Thesis for the Degree of Master of Science in Environmental Science and Management

# EFFECTIVENESS OF ECOSYSTEM BASED FLOOD ADAPTATION STRATEGIES IN INDIGENOUS COMMUNITY OF LOWER KARNALI REGION, NEPAL

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**Pokhara University, Nepal**

**November, 2025**

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**Supervised by Professor Dr Sanjay Nath Khanal**

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Environmental Science and Management


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**November, 2025**

# Declaration

I hereby declare that the Project paper entitled, **EFFECTIVENESS OF ECOSYSTEM BASED FLOOD ADAPTATION STRATEGIES IN INDIGENOUS COMMUNITY OF LOWER KARNALI REGION, NEPAL** is my original work and has not been submitted anywhere else for any academic award. All literature, data, or works done by others and cited within this report has been given due acknowledgment and listed in the reference section.

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## Letter of Recommendation

This is to certify that, this thesis entitled "**EFFECTIVENESS OF ECOSYSTEM BASED FLOOD ADAPTATION STRATEGIES IN INDIGENOUS COMMUNITY OF LOWER KARNALI REGION, NEPAL**" was prepared and submitted by **Rajan Paudel** in partial fulfillment of the requirement for the Degree of Master of Environmental Management awarded by Pokhara University, has been completed under our supervision. We recommend the same for acceptance by Pokhara University.

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## Certification

This is to certify that the thesis entitled "**EFFECTIVENESS OF ECOSYSTEM BASED FLOOD ADAPTATION STRATEGIES IN INDIGENOUS COMMUNITY OF LOWER KARNALI REGION, NEPAL**" submitted by **Rajan Paudel** is examined and accepted as partial fulfillment for the degree of Master of Science in Environmental Science and Management. The thesis in part or full is the property of the School of Environmental Science and Management and should not be used to award any other academic degree in any other institution.

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## Letter of Approval

This dissertation paper submitted by Rajan Paudel entitled "**EFFECTIVENESS OF ECOSYSTEM BASED FLOOD ADAPTATION STRATEGIES IN INDIGENOUS COMMUNITY OF LOWER KARNALI REGION, NEPAL**" has been accepted for the partial fulfillment of Master of Science in Environmental Management from Pokhara University.

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Rajan Paudel

November 2025

# List of Abbreviations

| | |
|---|---|
| ANOVA | Analysis of Variance |
| CBD | Convention on Biological Diversity |
| CB-DRR | Community Based Disaster Risk Reduction |
| CCA | Climate change Adaptation |
| DRR | Disaster Risk Reduction |
| EbA | Ecosystem based Adaptation. |
| FGD | Focus Group Discussion |
| GDP | Gross Domestic Product |
| HHS | Household survey |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature |
| KII | Key Informant Interview |
| LDCRP | Local Disaster and Climate Resilience Plan |
| MoHA | Ministry of Home Affairs |
| UNDRR | United Nations Office for Disaster Risk Reduction |
| UNEP | United Nations Environmental Programme |
| UNFCC | United Nations Framework Convention on Climate Change |
| WCMC | World Conservation Monitoring Centre |
| WHO | World Health Organization |

# ABSTRACT

Flood is a natural hazard that particularly affecting the Terai region of Nepal, Rajapur Municipality is significantly affected by flood yearly. This research explores the effectiveness of ecosystem-based flood adaptation strategies in the Indigenous community of Rajapur municipality of Bardiya district. The research focuses on five flood prone wards (1, 3, 4, 7, and 10) of Rajapur Municipality adjoining Karnali river and its branches. Mixed-method approach: a household survey (n=190), focus group discussion, and key informant interview (n=7) was used for the study. It has explored the major ecosystem-based adaptation strategies employed by indigenous people in Rajapur, finds out their effectiveness, and the role of women in EbA by using regression analysis.

Ecosystem-based adaptation, like afforestation (plantation of trees like *Bombyx ceiba*(simal), *Bambusa vulgaris*(bamboo), *Melia azedarach* (Bakaino), *Tectona grandis*, *Dalbergia sissoo*(sisam), *Syzygium cumini*(Jamun), *Eucalyptus*(sagun)etc. near agricultural fields, near irrigation canals, and banks of rivers, involves the construction of biodykes made up of (tree branches and wood, sacks filled with small stones, soil) and placed on the bank of rivers to build a wall-like structure were documented. Indigenous practice to protect seed for next year by keeping them in elevated houses, branches of trees, and a pot made up of mud and straw called "Dhehrai" (it is used for the protection of food grains and seeds from flood as well as pests) were also recorded. Tree plantation has shown effectiveness in improving soil health/quality, reducing soil erosion, and reducing flood impact due to their extensive root system and canopy cover. Effectiveness of walls made of branches of trees (biodykes), which help to reduce the risk of bank cutting, and its cost-effectiveness and features like easier to make, and can be built by farmers were also recorded. Women take part in many activities like afforestation, sustainable agricultural practices various training of EbA, implementing EbA activities in their community and play an important role.

Keywords: Flood, EbA, Indigenous community, Effectiveness

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# CHAPTER 1: INTRODUCTION

## 1.1 Background

Flooding can be defined as the spontaneous occurrence of water rising and overflowing the boundaries of a stream, river, lake, or drainage system (Méndez-Antonio et al., 2013). Floods are causing havoc in our world, with disproportionately high impacts on the poorest and most vulnerable (Jongman, 2018). Most of the people living in South and Southeast Asia have been directly affected by floods, which is about 23% of the global population (Rentschler et al., 2022). Floods accounted for about 44% of all disaster events, which affected 1.6 billion people globally, while Asia had the highest impacts, experiencing the majority of all the flooding events Over the past two decades, more than a billion individuals worldwide have been impacted (UNDRR, 2020).

Nepal has witnessed 927 flood incidents claiming 260 lives during the six years. From mid-2018 to mid-2024, floods causing 45, 42, and 41 deaths in Gandaki, Koshi, and Madhesh provinces, respectively, accounting for 49.23% of all deaths caused by floods (MoHA, 2024).

The Karnali River winds its way through the rugged mountains that lie between the Dhaulagiri and Nanda Devi ranges in western Nepal. The basin spans latitudes 28.2° to 30.4° N and longitudes 80.6° to 83.7° E, encompassing an area of 45,269 square kilometers with an average yearly discharge of 1441 cubic meters per second (Khatiwada et al., 2016). Within Rajapur municipality, the Karnali River basin is highly vulnerable to flooding and riverbank erosion. In recent years, the Karnali River has eroded riverside land and settlement areas due to natural, humanitarian, and climatic disasters. Rajapur faces annual flooding events that consistently impact the physical health, economic stability, social conditions, and psychological well-being of its residents (LDCRP, 2021). People of Rajapur are living a difficult life due to frequent flooding due to the heavy and continuous rainfall during the monsoon and pre-monsoon time. Communities within Rajapur Municipality face a significant threat from flooding (Chhinal, 2023).

EbA is defined as utilization of biodiversity and ecosystem services as a part of overall strategy to aid people in adapting to adverse effect of climate change (CBD, 2009). In 2010, this definition was clarified to emphasize a management approach focused on the sustainable care, protection, and revival of ecosystems. It highlights how these efforts fit into a broader strategy of adapting to change while recognizing the various social, economic, and cultural benefits that local communities gain from it. (Moreno-Mateos et al., 2020). Ecosystem-based approaches are becoming increasingly important as they can provide multiple benefits and are often considered cost-effective solutions as compared to technological approaches to tackling climate change. Ecosystem-based approaches recognize the vital connections between climate change, biodiversity, and the sustainable use of natural resources. By protecting and restoring ecosystems, these methods help communities more effectively manage climate impacts and adapt to changing conditions (Naumann et al., 2011). Natural ecosystems like wetlands, forests, and coastal areas help to lower the direct exposure to natural hazards. Well-managed ecosystems can provide natural protection against common natural hazards, such as flooding. The effectiveness of ecosystem-based methods relies on valuing and using local and traditional knowledge while also addressing the specific needs of vulnerable groups in the community, including women elderly, and the poor. Through effective ecosystem management, EbA contributes to biodiversity conservation and local economies (IUCN, 2017).

Despite the potential of EbA to provide adaptation outcomes and the growing interest by governments in this approach, there is still limited evidence on whether many types of EbA be seen as a helpful way for people to adjust to climate change, but the absence of strong proof makes it harder for EbA to be widely adopted (Naumann et al., 2011). Ecosystem-based Adaptation (EbA) is vital because healthy natural environments like well-preserved forests, wetlands, and coastal zones offer numerous benefits to nearby communities. These areas supply essentials such as firewood, clean water, medicine, shelter, and food. Additionally, they act as natural shields against severe weather, helping to reduce damage. Biodiverse forests, for example, can protect roads and other infrastructure from erosion and landslides (IUCN, 2017).

Men and women each have unique roles and duties when it comes to caring for the environment (Matos et al., 2023). Women are a foundational element of society and play a crucial role in environmental conservation, which relies heavily on their empowerment (Ghasemi et al., 2021). Strengthening women's capacity through training in skills related to climate change mitigation and adaptation, especially in the technology and innovation sector, is essential. Ensuring equal access to resources for effective climate change adaptation is imperative, as women often face limitations in accessing resources like land, water, and energy, which can hinder their ability to adapt to climate change (Matos et al., 2023).

The World Health Organization (WHO, 1999) Indigenous peoples are groups of communities who live in, or have strong connections to, specific traditional lands or ancestral areas. They see themselves as part of unique cultural groups that trace their roots back to the people who lived there long before modern countries and borders existed. These communities usually keep their own cultural and social ways of life, along with distinct social, economic, and political systems that are different from the larger, dominant society around them. (Nursey-Bray et al., 2022). Indigenous peoples carry distinctive languages, knowledge, and belief systems, along with priceless expertise in sustainably managing natural resources. Their ancestral territories are essential to their shared physical well-being and cultural identity. Their ideas of development are shaped by their own traditions, goals, needs, and values (OisikaChakrabarti, n.d.).

According to the (National Statistics Office (2021), the population of the Indigenous people is 35.08% of the total population, i.e., 29,164,578 in Nepal. The Indigenous (Tharu) community, which mainly resides in the Terai region, makes up 6.2% of the total population and population of Tharu people in Rajapur is about 77.8%. The Tharu are an indigenous group primarily found along the southern foothills of the Himalayas, with most of their community residing in Nepal. They possess unique languages, traditions, and ways of life. Living closely together in tight-knit social groups, the Tharu maintain strong social and economic bonds, reinforced by shared religious and economic relationships (Rajaure, 1981).

