepal at a total cost of more than Rs. 67 billion (approx. US\$ 800 million) and a combined irrigated area of about 570,000 ha have been constructed within 30 years after IMP implementation (DoWRI, 2019). These projects have included investment in infrastructure rehabilitation and command area development. There were about 728,000 ha of which 81 percent of the irrigated area (of surface water systems) 591,000 ha were on the Terai in 2019. The Hill zone accounts for 15 percent of the irrigated area and the Mountain zone 4 percent of the irrigated area (DoWRI, 2019).

The IMP 2019 sets an ambitious plan to rapidly develop irrigation infrastructure, and increase year-round irrigation across the country with a particular focus in the Terai. The GoN plans to significantly increase investments on: a) Inter-basin transfers that bring adequate quantities of water to large pockets of drier lands in the Terai; b) Emphasize groundwater development to offset longer implementation periods required for large projects. Development of new gravity systems will be a priority focus in the hills and mountains. The IMP 2019 also plans to develop non-conventional irrigation through electric and solar pumping wherever suitable, rehabilitation, and modernization of existing infrastructure to transfer management of irrigation systems to user groups, sub-national bodies, and, where appropriate, to the private sector under PPP schemes.

## 2.4 Empirical Studies

Agricultural productivity heavily depends on water availability, including its quality, quantity, and seasonal patterns. An empirical review of the global and national irrigation systems provides insights into their effectiveness, challenges, and impacts on agriculture, livelihoods, and the environment.

Agriculture accounts for the largest share of global water consumption (Velasco-Munoz et al., 2019). As there is rampant growth in the global, regional, and national populations, it poses the challenge of securing essential resources like food and water while promoting sustainable development, where water plays a critical role in human survival and supports a variety of services fundamental to societal well-being (Manju & Sagar, 2017). Water resources face significant degradation due to global climate change, changes in land use, agricultural and urban expansion, and overexploitation resulting from economic development (Damkjaer & Taylor, 2017; Liu et al., 2017; Zhang et. al., 2017).

Presently, about 275 million hectares (23% of cultivated land) of the land in the world have irrigation facilities and it is increasing annually at the rate of 1.3 percent (Hedley et al., 2014). These irrigated lands account for the 45 percent of total food production in the world (Gago et al., 2015; Zhang et al., 2017). Global food production must increase by 70 percent to meet the projected food demand by 2050 (of 10 billion population) due to the rampant population growth (Wu & Ma, 2015). It is estimated that there should be about a 53 percent increase in irrigation coverage (Fraiture & Wichelns, 2010) with a required increase of 50 percent in developing and 16 percent in developed countries (Fishcer et al., 2010). For example, Africa is facing an existential food security crisis due to the drought and climate emergency where only less than 10 percent of arable land is irrigated (Izzi et. al. 2021).

The development of irrigation systems should focus on enhancing water use efficiency and effectiveness to ensure their sustainability from both social and economic perspectives (Velasco-Munoz et al., 2019). A comprehensive analysis of the entire irrigation process, which spans from the water source to its application in agriculture is required to understand the efficiency, effectiveness, and sustainability of any irrigation system (Velasco-Munoz et al., 2019). According to Zhang et al. (2019), three key phases in irrigation are essential to

analyze the efficiency of the irrigation system such as i) extracting water from the source and transferring it through channels to the point of use; ii) distributing water to the root system, enabling crop absorption; and iii) encompassing the crop-growing process, where water is transported from the roots to the rest of the plant.

The history of irrigation is long and includes many examples of how humans have used water to grow crops. Ancient people in Mesopotamia used the flooding of the Tigris and Euphrates rivers to water their crops around 6000 BC. Around the same time, the Egyptians is also have been practiced in Egypt by developing several irrigation systems, including basin irrigation, which used the Nile's yearly flood to water crops (Sojka et al., 2002). The first major irrigation project was built around 3050 BC by the First Egyptian dynasty (Sojka et al., 2002; Angelakis et al., 2020). Modern irrigation technology likely originated with the Mormon settlement of the Utah Great Salt Lake Basin in 1847. By the end of the 19th century, their efforts had resulted in nearly 2.5 million hectares of irrigated land across the intermountain western United States (Sojka et al., 2002) and expanded heavily after World War II.

Farmer-led irrigation (FLID) has been practiced for centuries, though the term itself was first coined in 2017. World Bank developed the FLID implementation guidelines in 2021 and supported its expansion in the world. The FLID has been customized according to the culture and contexts of their respective countries and is presently expanded to many countries in Africa, Asia, and South America.

Nepal has a long history of irrigation through traditional systems such as Guthi-based canals and FMIS. Generally, the infrastructure of the FMIS is simple, lacks a permanent structure, and is cost-effective. It has been managed well and provides better yields. The FMIS has played a crucial role in the irrigated agriculture of Nepal for centuries (Bhandari & Pokharel, 1998). The Department of Irrigation, established in 1951, has implemented several interventions in farmer-managed irrigation systems under the modernization initiative in the past and has also introduced new irrigation schemes by taking off the management responsibilities to the state agencies from the farmers keeping them completely aloof (Bhandari & Pokharel, 1998). Original farmer-managed irrigation systems became the agency-managed irrigation systems.

In the other hand, large-scale systems like the Bagmati, Babai-Bheri Diversion, Ranijamara, Manusmara, and Sunsari-Morang Irrigation Project Systems have been implemented with external assistance. Despite significant investment and all efforts to centralization and technology development, the irrigation system could not develop at a faster speed in its coverage and efficient management. The modern systems often face issues like poor maintenance, institutional inefficiencies, and underperformance.

By the mid-1980s, the government recognized the significance and advantages of FMIS for the nation's agriculture. FMIS was again incorporated into the subsequent promulgation of the Irrigation Policy, Acts, and Regulations of Nepal. Presently, 70 percent of Nepal's irrigated areas have been managed by Farmers. It has been distinguished by its participatory management and effective local governance (Bhandari & Pokharel, 1998).

## 2.5 Conceptual Framework of the Study

This conceptual framework

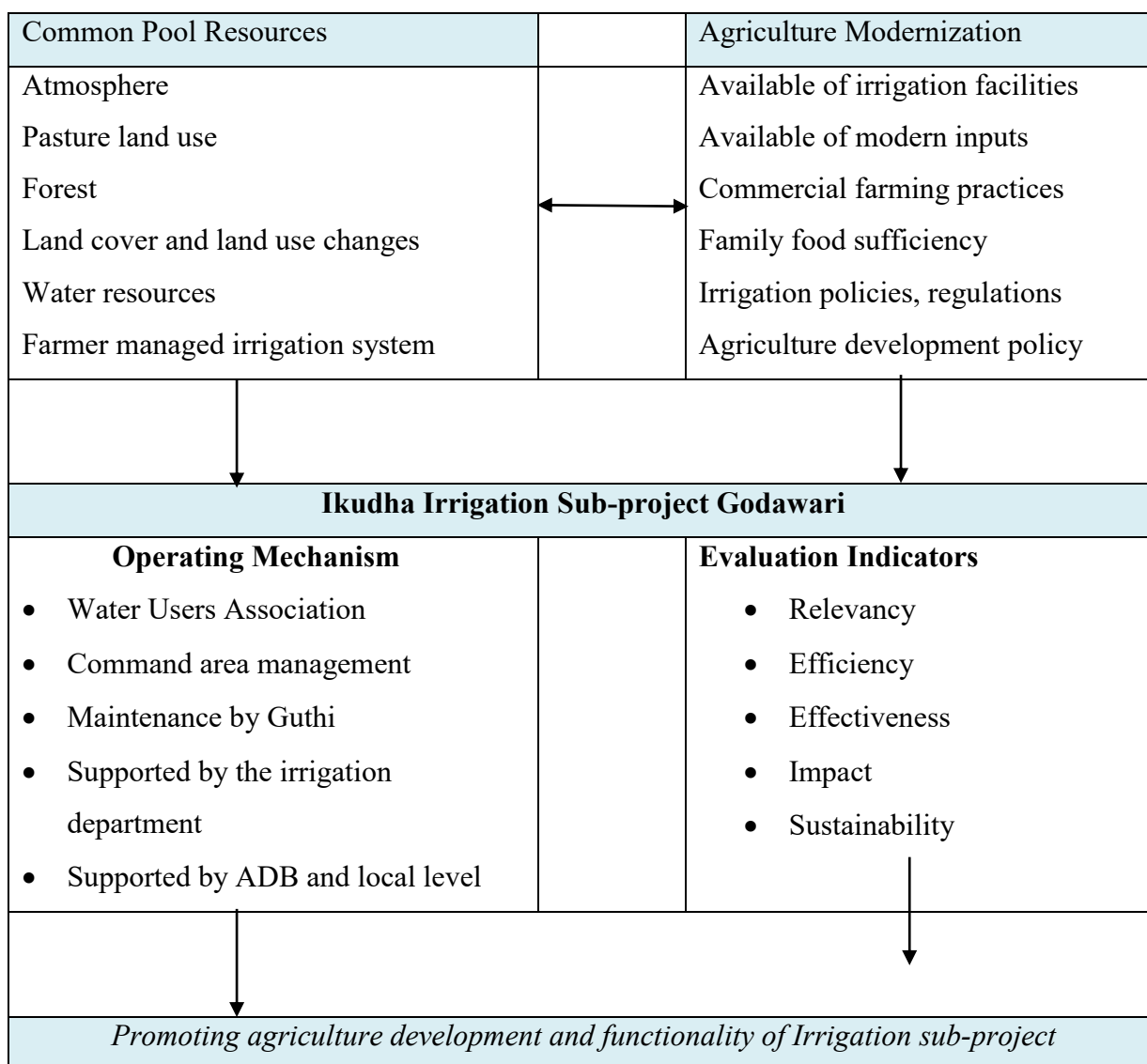


Figure 2.1. Conceptual Framework of the Study

## CHAPTER III

### RESEARCH METHODS AND METHODOLOGY

#### 3.1 Research Philosophy

A research philosophy systematically examines our understanding of research issues from philosophical assumptions. It is an overarching concept related to the development and nature of knowledge. Philosophical assumptions encompass views on the nature of reality (ontology), how knowledge is acquired (epistemology), the role of values in research (axiology) and the language used (rhetoric) (Creswell, 2009, p. 16). The philosophical assumptions of the study have been mentioned in Table 3.1.

Table 3.1. *Philosophical Assumptions of the Study*

Assumptions	Characteristics
Ontological	Objectivity
Epistemological	Deductive
Axiological	Value laden
Rhetorical	In/formal
Methodological	Structured

*Source:* Developed by the Researcher, 2023

#### 3.2 Research Paradigm

A paradigm is a lens through which we perceive, understand, and interpret any phenomena, serving as a broad framework for viewing the world. It represents a basic set of beliefs that directs action (Denzin & Lincoln, 2011). As a positivist, the researcher approaches the research issues from an objective standpoint, utilizing quantitative methods within a post-positivist research paradigm. In this research, a range of materials and methods were utilized for collecting numerical data as well as analysis of data based on theoretical interpretation. Primary data were gathered directly from the field survey, observations, and interactions with local communities.

#### 3.3 Research Design

This study used a case study research design to evaluate the operating mechanism of the Ikudha irrigation sub-project. Case study research is regarded as a comprehensive research strategy that helped researchers to understand specific

and contextual historical, economic, and cultural settings of the participants (Creswell, 2012). The unit of analysis is the perceived views of the 69 articulating respondents on the operating mechanism and management functions of the Ikudha Water Users Association.

### **3.4 Selection of the Study Area and Rationale**

This study purposively selected the Ikudha irrigation sub-project located in Godawari municipality. This municipality encompasses a total area of 96.11 square kilometres (Municipality Profile, 2023), and has a subtropical climate, with elevations ranging from 457 meters to 2,831 meters above sea level. This municipality houses the renowned National Botanical Garden and Phulchowki, the tallest hill in the Kathmandu Valley, known as a prominent hiking destination. Godawari is also rich in several religious heritages, including sites like Godawari Kunda, which attracts large gatherings of devotees every 12 years. Other notable religious sites include the Naudhara, Santaneshwor, Muktinath, and Bishankhunarayan Temples.

The origin of the Godawari River is from the Godawari-Phulchowki hills, located on the Eastern side of Godawari ward number 3. The Narsing khola, Sungure khola, Chisapani khola, and Kunako khola, all originated from Godawari-Phulchowki flow into the Godawari River near its origin. About 42.54 percent of the Godawari River watershed is steep (24.74%) to very steep (17.80%) terrain. The majority of the watershed is covered by Forests (2,225.6 ha), followed by cropland (1,887.6 ha), built-up area (500.3 ha), other wooded land (14.5 ha) and grassland (2.89 ha) (Figure 3.1). There has been a rampant increase in the built-up area and a reduction in agricultural land from 2000 to 2019 (Table 5.13).

Godawari is the tributary of the Bagmati River. It begins from the Godawari-Phulchowki hills and drains from Godawari and Mahalaxmi municipalities which meet the Hanumante River near Tikathali. The Godawari River is of fifth order with a sinuous pattern, having wide floodplains but narrow current meander belts (Tamrakar & Bajracharya, 2012). Urbanization in the Godawari River and its watershed as well as the command area is very rapid at present and is decreasing the irrigable land.