The Tharu community in the Terai region are among the groups most at risk from the impacts of climate change. Though they have adapted to natural hazards through their traditional knowledge and survival skills, the current changes in climate and its consequences may be overwhelming to deal with. Tharu people’s livelihood diversity is limited in comparison to communities from other places (Dhungel, 2011). Indigenous knowledge, often combined with scientific knowledge, has led to adaptations to reduce climate change risks, but they are not adequate. Adopting sustainable river management methods to control flooding and using farming techniques that are less harmful to the environment can help the Tharu and other local communities in Nepal’s Terai region become less vulnerable to natural disasters.(Chaudhary et al., 2018). The people here are mostly involved in agricultural practices, laborer in different field and other livelihood like having grocery shop, small hotels, and paintings etc.

Rajapur has been selected for the study because there are not a lot of studies about the effectiveness of ecosystem-based flood adaptation strategies in indigenous community. The study aims to find out EbA and the indigenous knowledge of people used for flood adaptation.

### 1.2 Statement of the Problem

Extreme precipitation during the monsoon season causes floods in Nepal every year. In the mountains and hills, flash floods and landslides are major climate-related hazards, riverine flooding and inundation of low-lying areas put the lives and economies of the people of the Terai region at risk (Jahan S., 2000).

The Rajapur Municipality is one of the most flood-prone sites in Nepal, and the communities are more vulnerable because of seasonal floods. The Karnali River basin of Rajapur municipality is a vulnerable area in terms of erosion and inundation. In recent years, the Karnali River has eroded riverside land and settlement areas due to natural, humanitarian, and climatic disasters. Every year, the people of Rajapur face repeated floods that harm their physical health, economy, social life, and mental well-being (LDCRP, 2021).

Every pre monsoon and monsoon, Rajapur receives heavy rainfall, which causes flood and inundation problems, especially in wards 1, 3, 4, 7, and 10. EbA helps strengthen ecosystems so they can better soak up floodwaters, prevent soil erosion, and safeguard indigenous communities. Many flood adaptation strategies are designed based on global or national frameworks, but their effectiveness depends on the local environmental, social, and economic context.

The study aims to identify the effectiveness of ecosystem-based flood adaptation strategies practiced by the indigenous community and how the people of Rajapur are adapting impact of floods using EbA. This research will also help to identify appropriate strategies for managing floods.

### 1.3 Research questions

1. What types of ecosystem-based adaptations are implemented by indigenous community in study area?
2. How effective is the ecosystem-based flood adaptation measures?
3. What is the role of women to implementing EbA to manage flood risk effectively?

## 1.4 Objectives of the Study

### 1.4.1 General Objective

To study the effectiveness of ecosystem-based flood adaptation strategies of the indigenous communities of Rajapur.

### 1.4.2 Specific Objectives

1. To study ecosystem-based adaptation practices employed by the indigenous community.
2. To evaluate the effectiveness of EbA measures in flood affected area.
3. To study the role of women in EbA practice.

## 1.5 Rationale of the Study

The effect of floods on individuals and communities varies widely depending on the severity of the event, available resources, and their ability to adapt (Ojha, 2023).

Ecosystem-based adaptation (EbA) is widely embraced as an effective approach to address climate change impacts and related issues, especially in low-income countries where people heavily rely on natural resources for their daily lives and survival. However, EbA implementation remains limited and inconsistent. It is not fully integrated into national and international policy processes and receives a lower proportion of adaptation finance. This is partly because the overall body of evidence supporting the effectiveness of EbA remains limited and inconclusive (Reid et al., 2019).

Ecosystem-based adaptation can provide flood adaptation strategies that can be beneficial for the people of Rajapur. It addresses sustainable and cost-effective solutions by utilizing natural ecosystems to reduce flood risk and enhance community resilience. Many flood adaptation strategies have been developed to control floods, but no study has been done to determine the effectiveness of ecosystem-based flood adaptation strategies. This study aims to find out the ecosystem-based flood adaptation strategies employed in Rajapur and their effectiveness.

## 1.6 Limitation of Study

- This study covers only affected and vulnerable wards of Rajapur municipality.
- The study focuses only on Tharu indigenous community.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Flood overview

(Jongman, 2018) discusses the increasing impact of flood globally and highlight the significant economic losses due to flood with global weather-related disaster losses exceeding $300 billion in 2017. The impacts of flooding go far beyond direct damages to assets and infrastructure.

Disasters such as floods and landslides are common in the southern part of Nepal bordering India, with different transboundary floods with a high number of fatalities. They affect the livelihood of the people and cause enormous damage to physical properties, e.g., destroy houses, infrastructure, agricultural land, and crops. It is necessary to identify probable future floods and inundation with available tools (Aryal et al., 2020).

Nepal is exposed to multiple hazards and disasters. Between that period January 2020 to September 2022, 9,886 weather and climate-related disasters of varying sizes caused 1,173 fatalities and resulted in economic damages amounting to NPR 6 billion. Climate change and DRR policies have recognized economic and non-economic loss and damages caused by climate-induced disasters (Man Singh et al., 2022).

(Pangali Sharma et al., 2022) analyzes the vulnerability of Tharu households to flood disasters in the Tarai region of Nepal, identifying factors such as small landholdings and limited income diversification, and aims to inform government strategies for flood management by addressing root causes.

The study assesses local perception and adaptation strategies for flood disasters in the Koshi River basin in Nepal. Finding current measures are insufficient and suggesting community-level initiatives and structural and non-structural management approaches as the most effective solution (Klein et al., 2019).

The community-based flood adaptation strategies in the west Rapti region. The study finds that local communities utilize traditional ecological knowledge to predict floods through techniques like monitoring rainfall patterns and assessing temperature variations. Preferred adaptation strategies include creating flood management plans pre-flood, effective communication during floods, and mutual assistance post-flood. The findings emphasize the importance of integrating traditional ecological knowledge with community-based strategies for effective flood management (Devkota et al., 2014).

In summary, Nepal faces frequent climate-induced disasters, with significant human and economic losses. Vulnerable communities, particularly small-scale farmers and marginalized groups like the Tharu, are disproportionately affected by floods. Adaptation strategies center on enhancing community-level actions, integrating traditional knowledge with modern management to better predict, prepare, and respond to flood events.

(Neupane G, 2023) describes the status and effectiveness of dykes in Rajapur. After building the dykes, there was a noticeable drop in the loss of farmland and the destruction of homes.

The effect of adaptation techniques on living expenses, revealing that learning new skills and migrating after learning new skills are associated with higher expenses. Learning new skills emerged as an effective strategy, leading to increased income through expanded job opportunities in Rajapur (Ojha, 2023).

The construction of dykes in Rajapur significantly reduced agricultural land erosion and the complete destruction of houses. Meanwhile, adaptation strategies involving learning new skills and migration after skill acquisition led to increased living expenses but were effective in boosting income through expanded job opportunities in the same region.

## 2.2 Ecosystem-based Adaptation

According to (R. K. Kamble, n.d.) knowledge of environmental systems and processes is a key factor in the management of disasters, particularly the hydro-meteorological ones. Ecosystem-based disaster risk reduction builds on ecosystem management principles, strategies, and tools in order to maximize ecosystem services for risk reduction.

Ecosystem-based strategies enhance community resilience by utilizing forests and trees to reduce vulnerability to climate variability. These strategies focus on managing the ecosystem services considering landscape characteristics and encourage community awareness to mitigate the risk of disaster and climate-related hazards in Indonesia (Fedele et al., 2016).

Ecosystem-based approach for flood risk management includes integrating biodiversity and ecosystem services to stabilize or reduce flood impacts, minimize environmental damage, and develop innovative approaches tailored to flood-prone areas, enhancing resilience and recovery for affected communities, explained by (Busayo et al., 2022).

Ecosystem-based flood adaptation strategies focus on utilizing natural processes and ecosystems to manage flood risk. These strategies emphasize sustainability and the importance of continuous monitoring and evaluation to enhance societal acceptance and effectiveness in flood management in coastal areas (Chiu et al., 2022).

EbA strategies were effective in reducing flood impacts in the Lake Naivasha catchment. EbA strategies like agroforestry and afforestation were highly adapted nonstructural strategies, while soil conservation terraces and rainwater harvesting were highly adapted structural strategy, effective in mitigating floods (Isindu et al., 2024).

Coordinated community and ecosystem-based actions offer a path for sustaining ecosystems and livelihoods in biologically diverse, multi-hazardous mountain environments, where extreme events threaten to become the norm. However, specialized DRR guidelines are needed for biodiverse and multi-hazard regions like mountains (Klein et al., 2019).
Ecosystem based approaches to flood risk management rely on understanding environmental system to employ ecosystem services for reducing impacts. These approaches enhance the community resilience by integrating natural elements like forest and biodiversity while promoting local awareness. They focus on sustainability societal acceptance to effectively adapt to flood risk in vulnerable area mostly.

### 2.3 EbA in Nepal

This research shows that Nepal's policies and plans prioritize ecosystem conservation, restoration, and management to cope with the effects of climate change to some extent. The EbA measures are incorporated into the action's component, which implies an action-oriented approach to mainstreaming EbA. The disparity in integrating EbA across climate, urban, and sectoral policies and plans, and the alarming focus on EbA measures to address climate change issues (Sherpa, 2024).
The impact of ecosystem restoration on community vulnerability to water-induced disasters in central Nepal and finds that restoration reduces vulnerability despite some of the limitations and emphasizes the need for integrating ecosystem-based adaptation principles to strengthen community resilience (Paudel et al., 2023).

Ecosystem-based adaptation and engineering options for Ajgada village to mitigate flood impact through reforestation, riverbed management, and targeted engineering solutions, enhancing the community resilience against climate change-induced flooding while promoting sustainable watershed development ( Phoju, 2019).

Nepal's policies partially prioritize ecosystem conservation and restoration for climate adaptation but show inconsistent integration of EbA across sectors. Ecosystem restoration in central Nepal reduces community vulnerability to water-related disasters, underscoring the need for stronger EbA integration. Combination of both ecosystem-based and engineering measures effectively mitigate flood impacts and enhance community resilience.

### 2.4 Women role

The governments of Ecuador, Liberia, and the Philippines are actively working to enhance women's participation in environmental decision-making processes. Each country has its unique obstacles and hurdles to overcome before gender balance is achieved and gender equality is improved; each country demonstrates that obstacles to women's participation and leadership vary among regions and levels of society (Aguilar et al., 2015).

This paper explores the involvement of South Australian women in green NGOs, their perceptions of environmental issues and empowerment, and their identification with ecofeminist ideologies, highlighting their contributions to environmental conservation in Australia (Mahour, 2016).

This study looks at how women are essential in taking care of natural resources both at home and in their communities, and how they are often the ones most impacted by environmental dangers. In communities around the world, women manage water, sources for fuel, and food, as well as both forests and agricultural terrain (Mago et al., n.d.).

This research has shown that the causes and effects of climate change differ by gender. Women are affected differently by climate change impact. Women are critical for establishing resilient systems and ensuring climate change adaptation, the role played by them in the climate change adaptation and mitigation processes. This study also uncovers evidence to support the smart agriculture ambassadors and climate change activists (Gicheru et al., 2024).

Women play a vital role in environmental conservation and climate adaptation worldwide, despite facing regional and societal challenges. In South Australia, women's participation in green NGOs empowers them and aligns with ecofeminist values. Globally, women manage key natural resources but are more vulnerable to environmental hazards. Climate change impacts women differently, and they are essential as activists and smart agriculture ambassadors.

The gender role in household water management in the context of climate change in Nepal's Melamchi watershed area, highlighting the increased workload on women due to decreasing water volume and geographical factors, and emphasizing the need for awareness and sensitization for climate change adaptation (Shrestha et al., 2019).

Women have made substantial contributions to adapting to climate change impacts through distinctive saving mechanisms; the study highlights the challenges women face in recovering from crop losses due to extreme natural events and the importance of savings groups in building adaptive capacity (Chhetri & Ghimire, 2023).

This study shows that the process of lengthy documentation, bureaucratic inconveniences, political turmoil, unconducive business environments, corruption, protest, and unionization are the concurrent factors affecting the entrepreneurial environment in Nepal. Despite the recent revisions in the Nepal Enterprise Act aimed at promoting women's entrepreneurship, the effectiveness of this policy support remains uncertain (Pandey, 2018).

Women face increased burdens from climate impacts, such as water scarcity and crop loss, requiring greater support for adaptation. Despite policy efforts, women's entrepreneurship in Nepal is hindered by bureaucratic and political challenges. Overall, addressing these issues is crucial for empowering women in climate resilience and economic development.

## 2.5 Indigenous knowledge

(Mavhura et al., 2013) underscored the important contribution of indigenous knowledge in mitigating flood effects in Muzarabani, Zimbabwe, highlighting the influence of customary leadership, cultural traditions, and time-honored practices, together with local early warning systems based on animal behavior.

The community, through generations, has developed numerous indigenous knowledge and practices. Community-based adaptation strategy developed by these people over generations remains scattered and uncared for. People in disaster-prone countries such as Bangladesh have repeatedly shown that traditional indigenous knowledge and local practices often provide effective solutions to challenges like natural disasters, resource management, waterlogging, and riverbank erosion, sometimes even more successfully than engineered structures (Haque, 2019).

In Western Australia Indigenous Land and Sea Management Programs are recognized as opportunities for exchanging both Western and Indigenous-generated knowledge, with a focus on traditional knowledge. The exchange of knowledge improves aspects of life related to self, community, family, and indigenous culture. Learning has a positive impact on well-being, but sharing can have negative effects if done in culturally inappropriate ways (Jarvis et al, 2021).

In summary, Indigenous knowledge is vital for effective, culturally appropriate disaster risk reduction and sustainable community resilience.

The application of indigenous knowledge in the conservation of natural resources and the environment in Nepal, highlighting its dynamic nature and importance in the cultural and religious context, with a focus on the need for scientific verification and policy inclusion (Kumar Lama, 2021).

The rich indigenous knowledge for disaster risk mitigation in Nepal highlighting community practices and advocating for the documentation and integration of knowledge with science-based knowledge to enhance disaster resilience (Luintel, 2018).

(Adhikari & Poudel, 2022) explores the significance of indigenous knowledge in wetland conservation and resource utilization in Nepal, highlighting the challenges of knowledge loss and potential solutions through the economic benefits of communities.

Indigenous knowledge, often combined with scientific knowledge, has led to adaptations to reduce climate change risks, but they are not adequate. Sustainable ways of river management to reduce flooding effects and less destructive farming practices to adapt to natural hazards could reduce the vulnerability of the Tharu and local communities in the Terai region of Nepal (Chaudhary et al., 2018).

Indigenous knowledge is indispensable for effective environmental conservation and disaster resilience in Nepal, but it must be better documented, scientifically validated, and integrated into policy frameworks. Promoting collaboration between local communities and scientists can enhance sustainability and adaptive capacity.

# CHAPTER 3: MATERIALS AND METHODS

## 3.1 Study Area

The Rajapur Municipality is one of the most flood-prone sites and communities are more vulnerable because of seasonal floods in rivers like Karnali and Geruwa (Ojha, 2023).

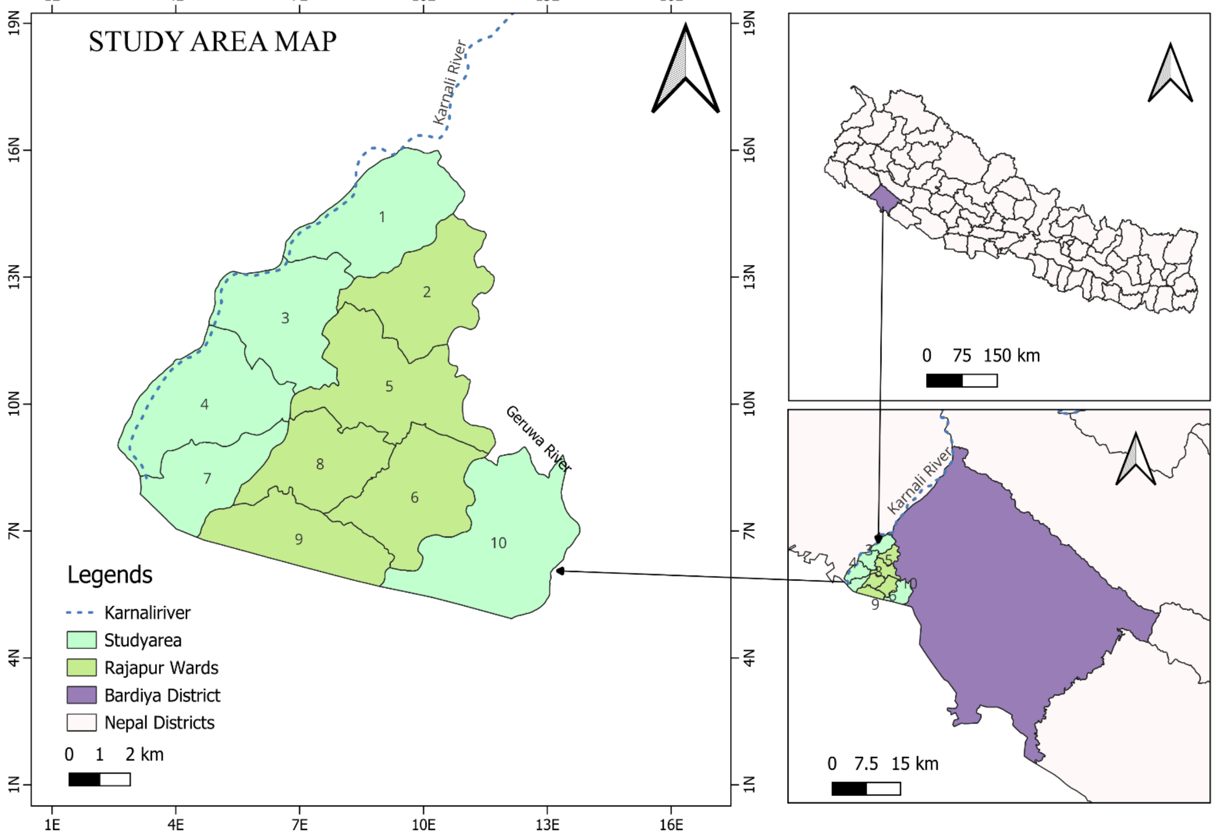


*Figure 1: Study area map*

Rajapur municipality covers an area of 127.08 sq. km. The population of Rajapur is 69873, where 35312 are male and 34561 are women. Ward no 1 has population 7019, ward no 23 has population 6799, ward no 4 has population 8303, ward no 7 has population 4847 and ward no 10 has population 8527. Wards no 1,3 4, 7, and 10 have been selected for the research because 1,3,4 is highly vulnerable and 7 and 10 are very highly vulnerable to flood and inundation problems (LDCRP, 2021).

Table 1: Vulnerability of wards against flood (LDCRP, 2021).

| SN | Vulnerability | Wards |
|---|---|---|
| 1 | Very highly vulnerable | 10,9,7 |
| 2 | Highly vulnerable | 4,3,1 |
| 3 | Medium vulnerable | 2,5,6,8 |
| 4 | Low vulnerable | |

From 14 to 15 August 2014, a large, slow-moving weather system deposited record-breaking rainfall in the foothills of the Babai and Karnali river catchments. Rainfall of 200 mm to 500 mm over 24 hours was recorded. The flood killed 222 people and badly affected 120,000 others, causing huge loss and damage across various sectors. The total loss of physical assets caused by the flood was estimated to be NPR 3.7 million (Man Singh et al., 2022). Rajapur area within Bardiya District is known for being predominantly settled by Tharu people. It is said that most of the Tharu people in this area are first- or second-generation migrants from the Dang district of Nepal. Most people living in this district are farmers. The district headquarters Gulariya lies on the Babai River, The Karnali, one of Nepal's largest rivers, is divided into multiple branches when it reaches the Terai. Bardiya has historically been an area of frequent flooding due to an extensive network of branches from the Karnali River. People of Rajapur are living a difficult life due to frequent flooding due to heavy and continuous rainfall during the monsoon and pre-monsoon time (Chhinal, 2023).

### 3.2 Research Design

The study was guided by a research plan. Then the objectives were set for the study based on the field visit HHs, KIIs and FGDs for Primary data collection and secondary data were collected from journals, reviews, studies related to ecosystem-based flood adaptation offices, data were analyzed through MS Excel and SPSS as well as graphical representation. Relevant literatures were studied during the entire study.