The municipality consists of 14 wards and is renowned for its natural beauty and popular tourist destinations (Figure 3.1). The Ikudha irrigation sub-project is located within the 3, 4, and 14 wards of Godawari at the elevation of 1425 to 1450 msl. The ward no. 3 is the largest, while ward no. 14 is the smallest ward in the municipality. The command area is about 70 hectares mostly comprised of gentle

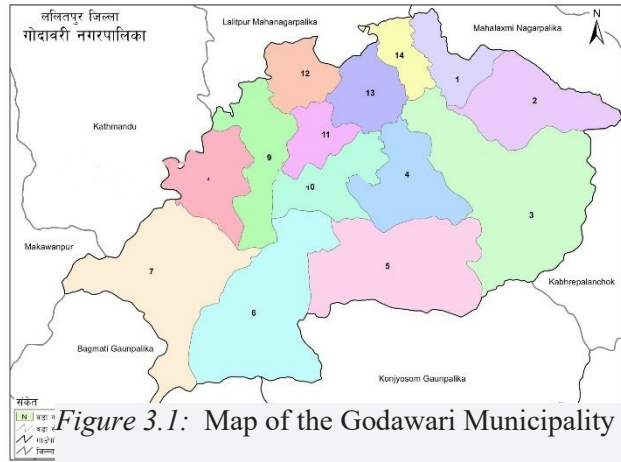


Figure 3.1: Map of the Godawari Municipality

slope and undulating topography (3 to 8% slope). The canal discharge is designed as 150-300 litres per second (ADB, 2009).

The selection of the Ikudha Irrigation Sub-Project as the study area was done primarily based on its long history of operation. This irrigation system was in operation for over 100 years in the Godawari region. Besides, there was intervention from the governmental agencies and local government for the modernization and maintenance of the canals for over fifty years. The farmers have a lot of experience in the operation of the irrigation system. In addition to this, it is the FMIS in the proximity of the city and its easy accessibility. The findings from this small-scale irrigation project can be applied in other similar farmer-managed irrigation systems in the country.

### 3.5 Nature and Sources of Data

The study collected both primary and secondary data for the study purpose. The primary information related to the management, utilization, and protection of the irrigation infrastructure was collected through household surveys, KII, and observation. Likewise, the secondary data was collected from published reports and policy documents of the government and development stakeholders. More precisely, the information was collected through documented publications of Governments, municipalities, different organizations, records of ward offices and irrigation offices, and so on. The constitution of the Water Utilization Association was also reviewed to understand its historical perspectives as well as the responsibilities and rights of the irrigation committee and local farmers.

### **3.6 Population, Sampling, and Sample Size Distributions**

There are a total of 268 beneficiaries households of the Ikudha irrigation sub-project command area Thaiba and Badegaun located in the ward no. 14 (IWUG, 2023). Out of the study population, this study randomly selected 69 households (26% of the sample population) for collecting the required data. The study also conducted five key informant interviews with the Chair of the Water User Association (WUA), local elected representatives, and role model farmers who benefited from the irrigation project. The data and information were collected during summer, monsoon, post-monsoon, and winter from July 2022 to October 2024. The site was also observed after the disastrous floods of the Godawari River in September 2024.

### **3.7 Data Collection Techniques and Tools**

#### **3.7.1 Household Survey**

The household survey was conducted with 69 households by using a structured survey questionnaire (Appendix A). The total area of the land irrigated, different crops, cropping intensity, cultivation practices, productivity, water fees, preparation of the WUA constitutions, maintenance, etc. were collected. The questionnaire consists three sections. The first section highlights demographic and socio-economic related information (variables 1-12). The second section highlights Ikudha irrigation sub-project related information (Variables 13-16). The third section highlights performance evaluation-related information (variables 17-21 with 39 items).

#### **3.7.2 Focus Group Discussion**

Focus Group Discussion (FGD) was conducted with three specific groups: beneficiaries, members of WUAs, and women members. The objectives of the study were shared among the participants before collecting their opinions about the operating mechanism, management functions and indicators-wise performance evaluation of the irrigation sub-project (Appendix B).

#### **3.7.3 Key Informant Interview**

The researcher conducted interviews with key persons in the command areas of the Ikudha irrigation sub-project. The Key persons were the ward chair of Godawari-14, the chair, and the advisors of Ikudha Rajkulo Water User

Association to explore the working modality, difficulties and opportunities, and future potential development in the Ikudha Command Areas (Appendix B). They also provided the “constitution” of the Water User Association and minutes of the decision, which were very useful in understanding the governance patterns.

### **3.8 Data Analysis and Interpretation**

The collected data were analyzed using mainly Microsoft Excel software. The descriptive statistics were analyzed by using STATISTICA 13.3 software. The qualitative information obtained from FGD, key informant interviews, and observation were analyzed to find out the situation of the project, various issues, international and external relationships, policy implications etc. Remote sensing and GIS tools such as Google Earth Satellite images and ArcGIS have been used with the support from experts to delineate the Ikudha irrigation sub-project command area and obtain the changes over the period of the last 10 years.

### **3.9 Ethical Consideration**

This study was conducted ethically, ensuring that no harm came to any individuals and communities during the fieldwork (Appendix E) and analysis processes. It respected the privacy and confidentiality of the participants, avoiding any intrusion into their personal or private matters. The purpose and objectives of the study were clearly communicated to the respondents, and their informed consent was obtained prior to conducting the survey. The intellectual property rights of the individuals have been duly honored. During the survey, local gatekeepers were mobilized to communicate with Newari native speakers as many individuals were found reluctant to speak with outsiders. The gatekeepers were also familiar with the canal operating system, households, people, and the local Newari language.

## CHAPTER IV

### INTRODUCTION OF THE STUDY AREA

#### 4.1 Godawari Municipality

Godawari municipality is located in the south of the valley adjoining the Godawari-Phulchowki mountainous series. The present Godawari municipality was established in 2073 BS. by including the previous 12 Village Development Committees: Godamchaur, Badikhel, Lele, Devichaur, Dukuchhap, Chhampi, Chapagaun, Thecho, Jharuwabasi and Thaiba (Municipality Profile, 2075). This municipality comes under the constituent number 3 of Lalitpur District in Bagmati Provision.

Godawari municipality is distributed in the elevation of 457 m to 2831 masl, and has an area of 96.11 km<sup>2</sup> with a width of 8.2 km (North-South) and length of 13.3 km (East-West). The municipality is borders Konjyosyom rural municipality and Kabhrepalanchowk in the East, Lalitpur metropolitan and Makwanpur districts in the west, Lalitpur metropolitan and Mahalaxmi municipality in the north and Konjyosyom and Bagmati rural municipalities in the south (Figure 4.1).

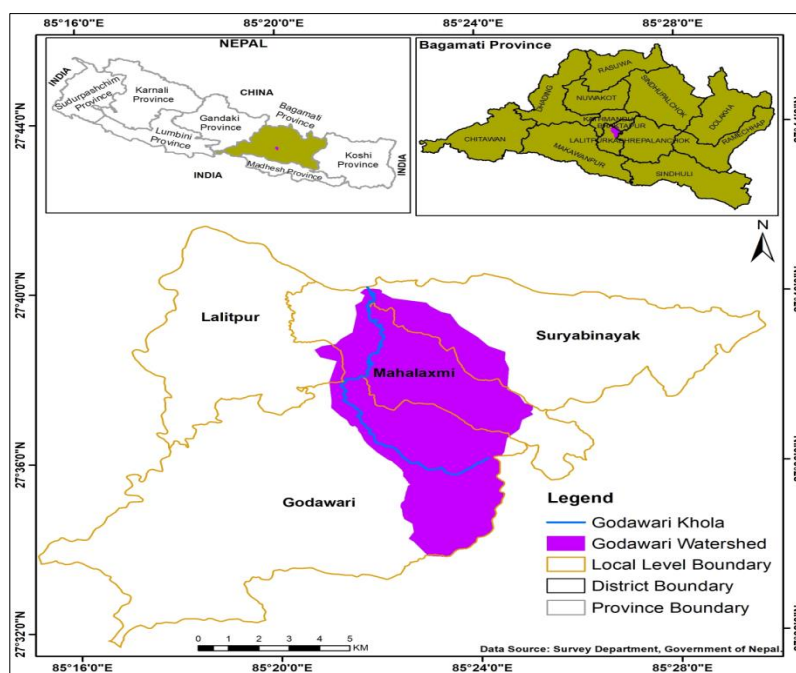


Figure 4.1. Map Showing the Study Area and Adjoining Municipalities

The municipality has the agriculture area of 48.29 km<sup>2</sup>, forest area of 39.08 km<sup>2</sup>, shrub land 6.94 km<sup>2</sup>, water bodies 0.30 km<sup>2</sup>, built-up area of 0.36 km<sup>2</sup> and barren land of 0.06 km<sup>2</sup> (Figure 4.2). The built-up area has been rapidly increasing at the cost of agricultural land in the last decade. Department of Forest Research and Survey also published the forest cover map of the Godawari municipality, to be 53.13 km<sup>2</sup> which is 55.52 percent of the area (DFRS, 2018). This does not separate jurisdictional differences between government and private forests.

There are altogether 24,045 households inside the Godawari municipality (NPHC, 2021) with a population of 97,633 (48,140 M & 49,493 F). The average household size is 4.11 and the average female-male sex ratio is 97.65 (NPHC, 2021). NPHC, 2021 data shows that there are 42.4 percent richest people, 26.24 percent richer, 17.78 percent of Middle, 10.38 percent Poorer, and 3.23 percent poorest households in the municipality (Table 4.1). The ward number 3 has just 7.8 percent poorer and poorest categories HHs, whereas it has 76.6 percent in the rich category. Similarly, ward number 14 has 9.35 percent in the poor class category and 74.48 percent in rich class households (NPHC, 2021).

Table 4.1: *Demographic Characteristics of the Households*

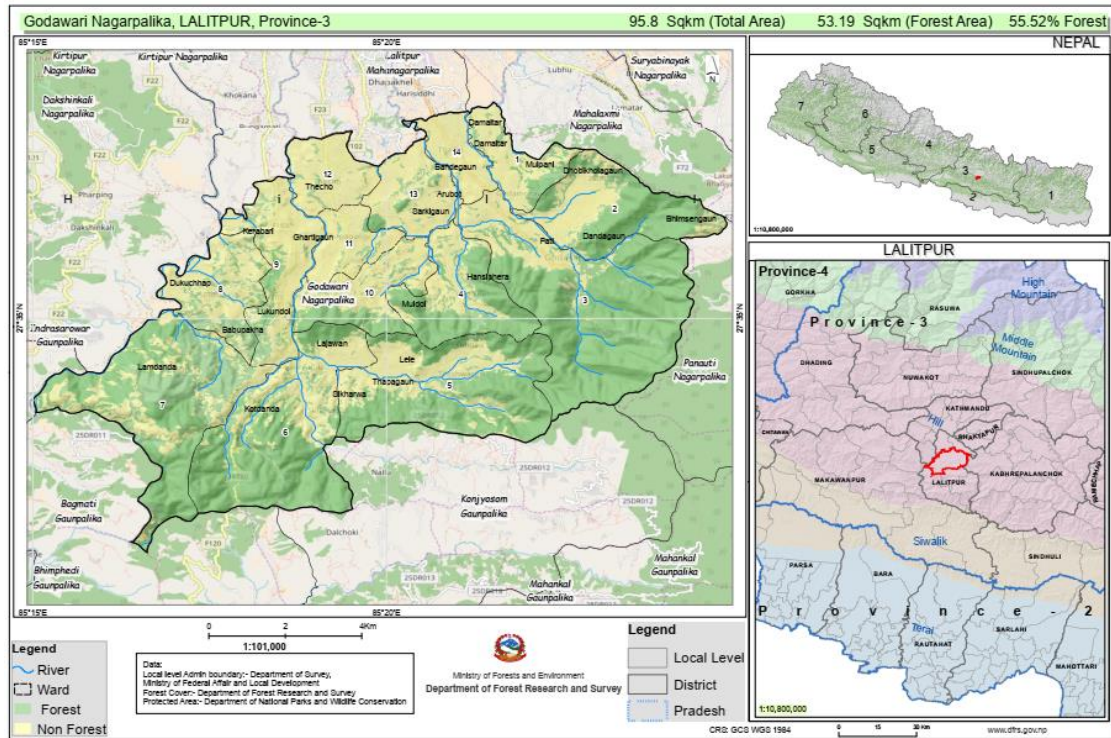
Ward	Number of households	Population			Average household size	Sex ratio
		Total	Male	Female		
1	1569	6369	3154	3215	4.06	98.10
2	1241	4954	2383	2571	3.99	92.69
3	2618	10057	4908	5149	3.84	95.32
4	1006	4307	2183	2124	4.28	102.78
5	1238	5238	2542	2696	4.23	94.29
6	1070	4477	2269	2208	4.18	102.76
7	719	2881	1410	1471	4.01	95.85
8	663	2968	1475	1493	4.48	98.79
9	1474	6007	2971	3036	4.08	97.86
10	1751	7379	3643	3736	4.21	97.51
11	2902	12010	5828	6182	4.14	94.27
12	3000	11928	5851	6077	3.98	96.28
13	1601	6718	3387	3331	4.20	101.68
14	3193	12340	6136	6204	3.86	98.90
Total	24045	97633	48140	49493	57.54	97.65

**Source:** NPHC 2021

The municipality is culturally diverse, with residents from various castes and religions, and languages spoken include Nepali, Newari, Tamang, Limbu, Tharu, Muslim, Bote, and Bhojpuri. Residents engage in a variety of occupations such as agriculture, business, tourism, government and non-government jobs, and

trading. Godawari Municipality holds significant potential to enhance its economy through agriculture, farming, tourism, and other sectors, and benefits from substantial market access.