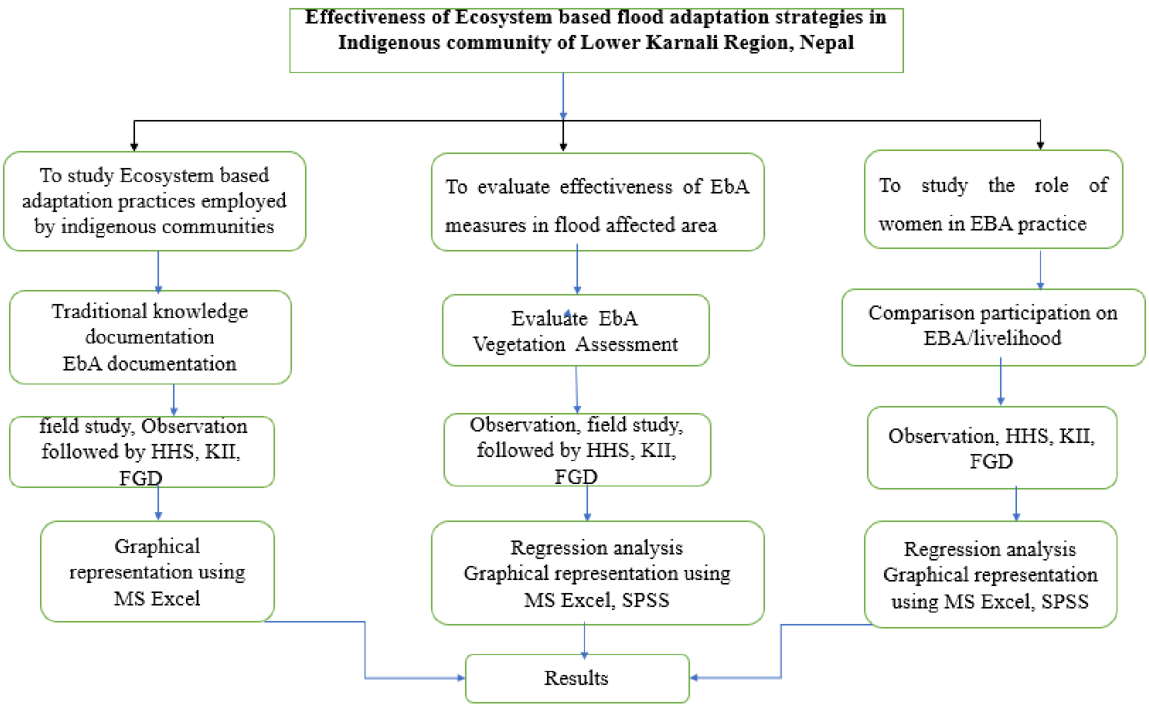


Figure 2: Research Flowchart

### 3.3 Research Matrix

Table 2: Objective wise research design

| SN | Objectives | Data Required | Data Collection | Data analysis method |
|---|---|---|---|---|
| **1** | To study Ecosystem based adaptation practices employed by indigenous communities | Demographic data Community-Based EbA Practices (Traditional knowledge and practices) | Household Survey (HHS), FGD KII, field study, observation | Graphical representation in MS Excel software |
| **2** | To evaluate the effectiveness of EBA measures in flood affected area. | Flood Reduction Approaches - Flood Risk Reduction, Effectiveness, socioeconomic data | Household survey and interviews with community members, field study, observation | Regression analysis, Graphical representation in MS Excel software, SPSS |
| **3** | To study the role of women in EBA practice | Socioeconomic data Demographic data Environmental factors Climatic factors | HHS, FGD, - Key informant interviews, field study, observation | Graphical representation in MS Excel, SPSS, Regression analysis. |

### 3.4 Sampling Technique for Data collection

#### 3.4.1 Sample Size Selection

By using Cochran formula, we calculate the sample size.

$n_{\circ}$=Z^2 pq/e^2

Z= critical value of desired confidence level (95%)

e= margin of error=7%=0.07

p is the estimated proportion of an attribute that is present in the population q= 1-p

by keeping the values

$n_\circ$= (1.96) ^2*(0.5) (0.5)/0.07^2

$n_\circ$= 196

Study on wards no 1, 3, 4, 7 and 10 of Rajapur municipality was decided because they are the most affected areas due to the flood.

From (CBS) in ward no 1, there are 1271 households, in ward no 3, there are 1233 houses, in ward no 4, there are 1751 houses, in ward no 7, there are 822 households, and in ward no 10, there are 1472 households, which are affected by Karnali and Geruwa rivers.

Total household = 6549

Keeping in formula,

N= $n_\circ$ [1+ {($n_\circ$-1)/N}]

N= 196[1+ {(196-1)/6549}]

N= 190.33~190

A stratified sampling method based on ward households was used. It is a method that involves dividing a population into smaller groups called strata, based on shared characteristics. Selected as per population, household pressure, and ward-wise proportionate selection in the section.

**3.4.2 Sample size based on wards.**

Sample size = (total households in ward/total no of municipality households sample taken) n

Table 3: Ward-wise sample of households for survey

| Ward no | Household (wards) | Sample size | Adjusted sample size |
|---|---|---|---|
| 1 | 1271 | 37.24 | 37 |
| 3 | 1233 | 35.24 | 35 |
| 4 | 1751 | 50.96 | 51 |
| 7 | 822 | 23.52 | 24 |
| 10 | 1472 | 43.12 | 43 |
| | 6549 | | 190 |

### 3.5 Research Method

**Primary data collection**

Data was collected by using Kobo toolbox and pen and paper method. The method that was applied in this include KII, FGD, HHS, observation, and field study.

Key Informant Interview (KII): A total of 7 Key Informant Interviews (KIIs) were conducted with the ward head and secretaries from wards 1, 3, 4, 7, and 10, and the chief administration officer, focal person of Rajapur municipality. The primary purpose of the KIIs was to identify the ecosystem-based adaptation strategies employed by the indigenous community to cope with a flood.

Focus Group Discussion: One Focus Group Discussion (FGD) was organized throughout my study. This discussion took place on June 1 and included local farmers and members of the indigenous community, with Badgar. During the FGD, open-ended questions were posed to explore the major ecosystem-based flood adaptation strategies they employ in their community to cope with flooding. The purpose of conducting this Focus Group Discussion was to gather qualitative insights and firsthand experiences from the community.

Household Surveys (HHS): A total of 190 household surveys were conducted in my study to understand the ecosystem-based flood adaptation strategies adopted by indigenous people in Rajapur Municipality. The survey employed a stratified sampling method based on wards and purposive sampling based on proximity of river. The structured questionnaire was designed with sensitivity and respect for indigenous knowledge, ensuring that local perspectives were considered. The primary goal of the survey was to identify the ecosystem-based flood adaptation strategies that people of Rajapur applied.

Observation and field study were done by visiting near river, irrigation canals and agricultural field to know about plantation and biodykes made on bank of river and asking some people working in agricultural field, grazing livestock about observed results etc.

**Secondary Data**

Secondary data were collected from different journals, published articles, books and thesis. Crucial information was obtained from relevant website. Socioeconomic status was analyzed by using data published by Central Beureu of Statistics now changed to National Statistics Office, Nepal

### 3.6 Data analysis

For the data analysis mainly quantitative and statistical analysis were performed. Data analysis was done after collection of all the required data by using Graphical representation, and software like MS Excel, SPSS. General information, demographic data, and flood related data were analyzed by using graphical representation.

#### 3.6.1 Ecosystem Based Adaptation Employed by Indigenous Community

Data analysis has been carried out by collecting information from KIIs, FGD, and HHS. In the beginning they were asked to tell about the EbA practices of that area and ask about indigenous practices they adopted over many years to neutralize flood impact in their place. And documented ecosystem-based flood adaptation strategies in Rajapur and other indigenous community.

#### 3.6.2 Evaluate the effectiveness of EbA measures in flood flood-affected area.

Evaluating the effectiveness by using regression analysis. The documented EbA practices and indigenous practices have effective significance or not, has been asked and analyzed by regression analysis method. Regression is a statistical method use to estimate the relationship between the dependent variable with independent variable**.**

$Y = B_{\circ} + \beta 1X1 + \beta 2X2 + \epsilon$

Where:

**Y** – Dependent variable

**X** – Independent (explanatory) variable

$B_{\circ}$ – Intercept

β1 to βn – Slope

**ϵ** – Residual (error)

**Independent Variable:** The vegetation type used (Trees, Shrubs, Herbs, Grasses).

**Dependent Variable:** The dependent variable or outcome affected by the vegetation (improve soil health/quality, reduce soil erosion, reduce runoff), individual benefit (reduced soil erosion, less waterlogging, reduced flood impact, improve crop production) among the community Based on survey and field study.

**R Square:** The coefficient of determination showing how much variability in the outcome is explained by the predictor. Values close to 1 indicate a strong model, values close to 0 indicate a weak one.

**F:** The F statistic from the ANOVA test checks if the regression model is statistically significant overall.

**Sig(F):** The p-value for the F-test. Values less than 0.05 indicate the overall model is statistically significant.

**B Unstandardized:** The unstandardized regression coefficient indicating the change in the dependent variable for a one-unit change in the independent variable.

**Beta (Standardized):** The standardized regression coefficient to compare effect sizes across predictors regardless of scale.

**Sig(t):** The p-value for the individual predictor's t-test. Values less than 0.05 indicate that the predictor significantly contributes to explaining the outcome.

### 3.6.3 Role of women in EbA practices

Question was asked about women family status, their role in family, livelihood of them, their distinct knowledge, participation of women in EbA activities. They were also asked the suggestion and support needed to improve participation in EbA activities. Data were analysed by using simple linear regression analysis.

$Y = B_{\circ} + \beta 1X1 + \beta 2X2 + \epsilon$

Where:

**Y** – Dependent variable

**X** – Independent (explanatory) variable

$B_{\circ}$ – Intercept

$\beta 1$ to $\beta n$ – Slope

**$\epsilon$** – Residual (error)

**Independent Variable**: Women, Women's Participation

**Dependent Variable**: Livelihood of women, afforestation, and sustainable agricultural practices

**R Square:** The coefficient of determination showing how much variability in the outcome is explained by the predictor. Values close to 1 indicate a strong model, values close to 0 indicate a weak one.

**F:** The F statistic from the ANOVA test checks if the regression model is statistically significant overall.

**Sig(F):** The p-value for the F-test. Values less than 0.05 indicate the overall model is statistically significant.

**B Unstandardized:** The unstandardized regression coefficient indicating the change in the dependent variable for a one-unit change in the independent variable.

**Beta (Standardized):** The standardized regression coefficient to compare effect sizes across predictors regardless of scale.

**Sig(t):** The p-value for the individual predictor's t-test. Values less than 0.05 indicate that the predictor significantly contributes to explaining the outcome.

Remaining data were analyzed by using graphical representations like a pie chart.

# CHAPTER 4: RESULTS AND DISCUSSION

## 4.1 Results

The total household survey done in Rajapur is 190, one focus group discussion and 7 key informant interviews. First asked question of demography. Also, they were asked to tell about the EbA practices of that area and ask about indigenous practices they adopted over many years to neutralize flood impact in their place. The EbA practices and indigenous practices have effective significance or not, has been asked and analyzed by regression analysis method. And asked about women family status, their role in family, livelihood, their distinct knowledge, participation of women in EbA activities. They were also asked about the suggestion and support needed to improve participation in EbA activities.

### 4.1.1 Gender

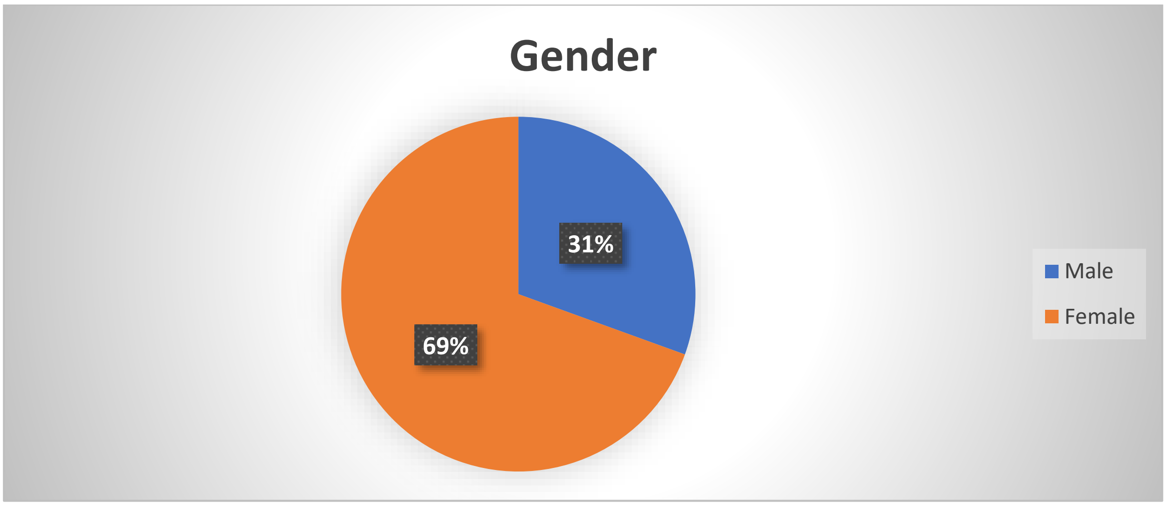


*Figure 3:Gender of Respondents*

The chart above shows that 31% of respondents were male and 69% of respondents were female.

### 4.1.2 Age Group of Respondents

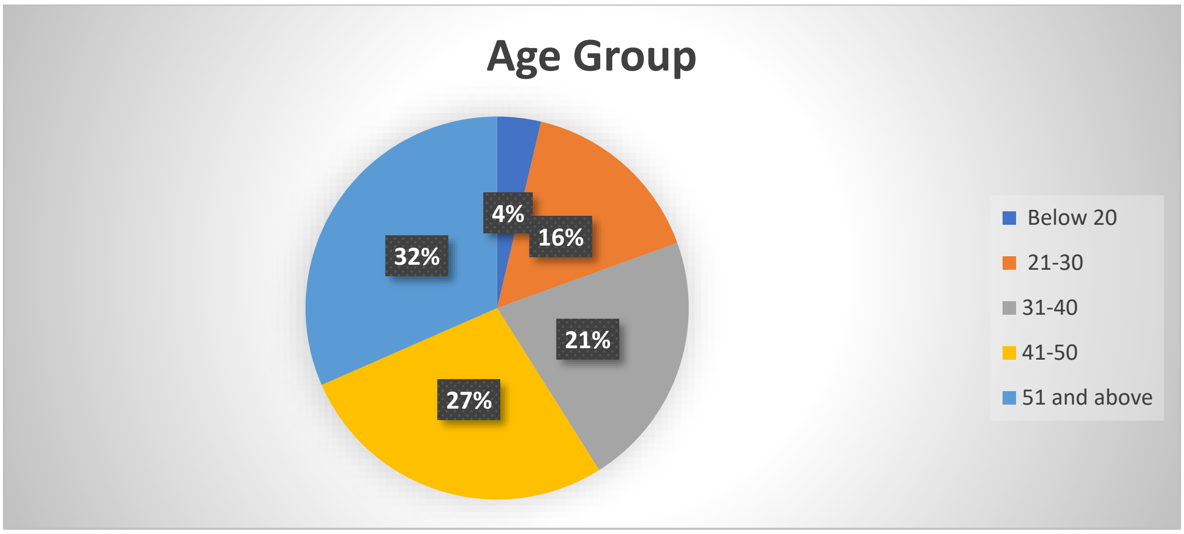


*Figure 4:Age Group of Respondents*

From the above chart, the age group of respondents below 20 years of age were 4%, age between 21 and 30 were found to be 16%, age between 31 and 40 were 21%, age between 41 and 50 were 27% and the age above 51 were found to be 32%.

### 4.1.3 Occupation of Respondents

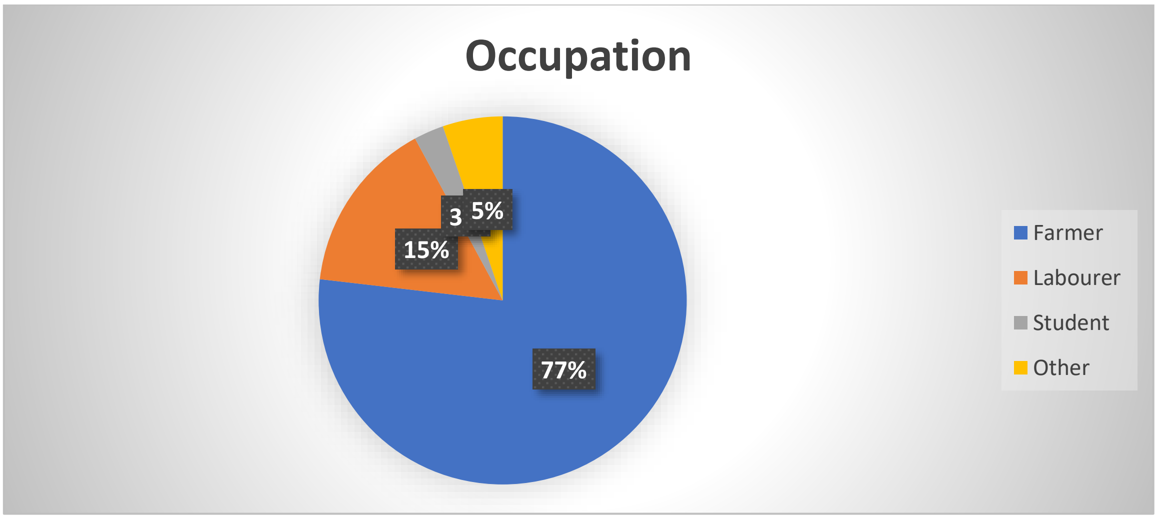


*Figure 5: Occupation of Respondents*

From the above figure, occupation the respondents of household survey in Rajapur municipality were found to be 77% of farmer, laborer constituents 15%, 3% reflecting students and other (grocery shop, fishing, tailoring, painting) were found to be 5% overall.

### 4.1.4 Education of Respondents

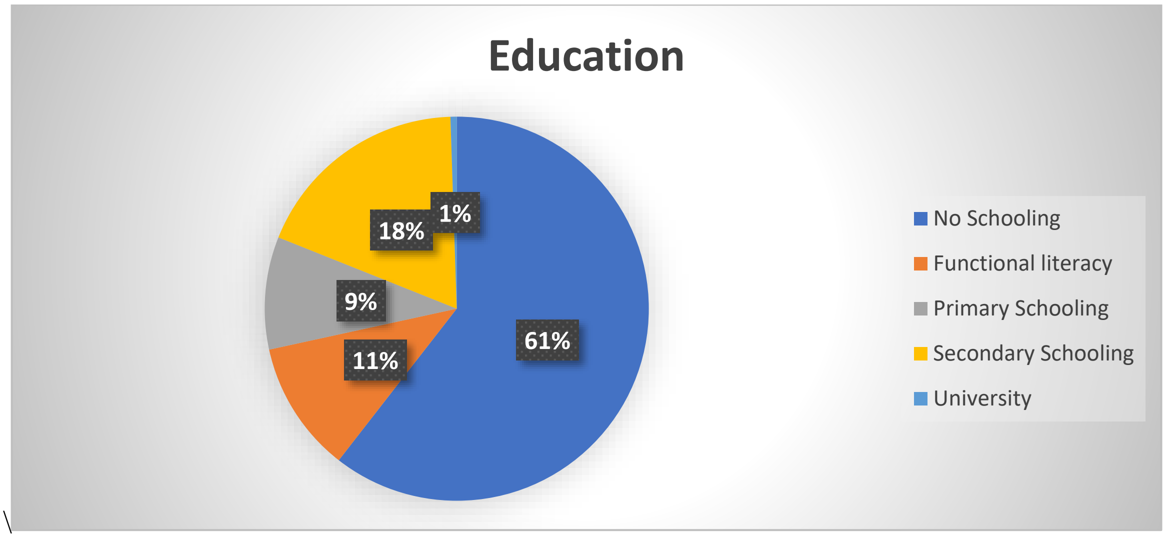


*Figure 6: Education of Respondents*

From the above figure it indicates that majority of respondents i.e., 61% has no formal education, the 11% of the respondents has their functional education, 9% of them has primary school education, 18% of them has secondary school education and only 1% had university degree.