Figure 4.2 Forest Cover Map of Godawari Municipality



**Source:** Department of Forest Research and Survey, 2075 B.S.

#### 4.2 Irrigation Systems in Godawari

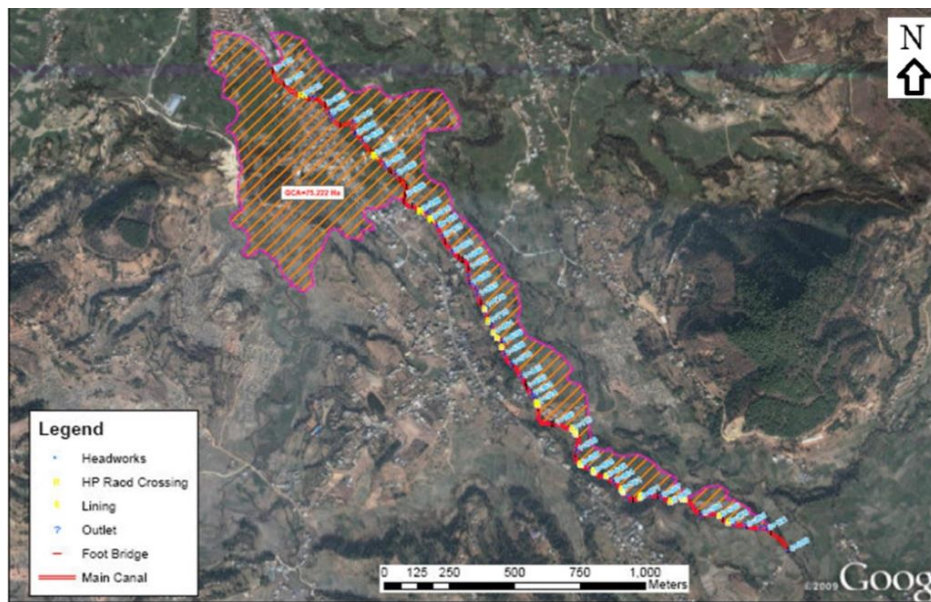
There were several locally built and run irrigation canals in Godawari areas in the past. All they were fed up from the Godawari River. The agricultural land of the Godawari, Badegaun, Thaiba, and Damaitar used to be irrigated from these canals. Among them, three canals were very important namely i) Mu-dha (Main Canal/kulo), ii) Tapa-Dha (Tapa Canal/Kulo), and iii) Iku-Dha.

The Mu-dha main canal/kulo was the largest of all and used to run almost parallel to the Godawari-Satdobato Highway in the past. Due to the expansion of the road and increase of the built-up area, the Mu-dha has been almost completely closed and therefore not functional these days. They have been converted into covered roads in many places.

Ikudha is in the middle and Tapadha runs along with close to the Godawari River (Figure 4.3). Tapa-dha is the right of the Ikudha and receives water from there. The main canal has an estimated length of 3.2 km, with one branch and two sub-branch canals branching off from it. The Ikudha mostly irrigates the land in

the east of the Godawari-Satdobato main road, but it crosses to the left side of the road near to Badegaun, feeding a few religious ponds and irrigated lands. In 2009, the main canal discharged water at a capacity of 0.15 m<sup>3</sup>/s (ADB, 2009). The canal's bed width ranges from 0.5 to 0.7 m, with a freeboard of 0.15 to 0.3 m. The field channel has a top width, bed width, and bank height of approximately 30 cm each, extending over a total length of 2 km throughout the command area and providing irrigation facilities to 331 farmers in 2009 (ADB, 2009).

*Figure 4.3: Location Map of Ikudha Irrigation Sub-project*



*Source:* ADB, 2012

### 4.3 History of Ikudha Irrigation Canal

The Ikudha irrigation system boasts a history of over a century of traditional management. About 100 years ago, the ancestors of the local community constructed the canal from the Godawari River. Since its establishment, the Ikudha irrigation system has consistently supplied water to the command areas. For a long time, agriculture has been the sole source of income and employment for the inhabitants of the area. However, the sources of employment and income for the people have diversified at present, resulting in reduced reliance on agriculture for their livelihoods and meeting their annual food needs.

Ikudha-Rajkulo Water Users' Association has been operational since 2061 BS, focusing on the conservation, management, and utilization of water and irrigation systems. The association has played a key role in maintaining the canals,

ensuring equitable water distribution among farmers, and resolving conflicts. The Government of Nepal contributed significantly to the modernization of the Ikudha irrigation canals, investing substantial funds through the Asian Development Bank for constructing canal heads, cement-lined canals, branch canals, and field channels. Additionally, the local Godawari Municipality allocates regular budgets, though not sufficient for most of the time, for canal maintenance. Despite these contributions, the majority of maintenance work continues to be carried out by mobilizing local users through the Ikudha-Rajkulo Water Users' Association. Currently, most of the canals are made of Reinforced Cement Concrete.

The land area in the Godawari area has changed rapidly. The cropland has reduced by 51.64 ha (-2.7%), forests by 314.9 ha (-12.4%) and built-up areas have increased by 381.63 ha (+321.5%) between 2010 and 2019. A similar trend of declining cropland and expanding built-up areas is evident in the Ikudha Rajkulo irrigation command area. The average landholding per household has significantly decreased, from 4.45 ropani in 2009 to 2.35 ropani per household in 2023.

The cropping intensity, crop diversification and per-unit productivity has been increased with the availability of water from Ikudha Irrigation. Despite increase in the productivity, the production is not sufficient to fulfill the year-around food demand for most of the farmers. However, they largely fulfill their vegetable needs from their production. Some farmers also use to sell their vegetables.

The maintenance of the irrigation canals, branch canals, overhead, and field channels is primarily done by the farmers without any payment. Ikudha-Rajkulo Water Users' Association mobilizes them for their maintenance. For the large-scale and costly maintenance, the Government agencies and local municipalities perform the maintenance. Farmers receive the required quantity of water during the monsoon, mainly for paddy plantations. There is a lack of demand and also a shortage of water supply during the winter and spring. Farmers are mostly found satisfied with the water availability. They responded to the increase in crop and vegetable production after the Ikudha irrigation sub-project. WUA committee administers the unbiased distribution of water among farmers and has adequate canals and branches to feed water to the cropland in the command areas. With the increased availability of water resources, there is almost no fallow land or barren land abandoned without cultivation.

The people have diversified agriculture cultivation, increased family income, reduced poverty, and increased investment in education and health services of the family members from the services of the Ikudha Irrigation Sub-project. Due to the rocketed land price and conversion to built-up areas, the cropland is steadily decreasing which may significantly lower the relevance of the Ikudha irrigation system in the future, creating problems for sustainability

Ikudha surface water irrigation system has been providing water to agricultural land for over a century. This farmer-managed system was initially built by local residents through their collective efforts and labor almost a century back. The farmers themselves dug the irrigation canal and continue to maintain and operate it, contributing both money and resources according to the size of their landholdings. His Majesty's Government, Department of Irrigation upgraded the irrigation system in 1978, 1981, and subsequent years from the government budget. Later on, the Government of Nepal with the financial and technical support from the Asian Development Bank constructed and modernized the irrigation systems. Detail description of the Ikudha Irrigation System is summarized in Table 4.2.

Table 4.2: *Descriptions of the key features of Ikudha Irrigation System*

S.N.	Particulars	Details
1.	Name of sub-project	Ikudha Farmer-Managed Irrigation project
2.	Name of water source	Perennial Godawari River
3.	Canal Discharge	~150-300 litre per second
4.	Establishment	Centuries back, rehabilitated in 1980s, 2010s
5.	Supporting Agency	Government of Nepal, Department of Water Resources and Irrigation, Godawari Municipality, Ward Offices and Water Users Association
6.	Command Area	~ 70 ha
7.	Beneficiaries HHs	Over 331
8.	Elevations	1425-1450 m asl
9.	Slope and Topography of the Command area	Gentle slope to undulated land (3 to 8% slope)
10.	Total Canal Length	3.2 km
11.	Cropping Intensity	220%
12.	Fee (Rs. per hour)	0

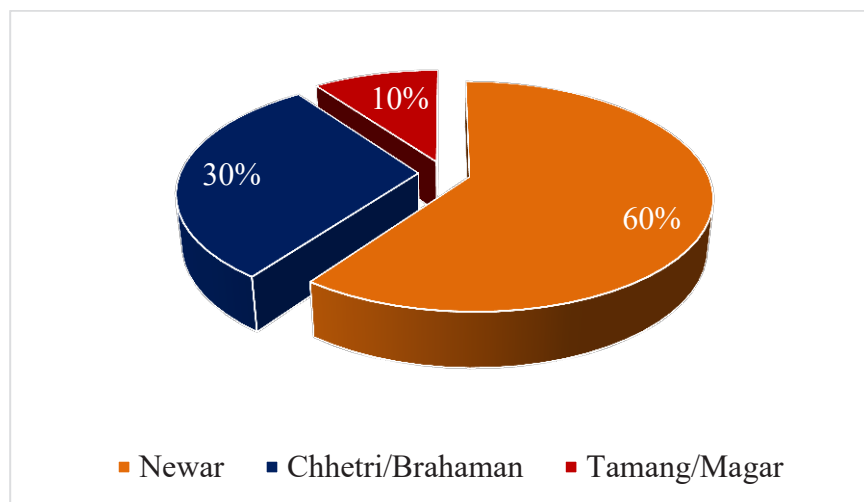
13.	Maintenance (Rs/HH)	Fee	Usually no but paid as per need
14.	Maintenance Methods		Regularly by WUGs and local Guthi by volunteer labour. Hired water keeper, paid minimum budget by Godawari municipality

**Source:** Field Survey, 2023; ADB, 2012

#### 4.4 Ikudha Water User’s Association

Ikudha Rajkulo Irrigation Water Users Association was registered in 2061 B.S. as per the provision of the Water Resource Act, 2049 (article 2) and Water Resource Regulation, 2051 (rules 3) at the District Water Resource Committee (DWRC). The DWRC used to be chaired by the Chief District Officer, whose members were chiefs of agriculture, forest, electricity, drinking water, irrigation, etc. offices, and the member secretary used to be the Local Development Officer of the respective District Development Committee.

About 60 percent of the users are indigenous Newar communities, whereas Chhetri and Brahman comprise 30 percent, and Tamang and Magar are the rest 10 percent (Figure 4.5). There is the provision of renewal of membership at the cost of Rs. 50, and also entry of the new members requires the payment of Rs. 200.



*Figure 4.5:* Ethnic Composition of Ikudha Water User Group

The general assembly of the association needs to be held at least twice a year, first just before the monsoon crop cultivation begins and second after winter crops. The fifty persons of the member's attendance are considered as the

fulfillment of the quorum at the first meeting call, and it drops to 25 percent for the second call of the assembly. The decision taken by the majority is considered as a valid decision.

WUG forms the WUC for the day-to-day operation of the business. The Management and Executive committee Meetings will be held at least 4 times a year. The Committee's work period is for two years. The 11-member executive committee (Appendix C) includes the position of the Chair, vice chair, General Secretary, Secretary, treasurer, and 6 members, and can be expanded as per need. The rights and responsibilities of the Ikudha WUC as per the constitution are as follows:

- a) Prepare and present the annual budget and program and other detailed information in the general assembly,
- b) Plan, manage, and implement annual work plan and budget,
- c) Prepare the resources required for the program implementation,
- d) Execute all necessary work and activities on behalf of the WUA,
- e) Fulfil the vacant position of the committee until a new general assembly is held.

## CHAPTER V

### DATA ANALYSIS AND INTERPRETATION

#### 5.1 Socio-economic Information

##### 5.1.1 Profile of the Respondents

The household survey was conducted with the support of a key local person. A total of 69 households were consulted. Only two out of 69 households were female-headed. The rest 67 (97.2%) of the houses were headed by males. The water users of the Ikudhawere are dominated by the Newar community mixed with Silwal Chhetri. A total of 16 Silwal (23.21%) and the rest 52 households were Newar (76.8%). Most of the households were nuclear families. However, about 10 households were joint families comprised of three generations of the family living in the same house. Most of households have a total of four family members comprising a couple and two children. However, the average family size was 5.4, ranging from 3 to 13. All of the respondents were literate; most of them had an education above 8 class passes. Some of them have university-level graduates and work in government services. All respondents are Hindu, with faith in Buddhism.

##### 5.1.2 Land Holding Status of the Farmers

The land of the Ikudha irrigation command area is highly fragmented. Due to the family expansion, and the rise of the land value, the agricultural land has been fragmented and inherited by their descendants. The average landholdings are 2.18 Ropani, ranging from 0.75 to 12 Ropani. The land has been fragmented and converted mostly into the built-up areas/Ghaderi. The average landholding of the farmer in the Ikudha irrigated command area was 4.45 Ropani in 2009 and it has decreased by 47 percent over the period of last 15 years (Table 5.1).

Table 5.1 *Average land size of the Ikudha Irrigation Command Area*

Year	HHs	Land Area (Ropani)	Average Land Holding/HH	Source
2009	331	1774.5	4.45	ADB, 2009
2023	69*	162.7	2.35	Field Survey

**Source:** Developed by the Researcher, 2023

Note: \*This information is estimated from 69 sampled households out of total HHs of the irrigation command area

### **5.1.3 Economic Status of the Farmers**

The irrigation command area is situated near the main Godawari-Satdobato road and a local trade hub. This region is also connected by a network of local roads, educational centers, and marketplaces, offering diverse economic opportunities for the community. Residents are engaged in a mix of economic activities and operate various enterprises, including well-known mustard oil and rice mills. Additionally, they engage in a range of small to medium businesses, such as grocery stores, dairies, livestock farming, mobile repair shops, stationery stores, and electrical shops. Many are also employed in government and private sector jobs. These income sources, along with agricultural productivity and employment opportunities, enable residents to meet their needs, and as a result, no one in this area falls below the poverty line.

Family income is primarily spent on food, followed by children's education, clothing, utility bills (such as electricity, internet, and water), healthcare, traditional festival celebrations, entertainment, loan repayments, and jewelry.

## **5.2 Operating Mechanism and Management of Irrigation Sub-project**

### **5.2.1 Formation of Water User Association**

There is the registered Ikudha Rajkulo Water User Association which is an autonomous, inalienable succession, not political and non-profit institution. It functions based on the registered “Constitution” of the water user association. There is an executive committee to run the operation issues. This constitution determines the rights of the executive committee, the rights and responsibilities of its members, conducting general assemblies and committee meetings, and addressing membership criteria, fees, and other procedural matters. There is the 15-member committee (excluding advisory members), consisting of 13 men and two women, reflects a male-dominated decision-making structure. The executive committee collaborates with the Godawari municipality and provincial irrigation-related offices.

### 5.2.2 Maintenance of the Irrigation Canals

The Ikudha has a main canal, six branch canals, tertiary canals, and field channels for feeding the water to the fields. The provisions of the water to the farmers and its maintenance works have been done according to the needs of the cropping systems and cultivation plans. The water is demanded highly and thus provides regular water proportionately to the lands of the farmers in the monsoon as the paddy crops demand the highest quantity of water. There is less demand for water during the winter and spring. Also, there is less water availability in the canals during this period. As the winter approached, there was very less quantity of water, hence not flowing on 02 November 2024.

The maintenance of the irrigation systems and canals has been mainly done by mobilizing local people or water users. However, they have been trained by the Department of Water Resources and Irrigation in the beginning and regularly provided refresher training. They have developed annual, seasonal, and urgent maintenance plans for the canals (Table 5.2).

Table 5.2: *Cost Sharing by the User Group in the Construction and Maintenance*

Average Irrigated land	Cost Sharing of Source Cost (%)	Cost Sharing of Main Canal Cost (%)	Cost Sharing of Branch Canal Cost (%)	Cost Sharing of Tertiary Channels Cost (%)
<0.5 ha	0	0	0	10
0.5 ha-1.0 ha	0	0	5	10
1.0 ha-5.0 ha	1	3	7	12
>5.0 ha	3%	5%	10%	15%

**Source:** Constitution of the WUGs, 2061 BS, Field Survey, 2023

### 5.2.3 Distribution and Availability of Water

The Ikudha irrigation sub-project is the main source of water for irrigation in Godawari-3 and 14. As most of the farmers demand water for paddy cultivation during the monsoon and there is also a high quantity of water flowing in the Godawari River; most of the farmers receive water as per their requirement (table 5.3). They usually have the tradition of distributing water proportionate to their land holdings. The wheat and other vegetable crops growing in winter require less water in comparison to the paddy growing in Monsoon.

Table 5.3. *Perceived Perception the Respondents on Water Availability*

Category	Seasons			Remark
	Monsoon	Winter	Spring	
Above requirement	31 (44.9%)	0 (0%)	0 (0%)	The winter and spring demands of water is also less.
Partial (50%) of required	35 (50.7%)	21 (30.4%)	5 (7.2%)	
Around 25% of the requirement	3 (4.4%)	27 (39.1%)	10 (14.4%)	
Less than requirement (<25%)	0 (0%)	21 (30.4%)	54 (78.3%)	
Total	69 (100%)	69 (100%)	69 (100%)	

**Source:** Field Survey, 2023

### 5.2.4 Governance Challenges and Issues

Ikudha Irrigation System has a long history of over a century. However, its modernization or latest development has the experience of over 50 years. This irrigation system had a prominent role in food security, employment generation, and productivity in the past. However, its importance and roles have been decreased in recent years. The price of the land in this area has increased manifolds in recent years. These catalyzes are about the conversion of the cropland into built-up areas, Ghaderi/plotting, and road networks. The per capita land holding has decreased by over 50 percent. The conversion of the cropland to the built-up area decreases the overall of production of the agricultural land despite the per unit increase in productivity.

The Ikudha main and branch canals in many places are covered to make roads. These hinder the flow of the water in the dry season whereas it floods sometimes in monsoon cloud outbursts. There is a lack of regular cleaning of the main canal, branch canals, and field channels as well as head works. The sedimentation of the headwork and canals deters the regular water flow/discharge in the canals. There has been a massive growth of plants, weeds, and invasive plant species creating problems in water flow.

The unrestricted drainage of wastewater, soil erosion, and the transport of soil particles and dust into the canals and their branches present ongoing major challenges. Local residents have also been using the canal as a sewage drain, disposing of waste and sewage into it, which has led to significant pollution of the irrigation channels. Additionally, the excessive dumping of plastic bags, bottles,

and packaging materials into the head works and canals has become a serious and threatening issue.

The recent continuous rainfall and cloudburst on September 27 and 28, 2024, over the Godawari Hills—the primary watershed of the Godawari River—caused flooding in this area, severely damaging irrigation facilities and depositing large amounts of sediment and pebbles. A new 24-hour record precipitation of 311.6 mm was set on Ashwin 12, 2081 (September 28, 2024), surpassing the previous record of 225.2 mm recorded on Shrawan 7, 2059 (July 23, 2002) (DoHM, 2024). This kind of accidental rainfall and floods damages the Ikudha irrigation system.

### 5.3 Evaluation of the Ikudha ISP

The Ikudha Irrigation sub-project was analyzed and evaluated following the major indicators such as its relevance, efficiency, effectiveness, impact, and sustainability. These are described in detail in the following paragraphs.

#### 5.3.1 Perceived Relevancy

The Ikudha Irrigation Project plays a vital role in boosting agricultural productivity within its command area. The residents consider the project essential not only for cultivating their land but also for replenishing several culturally significant ponds and traditional stone taps located downstream in the area. Numerous people, particularly women, were observed maintaining irrigation canals, and field channels, planting paddy, and harvesting crops during the fieldwork conducted in 2023 and 2024. The perceived relevancy-related item variables have been analyzed based on a seven-point agreement scale such as 7: strongly agree, 6: agree, 5: somewhat agree, 4: neutral, 3: somewhat disagree, 2: disagree, 1: strongly disagree (Table 5.4).

Table 5.4: *Perceived Relevancy of the Ikudha Irrigation Sub-Project*

Variables	7	6	5	4	3	2	1
Availability of water for irrigation has been increased	50 (72.5%)	10 (14.5%)	9 (13.0%)	0	0	0	0
Irrigation has helped to increase agricultural production	0	35 (50.7%)	14 (20.3%)	10 (14.5%)	0	0	0
Farming activities have been increased	2 (2.9%)	24 (34.8%)	33 (47.8%)	10 (14.5%)	0	0	0
Traditional farming is shifted	0	0	12	50	7	0	0

	to modern		(17.4%)	(72.5%)	(10.1%)		
Increase in cropping intensity and crop diversification	37	22	5	5	0	0	0
	(53.6%)	(31.9%)	(7.2%)	(7.2%)			
There is increase in self-employment	4	5	15	42	3	0	0
	(5.8%)	(7.2%)	(21.3%)	(60.9%)	(4.3%)		
The total agriculture area is cultivated & per unit productivity has increased	44	15	3	7	0	0	0
	(63.8%)	(21.3%)	(4.3%)	(10.1%)			

**Source:** Field Survey, 2023

All the farmers have agreed that the Ikudha irrigation system has increased the availability of water for irrigating their fields, mostly during the monsoon when they plant paddy. However, the water availability during the winter and spring is less. The water availability is crucial in increasing the per-unit productivity of the land.

About 50 percent of the respondents opined that per unit productivity of their land has increased. Notably, none of the responding farmers opined that the agriculture productivity has decreased after irrigation canal establishment. It has increased tremendously cropping intensity and crop diversification. Farmers have initiated year-round cultivation of crops such as Paddy, Maize, Wheat, Millet, Vegetables, Flowers, etc. The application of hand tractors for plowing, pesticide use, and fertilizers applications have been regularly done there. Some tunnel cultivation has been initiated there by renting the land to outsiders. Still, the adoption of modern technology from traditional farming has been less utilized aspect in this area. As the land conversion to the built-up areas (houses, roads, schools, etc.) has been increasing showing that in the future there might be much less use and relevance of the Ikudha Irrigation Sub-Project as farmers may leave from agricultural activities.

### 5.3.2 Perceived Efficiency

Efficiency in agriculture is defined as the ability to maximize production at the lowest possible cost. In the context of irrigation services, efficiency refers to achieving maximum water availability throughout the year fulfilling its demand with minimal cost and effort. During the FGD and KII, the land owners expressed that the Ikudha Irrigation System has been efficiently operating with the minimum support from the Governmental agencies. The perceived efficiency-related item variables have been analyzed based on a seven-point agreement scale such as 7:

strongly agree, 6: agree, 5: somewhat agree, 4: neutral, 3: somewhat disagree, 2: disagree, 1: strongly disagree (Table 5.5).

Table 5.5. *Perceived Efficiency of Ikudha Irrigation Sub-Project*

Variables	7	6	5	4	3	2	1
Farmers can get irrigation service on time	0	20 (29%)	13 (18.8%)	5 (7.2%)	20 (29%)	5 (7.2%)	6 (8.7%)
There is no bias in distributing water to the user groups	12 (17.4%)	25 (36.2%)	14 (20.3%)	10 (14.5%)	8 (11.6%)	0	0
There is adequate canals and distributary canals in the field	50 (72.5%)	12 (17.4%)	7 (10.1%)	0	0	0	0
DOI and other stakeholders are providing support for its rehabilitation regularly	0	0	18 (26.1%)	0	26 (37.7%)	14 (20.3%)	11 (15.9%)
Farmers are able to cultivate multiple crops	25 (36.2%)	33 (47.8%)	11 (15.9%)	0	0	0	0
There is regular WUA meetings	5 (7.2%)	50 (72.5%)	4 (5.8%)	0	0	10 (14.5%)	0
Current WUA is effective for water management and distribution	6 (8.7%)	21 (30.4%)	18 (26.1%)	0	0	14 (20.3%)	10 (14.5%)
Improved varieties of seed have been used	0	6 (8.7%)	45 (65.2%)	9 (13.4%)	9 (13.4%)	0	0
Total targeted area is under irrigation	28 (40.6%)	23 (33.3%)	8 (11.6%)	4 (5.8%)	3 (4.3%)	3 (4.3%)	0

**Source:** Field Survey, 2023

Farmers have responded that they obtain irrigation services on time mostly in monsoon season. However, due to the drought and less availability of water, they opined that they have not been receiving water in sufficient quantity during the winter and spring seasons, mostly for vegetable crops. The traditional bonding is so strong there; there are no biases while distributing water. However, about 12 percent of farmers responded that the relatively large farmers receive more water disproportionately marginalizing small landholders. There are adequate branch canals and field channels to distribute water to the fields. The RCC and earthen canals and field channels are available in command areas. However, it is reported that about 25-30 percent of water loss is due to the seepage in this area. The support from the federal government is limited only to the provision of technical

training these days. However, the ward office of the Godawari municipality provides minimal financial support for the maintenance of the irrigation canals.

They have formed the Ikudha Rajkulo Water User Association and operating for the last two decades. They used to organize a general assembly at least twice a year and regular meetings at least four times a year. About 2/3 of the respondents agreed that the present WUA has been effective for water management and distribution while 1/3 disagreed. And, the targeted area has been covered by the Ikudha Irrigation system. Similarly, about 70 percent of farmers have reported that they have been using an improved variety of seeds for cultivation and all respondents affirmed the multiple crops cultivation in their lands with the irrigation facilities and availability of the water.

### 5.3.3 Perceived Effectiveness

Effectiveness is defined as achieving desired results in agricultural production and boosting productivity. The Ikudha Irrigation Project has played a key role in increasing productivity and reducing the amount of fallow or abandoned land. Approximately 60 percent of farmers believe that the Ikudha Irrigation Sub-Project has helped enhance the yield of major crops like paddy, maize, wheat, mustard seeds, spinach, and other vegetables. The perceived effectiveness-related item variables have been analyzed based on a seven-point agreement scale such as 7: strongly agree, 6: agree, 5: somewhat agree, 4: neutral, 3: somewhat disagree, 2: disagree, 1: strongly disagree (Table 5.6).

Table 5.6. *Perceived Effectiveness of the Ikudha Irrigation Sub-Project*

Variables	7	6	5	4	3	2	1
Crop change patterns have increased production	18 (26.1%)	23 (33.3%)	17 (24.6%)	4 (5.8%)	3 (4.3%)	4 (5.8%)	0
Decreased in fallow land	55 (79.7%)	14 (20.3%)	0	0	0	0	0
Production of major crops have been decreased	0	0	0	0	6 (8.7%)	50 (72.5%)	13 (18.9%)
Commercial farming has been increased	9 (13.0%)	31 (44.9%)	4 (5.8%)	11 (15.9%)	9 (13.0%)	3 (4.3%)	2 (2.9%)
There is equal water	0	0	26 (37.7%)	4 (5.8%)	35 (50.7%)	4 (5.8%)	0

availability in total ISP command area							
Farmers response to ISP is satisfactory	5 (7.2%)	60 (87%)	4 (5.8%)	0	0	0	0
There is equal participation in operation and management of ISP	0	0	32 (46.4%)	0	26 (37.7%)	11 (15.9%)	0

**Source:** Field Survey, 2023

With improved access to water, agricultural inputs, and technology, per-unit productivity has risen significantly. All farmers reported a decrease in unused fallow land since the introduction of Ikudha Irrigation, and none observed a decline in major crop yields during the survey. Over 60 percent of farmers indicated that commercial farming has increased, although 20 percent felt this was not the case. Farmers also noted that farms located upstream receive more water compared to those downstream in the command area (Table 13), though nearly all expressed satisfaction with the Ikudha Irrigation Sub-Project. Regarding participation in the operation and management of the irrigation system, 46 percent of farmers felt there was equal involvement, while the remaining 54 percent disagreed.