### 4.1.5 Type of house

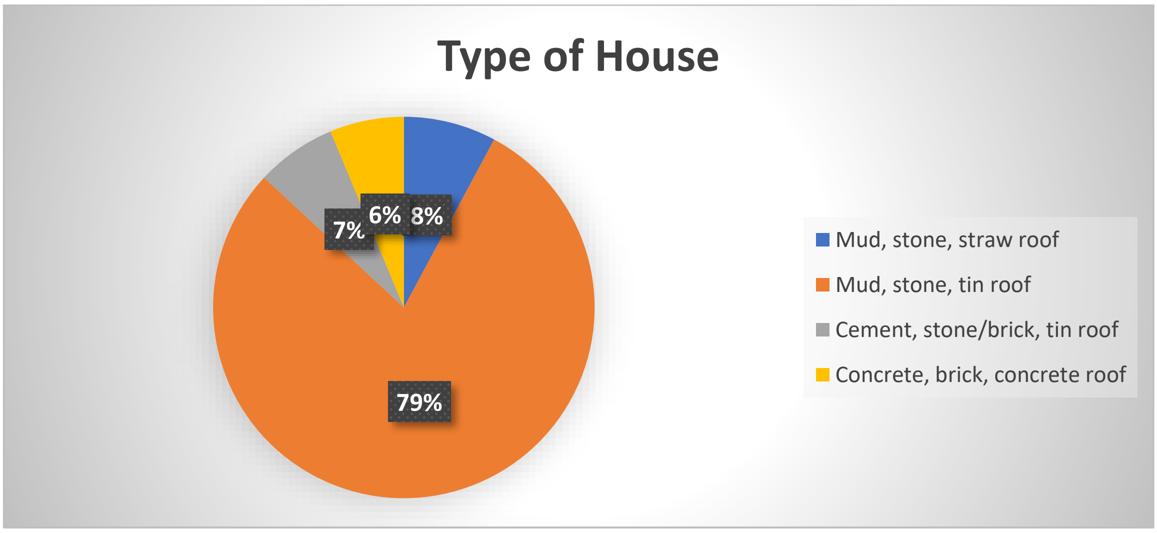


*Figure 7: Type of house*

The pie chart illustrates that 79% of the houses were made of mud, stone, wood, and had tin roofs. 8% of the houses constructed with mud, stone, wood, and straw roofs. Another 8% were made from cement, stone, brick walls and tin roofs. Additionally, 6% of the houses were made with cement, brick, and concrete roofs.

### 4.1.6 Occupation distribution of respondents by Gender

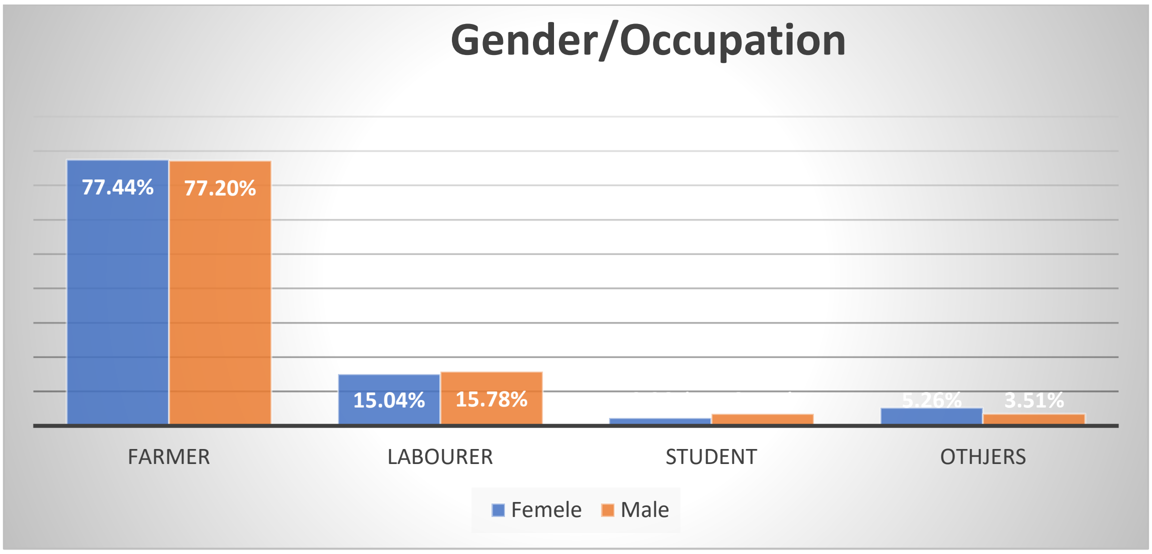


*Figure 8: Occupation of respondents by Gender*

The above graph shows, most people are farmers, with almost equal numbers of females (77.44%) and males (77.20%). The laborer category has the second-largest group, where males (15.78%) slightly less than females (15.04%). The student and other categories have comparatively smaller percentages. There are more male students (3.51%) than female students (2.26%), while the others (grocery shop, tailor, paint shop, hotel etc.) category shows more females (5.26%) than males (3.51%).

### 4.1.7 Age distribution of respondents by Gender

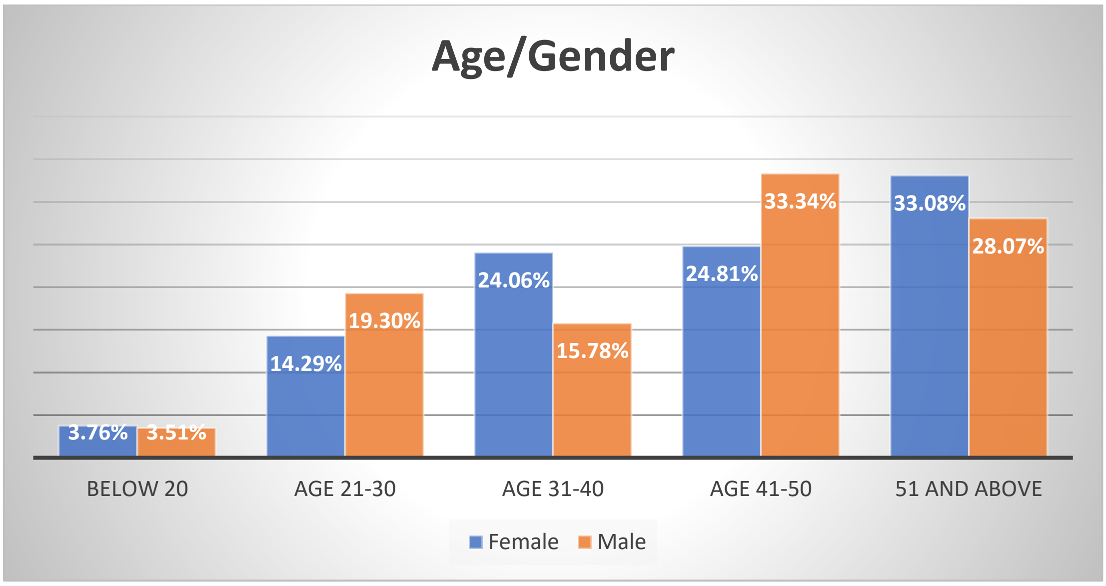


*Figure 9: Age distribution of respondents by Gender*

The data illustrates the distribution of males and females across various age groups. The respondents below 20 years, females slightly outnumber males, with 3.76% compared to 3.51%. Moving into the 21-30 age range, the proportion of males increases to 19.30%, surpassing females who represent 14.29%. In the 31-40 age group, where females make up a larger share at 24.06%, while males constitute 15.78%. The 41-50 age group shows a notable shift, with males comprising a higher percentage 33.34% than females 24.81%. Finally, in the 51 and above category, females again have the higher representation at 33.08%, compared to 28.07% for males.

### 4.1.8 Education distribution of respondents by Gender

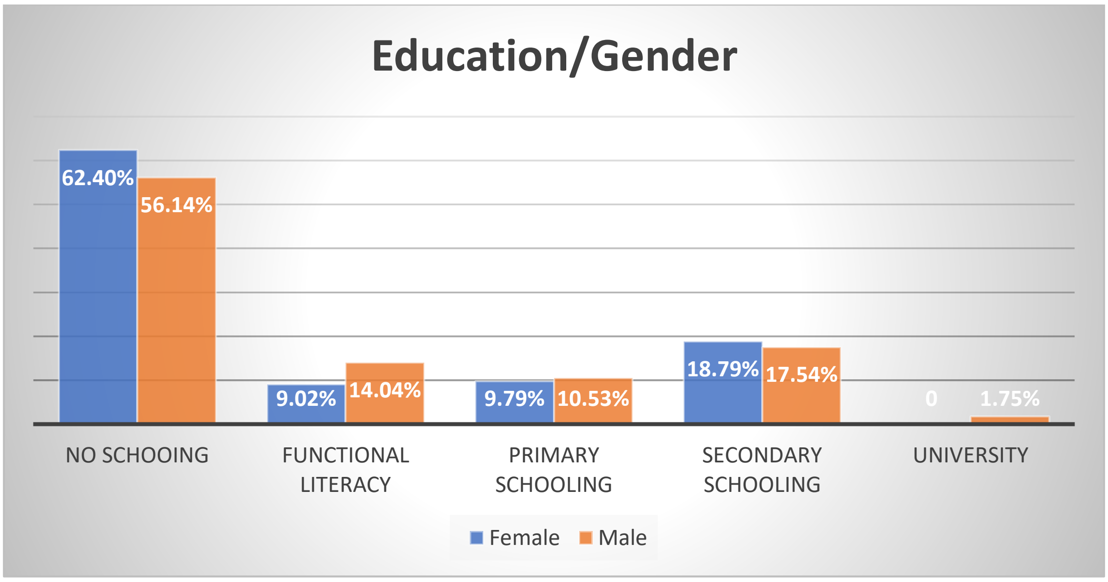


*Figure 10: Education distribution of respondents by Gender*

The above figure shows education levels by gender. Among females, 62.40% have no schooling compared to 56.14% of males. Functional literacy is observed in 9.02% of females and 14.04% of males. Primary schooling is attained by 9.79% of females and 10.53% of males. Secondary schooling is completed by 18.79% of females and 17.54% of males. University education is absent among females but comprises 1.75% of males.