#### 5.3.4 Perceived Impact

Impact refers to the significant and measurable changes or effects resulting from a specific action or intervention. It is often described as the long-term outcomes and consequences of a project or initiative, reflecting how it has influenced people, communities, systems, or environments. The perceived impact-related item variables have been analyzed based on a seven-point agreement scale such as 7: strongly agree, 6: agree, 5: somewhat agree, 4: neutral, 3: somewhat disagree, 2: disagree, 1: strongly disagree (Table 5.7).

Table 5.7. *Perceived Impacts of the Ikudha Irrigation Sub-Project*

Variables	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
People have diversified their agricultural production	25 (36.2%)	35 (50.7%)	8 (11.6%)	0	1 (1.4%)	0	0
Family income has been increased	0	60 (87%)	9 (13.0%)	0	0	0	0
It has helped to reduce poverty	0	0	45 (65.2%)	20 (29%)	4 (5.8%)	0	0
There is a significant improvement in living standard of people	0	0	14 (20.3%)	55 (79.7%)	0	0	0
Investment in education and housing has increased	60 (87%)	3 (4.3%)	4 (5.8%)	2 (2.9%)	0	0	0
The status of food security has increased	5 (7.2%)	4 (5.8%)	7 (10.1%)	53 (76.8%)	0	0	0
The rural economy has been generated through commercial farming	3 (4.3%)	6 (8.7%)	5 (7.2%)	40 (72.5%)	6 (8.7%)	5 (7.2%)	0

**Source:** Field Survey, 2023

The water availability through the Ikudha Irrigation Sub-Project has contributed significantly to product diversification. The contribution of agriculture to family income has largely increased as suggested by all respondents. There are other several income sources besides agriculture in these command areas as people have run businesses, work in governmental and private organizations, livestock farming, etc. The respondents did not agree on the sole contribution of irrigation in poverty reduction and improving the living standards of people. Simultaneously, the income from agriculture and other economic activities, people used to spend mostly on children's education and housing up gradation. Besides agriculture, there is plenty of income sources, therefore they can purchase any food items and fulfill their demands from adjoining markets.

There is not any shortage or food insecurity in this area; however, it depends on the supply from the market. As there is not much cultivable

agricultural land in this area, the production from the available land is not sufficient to fulfill the food demand of the growing population.

### **5.3.5 Perceived Sustainability**

The sustainability of any irrigation system encompasses infrastructural, institutional, economic, and socio-environmental factors (Cai et al., 2001). The infrastructural sustainability primarily relies on the design, construction, and condition of physical components, including head works, canal networks, cross-drainage structures, and water distribution facilities. The institutional sustainability of an irrigation system involves the roles of governmental irrigation offices, Water User Associations (WUAs), executive committees, and its general members. The bearing capacity of the management, operation, and maintenance cost of the irrigation project is considered as the financial/economic sustainability.

Technical support from the federal and provincial governments have been slashed over these years. However, the local government of Godawari municipality has been providing financial and technical support. This has been very important for the regular maintenance, operation, and functionality of the head works, canals, branch canals, and field channels. The perceived impact-related item variables have been analyzed based on a seven-point agreement scale such as 7: strongly agree, 6: agree, 5: somewhat agree, 4: neutral, 3: somewhat disagree, 2: disagree, 1: strongly disagree (Table 5.8).

Table 5.8. *Perceived Sustainability of the Ikudha Irrigation Sub-Project*

Variable	7	6	5	4	3	2	1
Technical support from federal, provincial and local government	5 (7.2%)	4 (5.8%)	30 (4.3%)	9 (13.0%)	15 (21.3%)	3 (4.3%)	3 (4.3%)
Maintenance support from federal, provincial and local government	6 (8.7%)	14 (20.3%)	34 (49.3%)	2 (2.9%)	3 (4.3%)	8 (11.6%)	2 (2.9%)
Technical and financial support from Department of Water Resources and Irrigation	0	6 (8.7%)	3 (4.5%)	7 (10.1%)	43 (62.3%)	4 (5.8%)	6 (8.7%)
Operational role of community irrigation project	40 (58.0%)	12 (17.4%)	6 (8.7%)	4 (5.8%)	7 (10.1%)	0	0
Maintenance role of community irrigation project	47 (68.1%)	15 (21.7%)	7 (10.1%)	0	0	0	0
Regular monitoring mechanism of physical structure of canals	5 (7.2%)	36 (52.2%)	18 (26.1%)	2 (2.9%)	8 (11.6%)	0	0
Accountability of WUGs and other groups	41 (59.4%)	19 (27.5%)	9 (13.0%)	0	0	0	0
Collecting irrigation charge and maintenance charge on time	0	0	0	0	0	0	0
Transparency is maintained related to financial activities of the project	25 (36.2%)	24 (34.8%)	20 (29.0%)	0	0	0	0

**Source:** Field Survey, 2023

Federal governments on the past used to provide maintenance support in the past. But, after the constitution and federalization of the government of Nepal, the responsibilities of the small irrigation project have been handed over to the provincial government. These days large-scale maintenance used to be done by the Water Resource and Irrigation Development Division, Lalitpur under the Bagmati provincial ministry of Ministry of Water Supply, Energy and Irrigation. About 1/3 households agreed upon the provisions of maintenance support from the federal, provincial, and local governments whereas about 20 percent disagreed with this statement. In contrast to this, 2/3 of households disagreed with the statement that the federal Department of Water Resources and Irrigation has been providing technical and financial support to the Ikudha Water User Association and groups.

The findings show that the local community provides the maximum operational role of irrigation projects (84%) and maintenance role up to 100 percent. Similarly, the WUG regularly monitors the physical structure of the canals and provides regular maintenance if needed. A total of 59.4 percent of the respondents strongly agreed that the WUGs have maintained the appropriate accountability. There are no provisions for paying irrigation fees/charges by the water users. There is no big budgetary support and does not hold a large sum of the money, however, the respondents fully agreed upon the transparency in the management of the budget/fund and any financial activities of the project. This information is shared at the regular meeting and general assembly and also provided information if somebody wants to know anytime.

## **5.4 Role of Irrigation Sub-project in Agricultural Development**

### **5.4.1 Irrigation and Agricultural Development**

The Ikudha Irrigation Sub-Project has been important for the development of the agriculture sector in command areas despite many agricultural lands having already been fragmented and converted to built-up areas. As the cropland of the country has reduced by 1.75 percent reaching 22.59 percent in 2022 from 24.34 percent in 2019 (FRTC, 2022; FRTC 2024), the cropland in the irrigation command area has rampantly decreased. However, almost 80 percent (55 HHs) have opined that they have been regularly obtaining water from Ikudha during

monsoon when the paddy used to be planted. Most of the farmers are producing cereals and vegetables.

Only a few households have rented out the land to vegetable growers from the Terai region of Nepal and are involved in commercial farming. About two-thirds of the farmers grow agricultural crops to fulfill their own demands. They have intensified the utilization of the land by diversification and year-round cultivation of their land; still, they have not changed their cropping and rotation patterns. They have increased the crop production and vegetable production per unit of the land compared to in the past (Table 5.9).

Table 5.9. *Agriculture Development after Irrigation Facilities*

Category	Responses			
	Yes		No	
	n	%	n	%
Regularly receiving irrigation facilities	55	79.71	14	20.29
Involving in commercial farming	24	34.78	45	65.22
Changing cropping pattern	14	20.29	55	79.71
Changing crop rotation pattern	19	27.53	50	72.47
Increased crop production	51	73.91	18	26.09
Increased vegetable products	60	86.95	9	13.05
Increased family food sufficiency	30	43.47	39	56.53
Total	69	100.00	69	100.00

**Source:** Field Survey, 2023

#### 5.4.2 Food Sufficiency/Adequacy

There are few agricultural tunnels raising tomatoes, mushrooms, brinjals, beans etc. have been done. Few of them have been run by the people from outside (Terai) in the rented land. The irrigation from the Ikudha is the main source of family food sufficiency (Table 5.10). Despite the tremendous increase in land prices, almost 5-7 times in the last decade, the local resident still cultivating the remaining parts of their land as of their tradition.

Additionally, high demand for vegetables, flowers, and ornamental plants serves as a significant income source for some families. There are agricultural tunnels for crops like tomatoes, eggplants, and beans, some of which are operated by people from the Terai region on rented land. Irrigation from the Ikudha system is essential for these operations.

Table 5.10. *Family Food Sufficiency from Own Production*

Crops	<3 months	3-6 months	6-9 months	9-12 months	>12 months	Total
Cereal Crops (Paddy, Maize, Wheat)	68	0	0	1	0	69
Vegetables	9	13	21	26	-	69

**Source:** Field Survey, 2023

The productivity of the area is high. However, due to the fragmented and small landholdings, the yield from irrigated land is not sufficient to fulfill the agricultural demands of the family. A total of 68 households responded that the cereal production from their agricultural land was sufficient only for less than

three months. Only one family said that the production is year-round sufficient to fulfill his family's requirements of cereal such as Rice, Maize, and Wheat.

However, the demand for vegetables, flowers, and some ornamental plants has been a great source of income for some families. The major vegetables are Chayote (Ishkush), Pumpkin, Guard, Bitter guard, Lady's finger, Sponge guard (Ghiraula), Beans, Peas, Cowpeas, Cauliflower, Cabbage, Radish, Spinach, Chilli, Tomato, Potato, Asparagus, Cucumber, Onions, Garlic, Oilseed Mustard etc.

#### 5.4.3 Functions of Performance Indicators for Agriculture Development

The Ikudha irrigation sub-project is widely regarded as a successful initiative, largely due to the active participation of residents. Local people have traditional water use patterns and self-governing indigenous systems, making them strong, effective, and self-sustaining. Regular maintenance, effective water distribution, a strong sense of community, and support from local government and other organizations have contributed to its sustainability. Therefore, the functions of this irrigation sub-project have been playing a transformative role in agriculture development (Table 5.11).

Table 5.11. *Functions of Agriculture Development*

Indicators	Functions for Agriculture Development
Relevancy	<ul style="list-style-type: none"> <li>▪ Availability of the Agriculture land</li> <li>▪ Availability of the perennial source of water (Godawari river)</li> <li>▪ Willingness of the People</li> </ul>
Effectiveness	<ul style="list-style-type: none"> <li>▪ Productivity increased</li> <li>▪ Crop diversification occurred</li> <li>▪ Cropping intensity increased</li> <li>▪ Introduction of the commercially important and improved variety occurred</li> </ul>
Efficiency	<ul style="list-style-type: none"> <li>▪ Per unit agriculture productivity increased</li> <li>▪ The cost of cultivation decreased due to the introduction of modern technology e.g. hand tractor, tunnel cultivation etc.</li> </ul>
Impact	<ul style="list-style-type: none"> <li>▪ The impact was high in the past</li> <li>▪ Sole source of income and employment in the past</li> <li>▪ Agri-based enterprises established e.g. rice mills, oil mills</li> <li>▪ Sale of vegetables, flowers increased</li> <li>▪ Development of the few markets for vegetables in Badegaun and Thaiba</li> <li>▪ Initiated the tunnel cultivation</li> <li>▪ Farm renting started for outsiders to grow vegetables, and tunnel farming</li> </ul>

Sustainability	<ul style="list-style-type: none"> <li>▪ Establishment of the Water User Association</li> <li>▪ Farmers participation in the maintenance and operation of the irrigation facilities</li> <li>▪ No major disputes and conflicts in water distribution</li> <li>▪ Regular support from the Godawari municipality</li> <li>▪ Capacity building training for the users from federal and provincial institutions.</li> <li>▪ Rapid land conversion to non-agricultural purposes, may pose threats to the long-term sustainability</li> <li>▪ Large landslides at Civil Home blocked the water flow in Ikudha canal (as of 13 Asoj 2081)</li> </ul>
----------------	---

**Source:** Field Survey, 2023

The findings of the study have played a key role in the agricultural development of the command areas (Badegaun and Thaiba). The beneficiaries have both an indigenous self-governance system and a modern organizational system of the WUA and constitution operating successfully for managing the irrigation system. It can also be inferred that the common-pool resources, such as small to medium-sized irrigation systems, can be effectively managed by the local people with support from governmental institutions. As the per-unit agricultural crop productivity has increased due to the water availability from the Ikudha irrigation, it has played a positive role in the lives of local farmers and promoted agriculture development and functionality of the irrigation sub-project.

#### **5.4.4 GIS Map Change Detection**

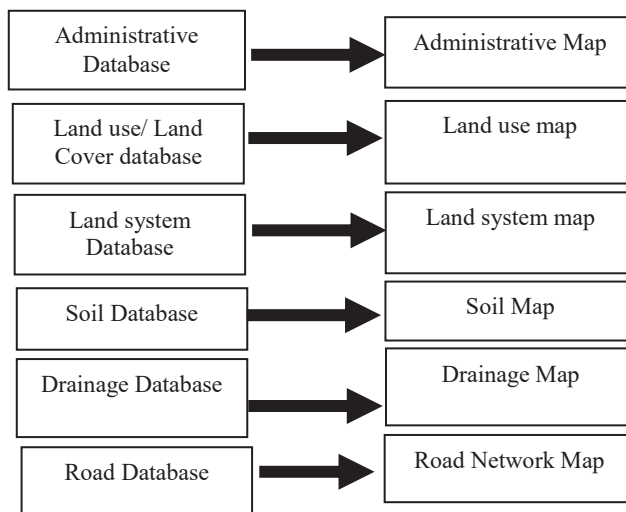
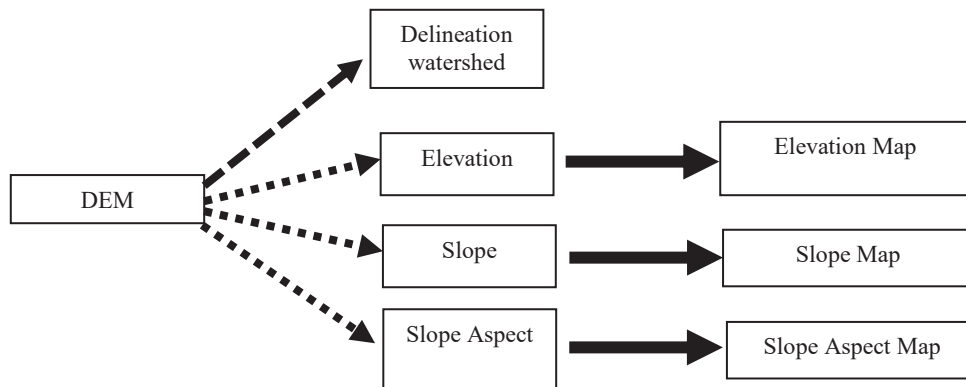
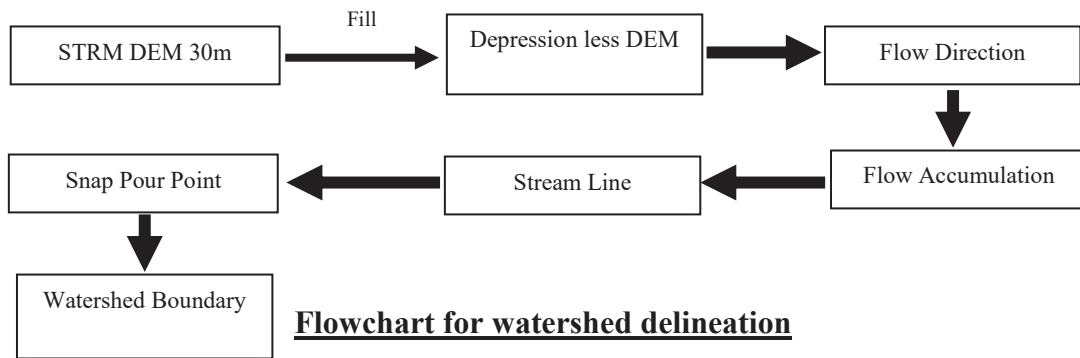
Google Earth Pro was used to depict the physical development and changes of the Godawari regions and Irrigation areas. The changes in the infrastructure development and changes from 2003 to 2022 were analyzed and depicted by using Google Earth. For the preparation of maps, Arc GIS 10.8 applications were used (Table 5.12). Likewise, the watershed of Godawari River, which is the source for the Ikudha ISP, was delineated with the help of a hydrology tool under spatial analysis in ArcGIS environment and verified with a Topographic map.

Table 5.12. *Data Types & Layers Used for Preparing GIS Map of Study area*

Data Class	Layer Name	Data Type	Theme	Source	Remarks
Land Use/Land Cover	Land_ar	Polygon	Land use/Land cover	FRTC Nepal, 2021	30m spatial resolution
Land System	Land_sys	Polygon	Land form	ICIMOD (Based on LRMP, 1986)	
Administrative Boundary	Admin_ar	Polygon	Administrative boundaries	Survey Department, GoN	
Drainage Line	Hydro_ln	Line	Rivers/Streams	Survey Department, GoN	
Village (Settlement)	Village_pt	Point	Village	Survey Department, GoN	
Road	Road.ln	Line	Road	DoR/DoLIDAR, 2016	
DEM	DEM	Raster	DEM	USGS (SRTM 30 m)	Raster image not reclassified
Slope	Slope.tif	Raster	Slope	Derived from SRTM 30 m, DEM	Reclassified into 5 classes
Aspect	Aspect.tif	Raster	Aspect	Derived from SRTM 30 m, DEM	Reclassified into 4 direction classes

**Source:** Developed by the Researcher, 2023

Figure 5.1. Methodology for Map Layout



**Source:** Developed by the Researcher, 2023

#### 5.4.5 Changes in Land Use

There has been a large increase in the settlement in the Godawari area. The agricultural land has been converted into a settlement or built-up area. The rampant changes have been seen in converting agricultural land into built-up areas, mostly settlement (Table 5.13; Appendix D).

Table 5.13. *Changes in the Land Cover from 2000 to 2019 in Godawari Area*

Category	Area (ha)			Area Changes	
	2000	2010	2019	2000-2019	2010-2019
Cropland	2,028.06	1,939.25	1,887.61	-140.45 (-6.9%)	-51.64 (-2.7%)
Forest	2,492.95	2,540.60	2,225.65	-266.3 (-10.7%)	-314.95 (-12.4%)
Other	53.51	29.45	14.49	-39.02 (-72.9%)	-14.96 (-50.8%)
Wooded land					
Built up areas	50.17	118.72	500.35	450.18 (+897.3%)	381.63 (+321.5%)
Grassland	6.31	1.98	1.89	-4.42 (-70.0%)	-0.09 (-4.5%)

**Source:** GIS/RS Analysis, 2024

## **CHAPTER VI**

### **SUMMARY OF FINDINGS, CONCLUSIONS AND IMPLICATIONS**

#### **6.1 Summary of Findings**

##### **Operating Mechanism and Farmer's Characteristics**

Ikudha-Rajkulo Water User Association was established to manage and oversee this irrigation sub-project. This is an autonomous, inalienable succession, not political and non-profit institution. While a traditional governance structure already existed, the association formalized its operations by creating a "Constitution" to guide its administration, which was also registered with the former Lalitpur District Water Resource Committee. This constitution outlines provisions for forming an executive committee, defining the rights and responsibilities of its members, conducting general assemblies and committee meetings, and addressing membership criteria, fees, and other procedural matters. There are 15-member committee (excluding advisory members), consisting of 13 men and two women, reflecting a male-dominated decision-making structure. The local government, Godawari municipality, provides a small budget for the maintenance and cleaning the canals. Still, the farmers volunteer most of time to clean and maintain the canals without any cash payment in return.

The community is fairly homogenous, with Newars making up about 60 percent of the population, followed by Brahmins and Chhetris (30%), and Tamangs and Magars (10%). The farmers' literacy rate is estimated to exceed 90 percent, well above the national average, with men showing higher literacy levels than women. Women primarily work in agriculture and small businesses, while men tend to be employed in government or private organizations, run larger businesses, or seek employment abroad.

##### **Performance of Ikudha Irrigation**

The Ikudha irrigation sub-project has been very much relevant to the development of the agriculture sector in the command areas from the beginning of its construction dating back to the century. Most residents are engaged in agriculture, small businesses, government or private sector jobs, and employment abroad. Some agriculture-based industries, such as rice mills and mustard oil

mills, have been operating for decades as part of their traditional enterprises. In the past, these mills could rely on local production and nearby purchases to meet their needs, but this is no longer the case.

This irrigation project has served the increase productivity for a longer period, and it has been important for the cultivation of the remaining pieces of croplands. Still, the majority of the residents in the command area are involved in the cultivation of agricultural crops. The Ikudha irrigation system greatly impacted livelihoods in the area, serving as the primary source of income and employment for farmers who depended on it to meet their essential needs, including food, shelter, education, health, and even recreation.

The establishment of rice and oil mills exemplifies how increased crop production, supported by irrigation, has spurred agricultural-based industries. Besides, local people are also earning from alternative income sources such as non-agriculture enterprises, government and private jobs, remittances, and selling their land property. Land fragmentation has been mounted due to family divisions and urban expansion. It has reduced available farmland, per-unit productivity has risen, and cropping patterns and intensity have improved significantly.

### **Role of Ikudha Irrigation Sub-project in Agricultural Development**

The government of Nepal, through its policy and legislation, has been providing immense priority to devolve/decentralize management authority to the farmers in the context of irrigation and other common pool resources. The promotion of the farmer-managed irrigation system through political and legal backing is one of the examples of decentralized management. In this respect, the successful operation of the Ikudha irrigation supports the legislative intentions of decentralizing the irrigation system management is appropriate. Currently, this irrigation sub-project supplies water to approximately 50 hectares of agricultural land, serving over 500 households on both sides of the Godawari-Satdobato main road. In 2009, it used to provide water to over 75 hectares of farmland for around 300 households. However, with population growth and family divisions, the number of farmers has increased to over 500, while the irrigated agricultural land has decreased to about 50 hectares.

The main irrigation canals, along with their branches and field channels, supply water to croplands, leading to an increase in per-unit land productivity.

Alongside this rise in productivity, data indicates that both agricultural diversity (species diversity) and cropping intensity in the command areas have grown. However, the conversion of agricultural land into built-up areas—such as housing, road networks, encroachments, and plot developments—has reduced the amount of cultivable land. Furthermore, average land holdings have shrunk by 50 percent, resulting in an overall decline in total cereal production within the command areas. As a result, farmers can now only meet about three months of their staple food needs from their production, relying heavily on other household incomes—such as employment, small businesses, or remittances—to purchase additional cereal crops from the local market.

However, vegetable and flower production in the irrigated areas has increased significantly. Farmers are now growing high-demand, high-value vegetables using improved techniques, such as tunnel farming, and applying more manure, fertilizers, and pesticides, which has greatly boosted vegetable yields. Off-season vegetable farming has also gained momentum in the area.

## **6.2 Conclusions**

This study comes to the conclusion that Ikudha irrigation sub-project has a history spanning over a century and holds significant contributions for local farmers. The functionality of operating mechanism also has been performing well which is rooted in historical, traditional, economic, and social values. However, following modernization with government support, the Ikudha-Rajkulo Water Users' Association was established and started managing Ikudha irrigation system. This farmer-led irrigation system has successfully overseen the operation and management of the Ikudha irrigation system. It has been conducting regular meeting and general assembly to take the operating mechanism and management related decision.

This study also comes to the conclusion that this irrigation sub-project is becoming highly relevant, efficient, effective and impactful within the command areas for a longer period. It has been playing a key role in promoting agricultural productivity. In the Ikudha irrigation command area, per-unit agricultural productivity has significantly improved. The availability of water through the Ikudha canals has led to increased species diversification, the introduction of commercially important crops, and higher cropping intensity. These developments

have positively influenced agricultural growth, farmers' income, and overall production. However, due to the increased land price, and conversion of agricultural land to built-up areas, sustainability issues exist. Ikudha-Rajkulo Water Users' Association has become unable to prevent the conversion of agricultural land into built-up areas.

Finally, common pool resource management is a complex issue, especially in a global context. Even in Nepal, the active participation of the people in the conservation of the common pool resources like irrigation systems is very challenging. However, the Ikudha irrigation sub-project can be considered a successful model of a farmer-managed irrigation system with a very long tradition from democratic to decentralized experiences. However, extensions of built-up areas, heavy downpours, sedimentation and landslides have damaged the canals extensively. Maintaining the head works, main canal, branch canals, and field channels is critical to ensuring efficient water flow and minimizing seepage. Sedimentation and water seepage are ongoing challenges; therefore, sediments and debris must be regularly removed. There is a need for a robust system backed up by the regulations, standard norms, and values required for the successful management of the Ikudha irrigation sub-project in the coming years.

### **6.3 Implications**

The Ikudha irrigation sub-project has long played a central role in managing the community's irrigation infrastructure. Maintaining the head works, main canal, branch canals, and field channels is critical to ensuring efficient water flow and minimizing seepage. Sedimentation and water seepage are ongoing challenges occurring due to urbanization, modern building constructions, and heavy downpour. Governmental agencies should support in bearing the cost of the bigger and costlier maintenance whereas the regular maintenance should be done by the WUA. Therefore, the findings of the study are applicable at theoretical level, policy level, and managerial levels.

#### **6.3.1 Theoretical Level Implication**

The common pool resources are vital for livelihoods, especially in rural and subsistence-based communities. Sustainable management of common pool resources ensures long-term ecological and economic stability. However,

sustainable management of common pool resources is a very complex issue. There used to be the free-raider behavior of the users. The limited availability of resources gets degraded or depleted due to over-harvesting without thinking about sustainability.

Theoretically, the Ikudha irrigation sub-project also has been facing triple water resource management-related challenges. First (overuse): there is excessive use by individuals leads to resource depletion (e.g., over-harvesting, overfishing, or deforestation) and degradation. Second (the tragedy of commons): Without regulation and proper management, users acting in self-interest can deplete/damage the resource, causing over-exploitation and unsustainable utilization harming all in the long term. The Ikudha irrigation system has both formal and informal regulations so that the sustainability issues are maintained. Third (conflict): Competing interests among users can lead to disputes over resource allocation. These used to happen sometimes during the highly demanding time for irrigation but the executive committee and association come to maintain harmony by resolving conflicts. These triple challenges can be addressed with collective efforts of the water users association, the Guthi system of local communities, local government as well as government and non-government agencies.

### **6.3.2 Policy Level Implication**

Nepal has shown great successful examples to the world in common pool resource management. Community forestry and biodiversity conservation efforts through decentralized and devolved power/jurisdictions are regarded as the best examples of common pool resource management. The country also has been successful in increasing forest coverage and the number of mega mammal species such as Tiger, Rhinoceros, Gaur, Swamp deer, Water Buffalo etc.

A similar kind of success has been also witnessed in managing the irrigation canals by utilizing the active participation of the beneficiaries. The community-managed irrigation system of Ikudha has been becoming successful in the operation, management, utilization, and resolution of conflicts. This irrigation project has implemented both formal and informal rules and regulations to operate and manage this irrigation sub-project. The active participation of the local community through the traditional Guthi system is one of the best practices of this

irrigation sub-project. Therefore, the Government of Nepal can develop and implement community-based irrigation policies. The farmers should be capacitated in the aspects of the water management. The monitoring and evaluation of the performance of the water user association should be regularly done by the irrigation department and local government.