#### 4.1.9 Impacts of flood

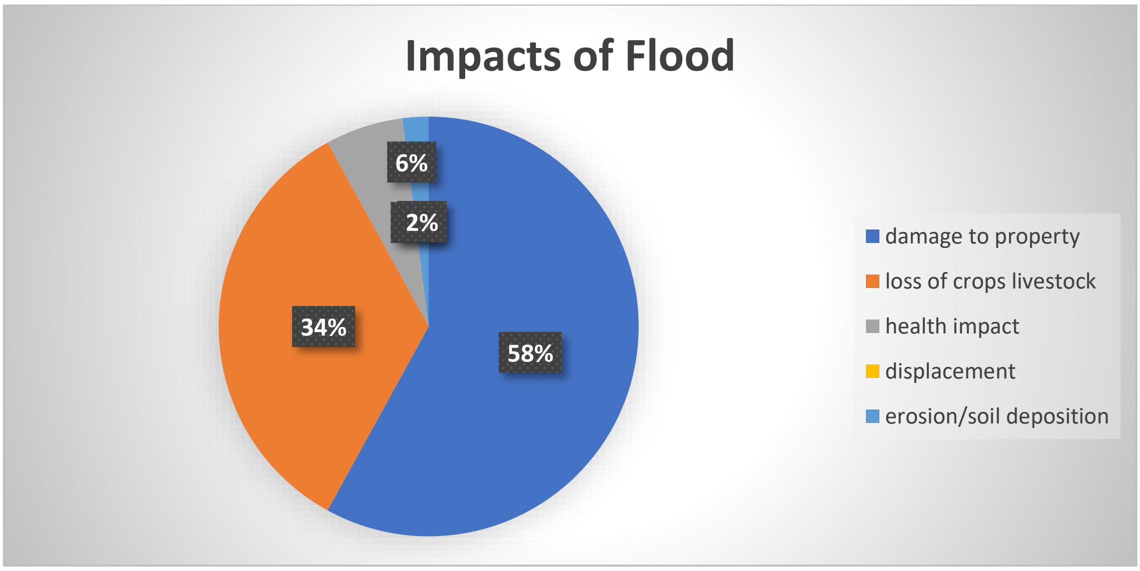


*Figure 11: Impacts due to flood.*

The major impact of flood was property damage (58 %) followed by crop and livestock losses (34%). Other impacts were on health (6%) and soil erosion/deposition (2%). Flood has made substantial implications to agricultural livelihood of the population.

The flood impact on property of people has been high on Rajapur like house, animal shed toilet, tube well and other structures were damaged.

About 60 bigaha land where paddy cultivated has flooded 2077BS and livestock like chicken, goat and small buffalo were died by same flood in ward 1,3,4,7. 15 bigaha of maize crops has been flooded in 2077 BS in ward no 10.

Health problem like fever, diarrhea, typhoid, and mental tension has caused impact on the people.

Soil deposition on the agricultural land and near their houses has caused a lot of problem in Rajapur. People has to do a lot of hard work to remove all deposition near houses and deposition in their agricultural land. That has also caused land degradation.

### 4.1.10 Effect of flood on Houses

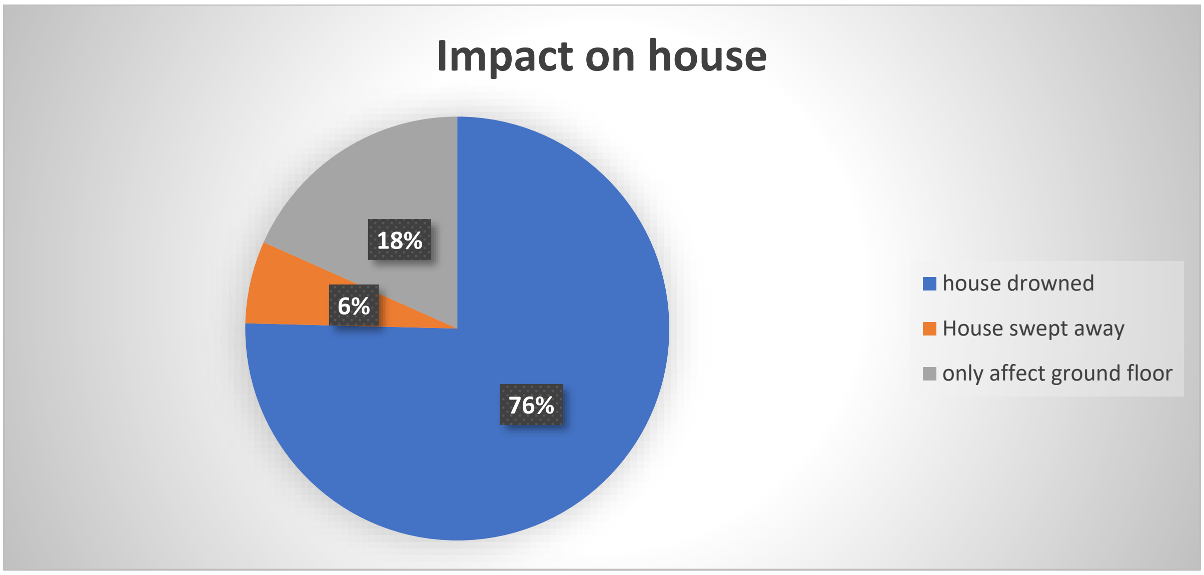


*Figure 12: Impacts on houses*

From the survey, it was found that 6% of the homes in the survey were swept away by the flood. 76% of the homes were flooded or drowned, while only affect ground floor was 18%. Homes in low elevation and proximity(30-450m) to the Karnali River are the primary causes of the flooding. This region regularly experiences flooding due to the Karnali River, which damages nearby properties.

### 4.1.11 Ecosystem Based Adaptation Employed by Indigenous Community

The ecosystem-based adaptation used to control floods was afforestation, in which they plant trees, herbs, shrubs, and grasses on the bank of the river, near irrigation canals, and near their agricultural land. Most people plant trees (59%) (Bamboo, Sisam, Simal, eucalyptus etc.) Herbs (*Vigna mungo*, *Achyranthes bidentate*) are planted about 10% by people. Shrubs (*Justicia adhatoda* (Asuro) make up around 4% of the vegetation planted., while grasses (Vetiver) make up about 6% and 21% of them have not planted.

They also use to make a wall (biodykes), that is temporary and made in the monsoon season, which helps to decrease the erosion of the river. It is made on monsoon season to reduce bank erosion and bank cutting. Length may be varying from year to year depending upon the need. This year length is 500m, height is 5m and breadth is 30cm constructed in Karnali riverbank, it is feasible to 200-300m range from river.

They save the seed and grains for next year, keeping them in elevated houses which are made to protect food grains from flooding, and a few of them keep them in a container made up of straw and mud. This is an indigenous practice. 88.48% of them have said that people use to store grains and seeds in Dhehari and 3% of them use tree branches near home to protect maize seed for next year.

About 1 bigaha of land (in Tighra village) seasonal vegetables were cultivated on the bank of the river, which gives people the opportunity to grow a good amount of fruit and vegetables. (Field study and observation)

Plants used for plantation (EbA)

People have been planting various types of trees, shrubs, and grasses. Plantation activities have been carried out in this area for a long period of time to prevent flood and erosion caused by flood. Most plants are planted in places vulnerable to erosion and flooding, such as riverbanks and irrigation canals. People also plant trees near their agricultural land to protect the soil from erosion. Through these efforts, the community shows a strong willingness to control erosion by planting. The plants mostly used for plantation are listed in the table below:

Table 4: List of plants planted by people.

| Plant Name | English Name | Local Name | Type |
|---|---|---|---|
| *Morus rubra* | Red Mulberry | Kimbu | Tree |
| *Leucaena leucocephala* | Ipil-Ipil | Ipil Ipil | Tree |
| *Justicia adhatoda* | Adhatoda | Asuro | Shrub |
| *Chrysopogon zizanioides* | Vetiver, Khus | Khus | Grass |
| *Bombax ceiba* | Silk Cotton Tree | Simal | Tree |
| | - | Laptis | Herb |
| | | Khas Khas | Grass |
| *Bambusa vulgaris* | Bamboo | Bamboo | Grass/Tree |
| *Melia azedarach* | Chinaberry | Bakain | Tree |
| *Tectona grandis* | Teak | Bhillor | Tree |
| *Dalbergia sissoo* | Indian Rosewood | Sisau | Tree |
| *Syzygium cumini* | Jamun, Black Plum | Jamun | Tree |
| *Eucalyptus tereticornis* | Eucalyptus | Sagun | Tree |
| *Mangifera indica* | Mango | Aap | Tree |
| *Vigna mungo* | Black gram beans | Mas | Herb |
| *Achyranthes bidentate* | Prickly chaff flower | Dattiwan | Herb |

According to (LDCRP, 2021) the area covered by forest in ward no 1 is 112.51 hectare, ward no 3 is 153.51 hectare, ward no 4 is 355.35 hectare, ward no 7 is 144.73 hectare and ward no 10 is 298.5 hectare. Forest of ward no 1,3,4,7 is forest developed from afforestation only and forest of ward no 10 are mix of both afforestation and natural forest.

According to locals: the afforestation done in ward no 1 is 10158.615-meter square, afforestation done in ward no 3 is 13554.82-meter square, afforestation done in ward no 4 is 16931-meter square and ward number 7 is 10158.615 meter square and ward no 10 is 20317.23-meter square of land which will decrease the risk in approximately 20-30% of agricultural land nearer to the riverbank where afforestation is done in recent time.

Figure 1: Plantation done in different areas.

Tree plantation has been done on the banks of the river, in irrigation channels, near agricultural land, and along the boundary of their home to protect the land from erosion due to the flood which frequent occur in that place.

The trees that are planted near bank of river are Bamboo, Sisam, Simal, Jamun, eucalyptus etc.

People plant other trees near their houses, like Mango, Bakaino, Guava, Mulberry, several plants such as jackfruit, sitafal, and others play important roles in agricultural landscapes. Additionally, species like Asuro, Ipil Ipil, Laptis, khus, and khas khas are commonly grown near farmlands to help protect the soil from erosion, especially during floods.

Vetiver grass thrives in hot, humid tropical and subtropical regions. It prefers full sunlight and can withstand both drought and flooding. This grass adapts to almost all soil types and is often found growing along the earthen bunds of farms, in barren patches, and near irrigation canals around areas like Rajapur, Nepal.

*Dalbergia sissoo* typically grows in tropical and subtropical zones with well-drained, porous soils ranging from sandy to alluvial in texture. It is commonly found along the banks of larger rivers such as the Karnali, as well as smaller streams like Budi Khola and near irrigation channels.

Ipil Ipil grows well in sub humid to humid climates and can survive dry periods lasting 6 to 7 months. This plant prefers soils that drain well.

*Eucalyptus tereticornis*, also known as red gum, grows best in tropical and subtropical climates. While it can tolerate drought once mature, young plants need regular watering for optimal growth. It favors well-drained, loamy soils rich in organic material and is often found adjacent to agricultural fields.

Bamboo flourishes in tropical to warm temperate climates, preferring moist, well-drained, porous soils with ample organic matter, such as sandy loams to clay loams. It commonly grows in various environments including degraded lands, riverbanks, and slopes.