### **6.3.3 Managerial Level Implication**

The Ikudha irrigation sub-project must develop and implement rules and regulations that limit resource use (e.g., water-use limits) and contribute to the maintenance of the canals. Water user associations should be strengthened, encouraged, and capacitated to collectively manage the resource with agreed-upon norms and practices. Introducing property rights or pricing mechanisms (e.g., levying water fees and maintenance costs). The water users association must consult with government and non-government agencies regularly to get technical support and collect maintenance funds. The association also needs to play an institutional agency role to halt the conversion of irrigated agricultural land into non-agricultural proposes. They must collaborate with the municipal government to control building houses and other infrastructure in the irrigation command area.

The farmer should pay water charges regularly to the WUA so that the maintenance funds get increased. This fund can be utilized in case of urgent needs for the small maintenance of canal and remove sediments. Also, they should regularly participate in the maintenance of the canals. The regular meeting of the WUA needs to be organized and the farmers should participate in the meeting and provide their opinion for better performance.

Finally, the pollution-related issues which includes wastewater, plastics, and other waste materials, must be immediately addressed. The local government, especially the ward office, should take proactive legal action to protect the Ikudha irrigation canals from encroachment and pollution. Without firm measures, preserving this historically significant irrigation system may be nearly impossible.

### **6.4 Areas for Further Research**

This study evaluates the operating mechanism and management of the Ikudha irrigation sub-project located in Godawari municipality. The study could not cover other issues such as the encroaching of canals by local residents, covering the

canals with RCC to build roads, and wastewater from households is often discharged directly into the canals, treating them as sewage drains. There is a disconnect between protecting agricultural land and expanding irrigation facilities. Therefore, these issues can be addressed by other researchers in the coming year. Similarly, there are mainly three irrigation canals: Mudha (Main Canal/kulo), Tapadha (Tapa Canal/Kulo) and Ikudha in Godawari municipality. This study is focused on the Ikudha irrigation sub-project. Therefore, other researchers can focus on two distinct irrigation projects.

Methodologically, this study used a case study research design in which required information was collected from a small sample size of 69 articulating households. Other researchers can use a comparative case study research design and can be collected data from large sample number. Statistically, this study uses simple descriptive statistical tools and summative analysis tools for analyzing the data. Other researchers can apply multivariate statistical tools like path analysis, linear regressions, and economic modelling.

## REFERENCES

- ADB (Asian Development Bank). (2009). *Nepal: Community-managed irrigated agricultural sector project Ikudha irrigation sub-project, Lalitpur district*.
- Angelakis, A. N., Zaccaria, D., Krasilnikoff, J., Salgot, M., Bazza, M., Roccaro, P., Jimenez, B., Kumar, A., Yinghua, W. & Baba, A. (2020). Irrigation of world agricultural lands: Evolution through the millennia. *Journal of Water*, 12(5), 1285. <https://doi.org/10.3390/w12051285>
- Bhandari, R. P. & Pokharel, D. R. (1998). *Modernization of farmer-managed irrigation systems in Nepal: Process and learning*. In the modernization of irrigation system operations proceedings of the 5th ITIS network international meeting, Aurangabad, 28-30 October 1998.
- Biswas, A. K., (1989). Irrigation in Nepal: Opportunities and constraints. *Journal of Irrigation and Drainage Engineering*, 115(6), 1051. [https://doi.org/10.1061/\(ASCE\)0733-9437\(1989\)115:6\(1051\)](https://doi.org/10.1061/(ASCE)0733-9437(1989)115:6(1051))
- Creswell, J. W. (2009). *Research Design: Qualitative, quantitative and Mixed Methods Approaches* (3rd ed.). University of Nebraska-Lincoln: Sage Publication.
- Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). USA: Pearson Education Inc.
- Cai, X., McKinney, D. C. & Rosegrant, M. W. (2001). *Sustainability analysis for irrigation water management: Concepts, methodology and application to the Aral Sea Region*. International Food Policy Research Institute.
- Damkjaer, S. & Taylor, R. (2017). The measurement of water scarcity: Defining a meaningful indicator. *Ambio*, 46, 513–531.
- Denzin, N. K. & Lincoln, Y. S. (2011). *Handbook of qualitative research* (4th ed.). London: Sage.
- DFID (Department for International Development). (2017). *DFID's 2017 agriculture policy: An interim evaluation*.
- DFRS (Department of Forest Research and Survey). (2018). *Forest cover maps of local levels (573) of Nepal*.
- DoHM (Department of Hydrology and Meteorology). (2024). *The record breaking 24 hours precipitation in different parts of Nepal*. Press Communique of 13/06/2081 (30.09.2024).
- DoI (Department of Irrigation). (2009). *IEE report of Nepal: Community managed irrigated agriculture sector project, Ikudha irrigation sub-project, Lalitpur district*.
- DoWRI (Department of Water Resources and Irrigation Ministry of Energy, Water Resources, and Irrigation). (2019). *Irrigation master plan*. Government of Nepal

- Duker, A. E. C., Maseko, S., Moyo, M. A., Karimba, B. M., Bolding, A., Prasad, P. & Zaag, P. (2023). The changing faces of farmer-led irrigation: Lessons from dynamic irrigation trajectories in Kenya and Zimbabwe. *The Journal of Development Studies*, 59(9), 1317–1336. <https://doi.org/10.1080/00220388.2023.2204176>
- FAO (Food and Agriculture Organization of the United Nations). (2012). *Coping with water scarcity: An action framework for agriculture and food security*.
- FAO (Food and Agriculture Organization). (2021). *Trade of agricultural commodities 2000–2020*. FAOSTAT Analytical Brief 44.
- Fischer, G., Tubiello, F. N., Velthuisen, H. & Wiberg, D. A. (2007). Climate change impacts on irrigation water requirements: Effects of mitigation, 1990–2080. *Technol. Forecast. Soc.* 74, 1083–1107.
- Fraiture, C. & Wichelns, D. (2010). Satisfying future water demands for agriculture. *Agric. Water Management*, 97, 502–511.
- FRTC (Forest Research and Training Centre). (2022). *National land cover monitoring system of Nepal, 2020-22*.
- FRTC (Forest Research and Training Centre). (2024). *National land cover monitoring system of Nepal, 2022-24*.
- Gago, J., Douthe, C., Coopman, R. E., Gallego, P. P., Ribas-Carbo, M., Flexas, J., Escalona, J. & Medrano, H. (2015). UAVs challenge to assess water stress for sustainable agriculture. *Agric. Water Management*, 153, 9–19.
- Gajmer, B. (2014). Nepal: Irrigation and water resource management. The World Bank. <https://www.worldbank.org/en/results/2014/04/11/nepal-irrigation-and-water-resource-management.print>
- Gautam, A. (2020). *Performance assessment of selected farmer managed irrigation system in Kaski district, Nepal*.
- Hedley, C. B., Knox, J. W., Raine, S. R. & Smith, R. (2014). Water: Advanced irrigation technologies. In *encyclopaedia of agriculture and food systems*, (2nd ed) (pp. 378–406). Elsevier Academic Press.
- Izzi, G., Denison, J. & Veldwisch, G. J. (Eds.). (2021). *Farmer-led irrigation development guide: A what, why and how-to for intervention design*. World Bank.
- Liu, J., Wang, Y., Yu, Z., Cao, X., Tian, L., Sun, S. & Wu, P. (2017). A comprehensive analysis of blue water scarcity from the production, consumption, and water transfer perspectives. *Ecol. Indic.* 72, 870–880.
- Manju, S. & Sagar, N. (2017). Renewable energy integrated desalination: A sustainable solution to overcome future fresh-water scarcity in India. *Sustain. Energy. Rev.* 73, 594–609
- MoALD (Ministry of Agriculture and Local Development). (2020). *Statistical information on Nepalese agriculture, 2018/19*.
- MoALD Ministry of Agriculture and Local Development). (2022). *Statistical information on Nepalese agriculture, 2020/21*.

- MoEWRI (Ministry of Environment, Water Resource and Irrigation). (2018). *Present status and future roadmap of energy, water resources and irrigation sector* (White Paper)
- MoF (Ministry of Finance). (2021). *Economic survey, 2020/21*.
- Narayanmoorthy, A. (1997). Economic validity of drip irrigation: An empirical analysis from Maharashtra. *Indian Journal of Agricultural Economics* 52(4), 721. <https://doi.10.22004/ag.econ.297570>
- NPC (National Planning Commission). (2008). *Eleventh three year interim plan*. Government of Nepal.
- NPC (National Planning Commission). (2020). *The fifteenth plan* (Fiscal Year 2019/20 – 2023/24).
- NRB (Nepal Rastra Bank). (2022). *Current macroeconomic and financial situation of Nepal* (Based on annual data of 2021/22). Economic Research Department. <https://www.nrb.org.np/contents/uploads/2022/08/Current-Macroeconomic-and-Financial-Situation-English-Based-on-Annual-data-of-2021.22-2.pdf>
- NSO (National Statistics Office). (2021). *National housing census, 2021*.
- Ostrom, E. (2002). Common-pool resources and institutions: Toward a revised theory. In B. L. Gardner and G. C. Rauser (Eds.), *Handbook of agricultural economics* (pp. 1315-1339). Elsevier.
- Perry, C., Steduto, P., Allen, R. G. & Burt, C. M. (2009). Increasing productivity in irrigated agriculture: Agronomic constraints and hydrological realities. *Agricultural Water Management*, 96(11), 1517-1524
- Poudel, O., Kharel, K. R. & Upadhyay, Y. M. (2021). Assessing the contribution of agriculture for boosting Nepalese economy. *BMC Journal of Scientific Research*, 4(1), 31–41. <https://doi.org/10.3126/bmcjsr.v4i1.42246>
- Pradhan, P. & Belbase, M. (2018). Institutional reforms in irrigation sector for sustainable agriculture water management including water users associations in Nepal. *Hydro Nepal: Journal of Water, Energy and Environment*, 23, 58–70. <https://doi.org/10.3126/hn.v23i0.20827>
- Pradhan, P. & Yoder, R. (1990). *Irrigation development: The management and use of irrigation in the Mountains of Nepal*. MFS Series Number 16, ICIMOD, Kathmandu, Nepal.
- Pradhan, P. (1989). *Patterns of irrigation organization in Nepal: A comparative study of 21 farmer-managed irrigation systems*.
- Pradhan, P. (2000). *Farmer managed irrigation systems in Nepal at the crossroad*. Paper presented in the 8th Biennial Conference of the International Association for the Study of Common Property (IASCP), held in Bloomington, Indiana, the USA from May 30 to 4 July, 2000.
- Saunders, F. P. (2014). The promise of common pool resource theory and the reality of commons projects. *International Journal of the Commons*, 8(2), pp.636–656. <https://doi.10.18352/ijc.477>

- Sojka, R. E., Bjerneberg, D. L. & Entry, J. A. (2002). Irrigation: A historical perspective. In R. Lal (Ed.), *Encyclopedia of soil science* (pp.745-749), Marcel Dekker, Inc.745-749.
- Tamrakar, N. K. & Bajracharya, R. (2012). Basinal and plan form characteristics of the Kodku and the Godavari Rivers, Kathmandu, Central Nepal. *Bulletin of the Department of Geology*, 15, 15–22. Tribhuvan University.
- TEPC (Trade and Export Promotion Center). (2021). *Foreign trade statistics of Nepal*.
- UN (United Nations). (2022). *The sustainable development goals report, 2022*. <https://unstats.un.org/sdgs/report/2022/>
- Velasco-Munoz, J. F., Aznar-Sánchez, J. A., Batlles-dela Fuente, A. & Fidelibus, M. D. (2019). Sustainable irrigation in agriculture: An analysis of global research. *Water*, 11(9), 1758. <https://doi.org/10.3390/w11091758>
- WB (World Bank). (2022). *Supporting safe trade to improve Nepal's export position*.
- WECS (Water and Energy Commission Secretariat). 2011). *Water resources of Nepal in the context of climate change*. <https://www.scirp.org/reference/referencespapers?referenceid=1119869>
- Wu, W. & Ma, B. (2015). Integrated nutrient management (INM) for sustaining crop productivity and reducing environmental impact: A review. *Sci. Total Environment*, 15, 512–513, 415–427. <https://doi:10.1016/j.scitotenv.2014.12.101>
- Zhang, B., Fu, Z., Wang, J. & Zhang, L. (2019). Farmers' adoption of water-saving irrigation technology alleviates water scarcity in metropolis suburbs: A case study of Beijing, China. *Agric. Water Management*, 212(C), 349–357. <https://doi.10.1016/j.agwat.2018.09.021>
- Zhang, Y., Chen, H., Lu, J. & Zhang, G. (2017). Detecting and predicting the topic change of Knowledge-based Systems: A topic-based bibliometric analysis from 1991 to 2016. *Knowl. Based Syst.* 133, 255–268. <https://doi.org/10.1016/j.knosys.2017.07.011>
- Zhang, Y., Zhang, Y., Shi, K. & Yao, X. (2017). Research development, current hotspots, and future directions of water research based on MODIS images: A critical review with a bibliometric analysis. *Environ. Sci. Pollut. Res. Int.*, 24(18), 15226–15239. <https://doi.10.1007/s11356-017-9107-1>

## APPENDICES

### EVALUATING PERFORMANCE OF IKUDHA IRRIGATION SUB-PROJECT IN GODAWARI MUNICIPALITY, LALITPUR

#### Appendix A: Household Survey Questionnaires

##### Section A: Demographic and socio-economic related information (1-12)

1. Address: ..... Municipality..... Ward No: .....
2. Sex group: Male Female
3. Marital status: Single Married Divorced Widow  
Separated
4. Religion: Hindu Budhhist Christian Muslim
5. Ethnicity: Brahman Chhetri Janajati Dalit Muslim  
Others
6. Family system: Joint Family Nucleated Family
7. Total family member:

Age group (year)	Female	Male	Total
0-14			
15-64			
>65			

##### 8. Family occupation:

Occupation	Yes	No
Agriculture		
Local shop		
Trade		
Government job		
Private job		
Wage/Labour		
Agri-enterprise		
Non-agri-enterprise		
Remittance		
Others		

##### 9. Land holding status:

S.N.	Land	Personal land (Ana/Ropani)	Share cropping land (Ana/Ropani)	Leasehold land (Ana/Ropani)
1	Khet			
2	Bari			
Total				

### 10. Food Sufficiency from own production

Months	Sufficiency
None	
<3 months	
3-6 months	
6-9 months	
9-12 months	
Surplus	

### 11. Annual family income:

Sector	NRs
Agriculture	
Local shop	
Trade	
Agri-enterprise	
Nonagri-enterprise	
Government job	
Private job	
Daily wage	
Remittance	
Others	

### 12. Annual family expenditure:

Particulars	NRs
Food items	
Clothing	
Accessories/gold	
Child education	
Visit/pilgrimage	
Cultural celebration	
Medicine	
Philanthropy	

## Section B: Irrigation Sub-project related Information (13- 16)

### 13. Project Status

Category	Response
Established year	
Funding agency	
Coverage area	
Coverage settlements	
Numbers of user groups	
Numbers of user members	
Beneficiaries' households	
Irrigation charge per hour	
Collection of maintenance charge per person/per year	
Total collection of maintenance fund per year	

### 14. Availability of water

Category	Seasons		
	Monson	Winter	Autumn
A: Above requirement			
B: Partial (50%) of required			
C: Around 25% of the requirement			
D: Less than requirement (<25%)			

### 15. Irrigation and agriculture development status

Category	Response	
Regularly receiving irrigation facilities	Yes	No
Involving in commercial farming		
Changing cropping pattern		
Changing crop rotation pattern		
Increased crop production		
Increased vegetable products		
Increased family food sufficiency		

### 16. Production and distribution status

Category	Production		Distributions (Sale)	
	Before irrigation (Quintal)	After irrigation (Quintal)	Before irrigation (NRs.)	After irrigation (NRs.)
Major crops				
Vegetable				
Fruit				
Flower				

## Section C: Evaluation Related Information

### 17. Relevancy (7 Items)

Items	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
Availability of water for irrigation has been increased	7	6	5	4	3	2	1
Irrigation has helped to increase agriculture production							
Farming activities have been increased							
Traditional farming is shifted to modern							
Increase in cropping intensity and crop diversification							
There is increase in self-employment							
The total agriculture area is cultivated and per unit productivity has increased							

### 18. Efficiency (9 Items)

Variables	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
Farmers can get irrigation service on time							
There is no bias in distributing water to the user groups							
There is adequate canals and distributary canals in the field							
DOI and other stakeholders are providing support for its rehabilitation regularly							
Farmers are able to cultivate multiple crops							
There is regular WUA meetings							

Variables	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
Current WUA is effective for water management and distribution							
Improved varieties of seed have been used							
Total targeted area is under irrigation							

### 19. Effectiveness (7 Items)

	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
Crop change pattern have increased production	7	6	5	4	3	2	1
Decreased in fallow land							
Production of major crops have been decreased							
Commercial farming has been increased							
There is equal water availability in total ISP command area							
Farmers response to ISP is satisfactory							
There is equal participation in operation and management of ISP							

### 20. Impact (7 Items)

Variable	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
People have diversified their agriculture production							
Family income have been increased							
It has helped to reduce poverty							
There is significant							

improvement in living standard of people							
Investment in education and housing have increased							
Status of food security have increased							
Rural economy has been generated through commercial farming							

## 21. Sustainability (9 Items)

Variable	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
Technical support from central, provincial and local government							
Maintenance support from central, provincial and local government							
Technical and financial support from support from irrigation department							
Operational role of community irrigation project							
Maintenance role of community irrigation project							
Regular monitoring mechanism of physical structure of canals							
Accountability of WUGs and other groups							
Collecting irrigation charge and maintenance charge on time							
Transparency is maintained related to the financial activities of the project.							

## **Annex B: FGD and KII Guidelines**

1. Formally registered year
2. Formation process of the Water Users Association
3. Members of the Water Users Association
4. Operating mechanism before and after registration
5. Technical and financial support received from the supporting agency
6. Technical and financial support received from the Department of Irrigation
7. Technical and financial support received from municipal and ward-level
8. Command areas of the irrigation subproject
9. Numbers of beneficiaries' household
10. Irrigation fee charge
11. Cannel maintenance methods
12. Sources of water
13. Land use changes in Godawari municipality
14. Land cover changes in Godawari municipality
15. Contributions of irrigation canals in agriculture development and productivity
16. Relevancy, efficiency, and effectiveness of irrigation sub-project
17. Impact and sustainability of irrigation sub-project
18. Challenges of irrigation subproject

### **Annex C: Members of Ikudha Rajkulo Water User Association's**

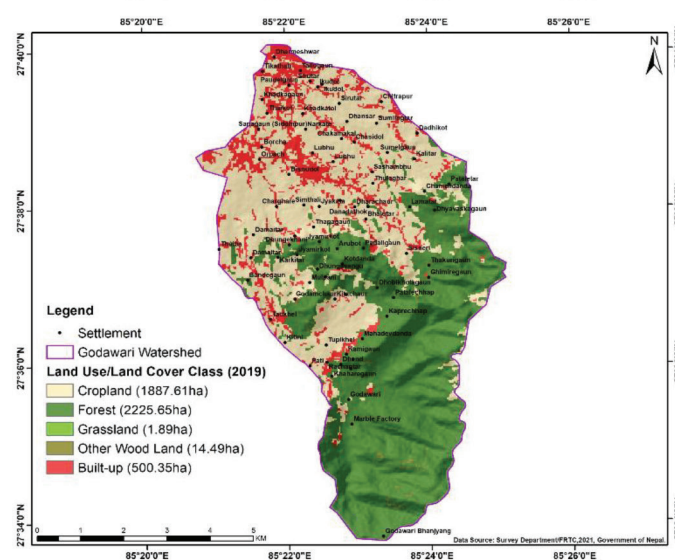
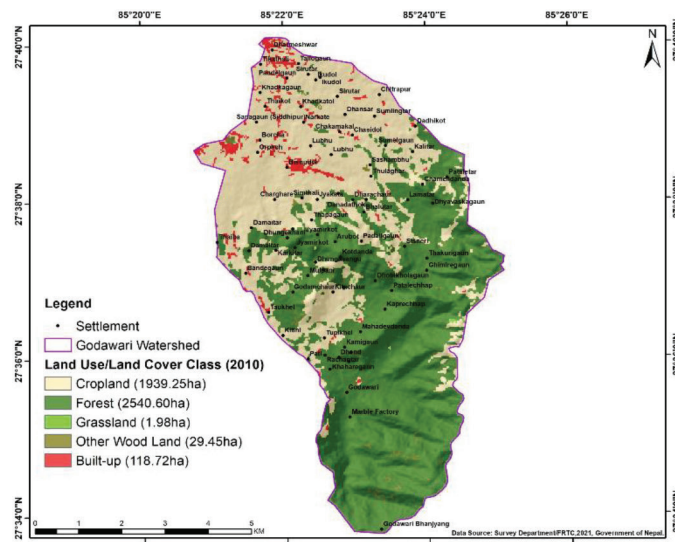
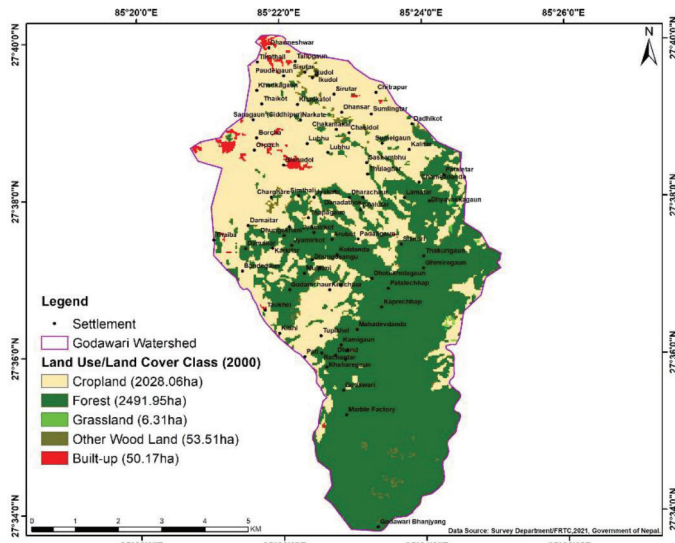
Chair : Mr. Suresh Bajracharya  
Vice Chair : Mr. Ram Maharjan  
Secretary : Ms. Basuram Maharjan  
Joint Secretary: Mr. Ganga Ram Maharjan  
Treasurer : Ms. Tatwa maya Shrestha  
Members : Gyan Lal Maharjan

Mr. Jog Bahadur Maharjan  
Mr. Ram Govinda Maharjan  
Mr. Krishna Govinda Maharjan  
Mr. Pushkar Maharjan  
Ms. Shoba Maharjan  
Ms. Sarita Maharjan  
Ms. Nanichhori Bajracharya  
Ms. Laxmi Shova Bajracharya  
Mr. Babukaji Maharjan  
Mr. Binod Silwal  
Mr. Rabindra Silwal

#### **Advisors:**

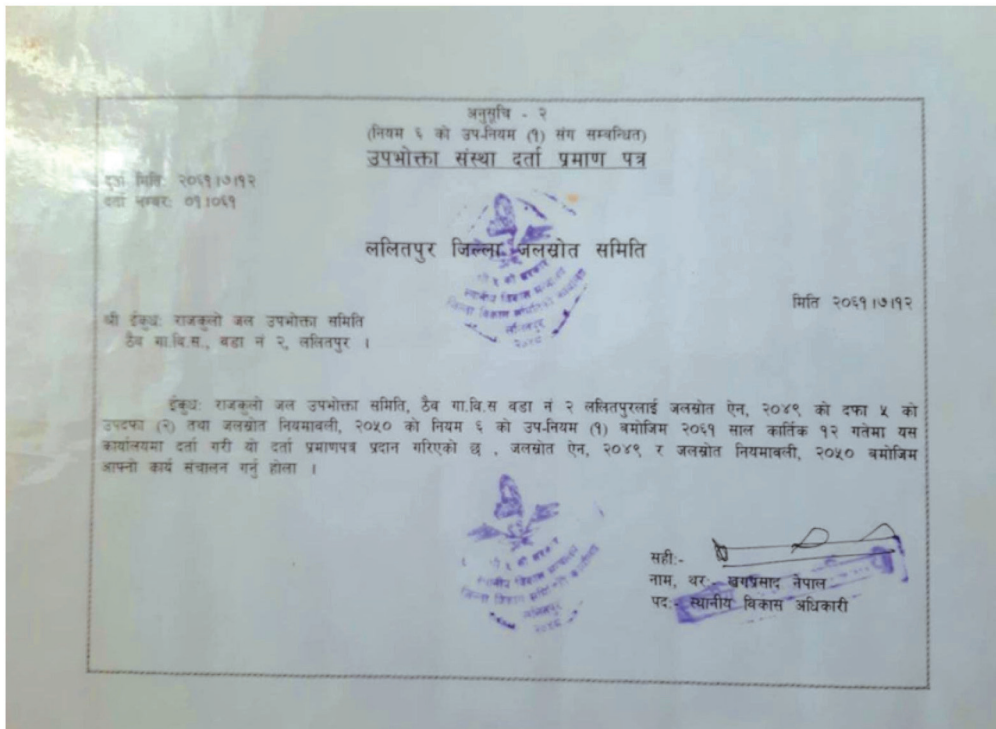
Mr. Shrigovinda Maharjan  
Mr. Purushotam Silwal  
Mr. Jitgovinda Maharjan  
Mr. Pashupati Maharjan  
Mr. Narayan Bahadur Bist

## Appendix D: Land Use Changes in the Godawari Watershed & Command Areas



Land use changes in the Godawari watershed and command areas from 2000 to 2010 to 2019

## Appendix E: Glimpses of the Field Study



*Certificate of registration*



*Researcher with the key informant at Badegaun*



*Maintaining the irrigation canal*



*Observing the maintenance of the canal*



*Command area harvesting time*



*Paddy cultivation at command area*



*Interviewing farmers in the field*



*Branch canal near Badegaun*



Water flowing in the branch canal



Wheat before harvesting



Water flowing in the branch canal



*Irrigated land conversion to plotting*



Branch canal requiring maintenance



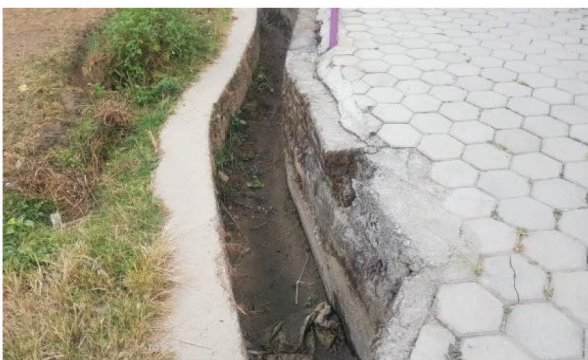
Water flowing in the branch canal



Farmers working in the farmland



Irrigated paddy field



*Disturbance and encroachment around irrigation canals at Badegaun command area*



*Destruction of the Godawari River, the source of Iku-dha Irrigation Canal, due to the recent catastrophic rainfall of September, 2024*



*Agricultural production in the irrigation command area*