Bombax ceiba thrives in warm tropical to subtropical climates, favoring deep, fertile, well-drained soils like sandy loams from granite origin. Though adaptable to various soils, it prefers fertile soils with neutral to slightly acidic pH levels. This tree is often found in alluvial plains, near rivers, and on grasslands.

*Morus rubra* (red mulberry) grows well in deep, fertile clay loam or loam soils. It is usually planted near homes and irrigation canals. Justicia adhatoda grows in tropical to subtropical climates and is commonly found along irrigation canals and farm boundaries.

Jackfruit prefers warm, humid tropical to subtropical areas with fertile, well-drained sandy loam to loam soils. It avoids waterlogged conditions and is frequently cultivated near homes, valued for producing both fruit and vegetable yields within the same season.

Jamun, mango, Guava, sitafal, etc. are planted by people for fruit as well as to reduce erosion near house, irrigation canal, and near the agricultural field.

#### 4.1.11.1 Plantation

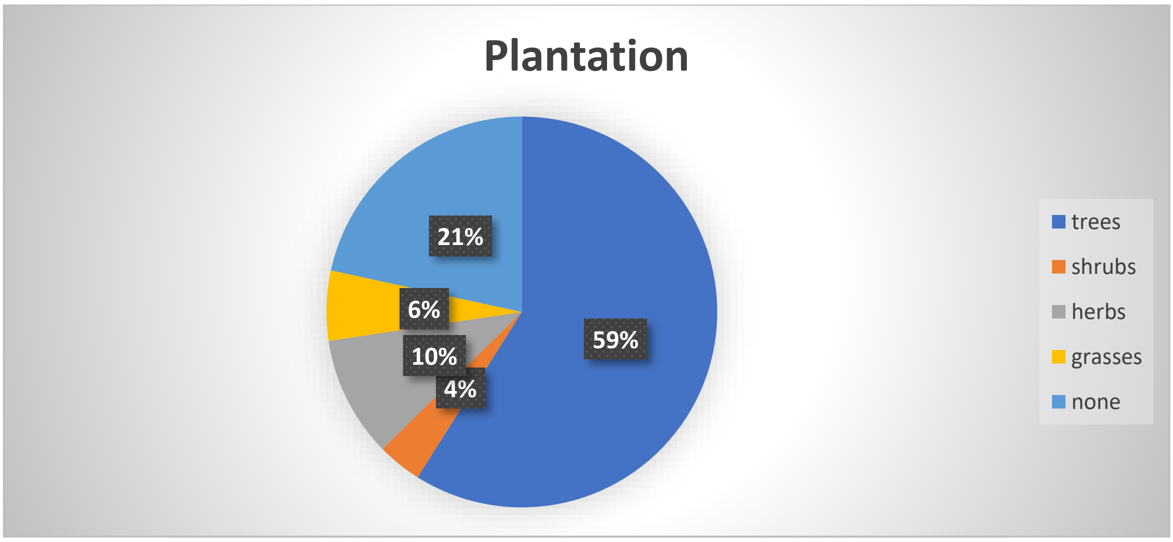


*Figure 13: Plantation*

In Rajapur, most people plant trees 59%, shrubs are planted about 4% by people. Herbs make up around 10% of the vegetation planted., while grasses make up about 6% and 21% have not planted.

| KII |
| --- |
| KII from different persons like Chief administrative officer, Focal person, Ward chairperson and Ward secretariat of Rajapur Municipality, it has been found that Rajapur has been suffering from flood problem since a long time. Ward and municipality work together in the time of flood and help the people with basic needs like food, drinking water and safe shelter in this time they also get help from different NGOs and INGOs like Red Cross and BEE group. They had adapted afforestation, making biodyke in bank of river etc. to stop bank cutting and reduce soil erosion as Ecosystem based flood adaptation. People of Rajapur work as free labour to make biodyke in riverbank every year. |

#### 4.1.11.2 Participation on EbA programs

Most people participate in tree plantation programs, 75%. Participation in awareness programs is about 19%, while involvement in local planning and decision-making is around 6% only. This indicates that participation in tree plantation programs is higher than in other activities. This may be because people already understand the importance of planting trees near rivers and irrigation canals.

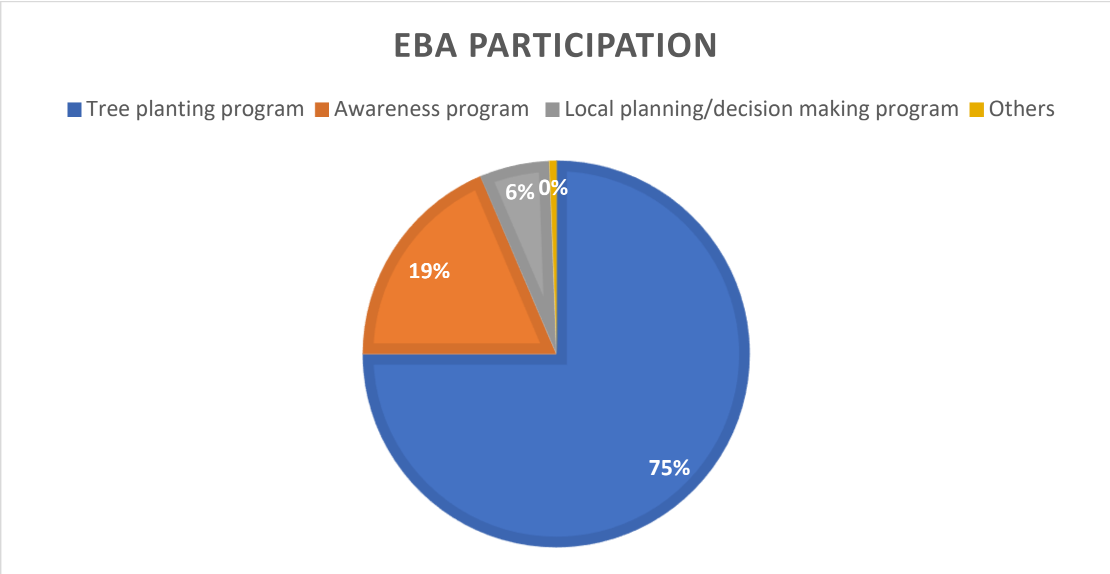


*Figure 14: Participation on EbA program*

#### 4.1.11.3 Indigenous Practices (EbA)

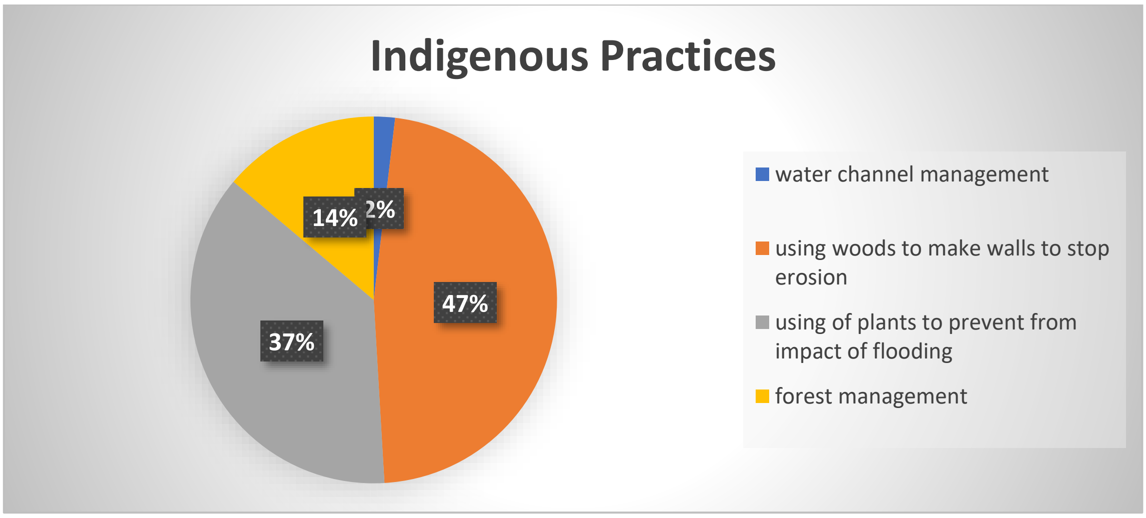


*Figure 15: Indigenous practices*

The people of Rajapur have various indigenous practices to control erosion and flooding. These practices include water channel management (e.g., they dug small way to put all excess water to irrigation canal and another field), which is 2%. Using wood to build walls to prevent erosion is 47%, while 37% use plants to reduce the impact of floods. Forest management (replacing old, decayed woods, cleaning wastages like dried leaves to save forest from forest fire and planting trees saplings if needed) accounts for 14% of these practices.

**Preparing wall (biodykes) to stop erosion and impact of flood.**

The people of Rajapur have adapted type of wall to control bank erosion of the river. This wall is temporary and made during the monsoon season. This work has been done by them for a longer period. In this process, the people of different wards or villages work as free labor for preparing this wall. Length may be varying from year to year depending upon the need. Mostly length is 500m, height is 5m.

Preparation Process according to locals:

-Tree logs are placed like pillars.

-Tie ropes on logs/trees.

-Keep the branches of trees in between ropes and logs.

-Put small stones, soil, and mud in the sack and make it strong like stone.

-Place the Sack in between the logs, ropes, and branches of trees (Jhalapatela).

-Place the branches of trees with sacks and make wall like structure in the bank of the river.

Figure 2: Wall in the bank of river made by using locally available resources(biodyke)

(Source: Rajapur Nagar Pramukh Dipesh Tharu Ko Sachibalaya)

**Preserve Seed Varieties (Indigenous practice)**

For centuries, people have employed various adjustments and adaptations to preserve seed varieties. A primary concern, especially during the monsoon season, has been protecting seeds from flood damage. Local communities have developed several indigenous practices to safeguard their seeds, often drawing on traditional knowledge. One common method involves using a special container known locally as a "Dhehari." This pot, crafted from mud and straw, provides a secure storage solution. To further protect the seeds from both flood and pests, they are often mixed with neem leaves and other medicinal herbs. These Dheharis are typically placed in elevated locations to keep them safe. Other adaptation practices include storing seeds in cotton clothes or sacks. Placing these packages inside jerkins or bottles for an added layer of protection, ensuring they remain viable for the following year's planting. Perhaps one of the most important and unique methods for preserving maize seeds involves storing them in trees. The maize is securely bound, often with its husks intact, and tied to the branches high above the ground. This is an indigenous practice. 88.48% of them have said that people use to store grains and seeds in Dhehari and 3% of them use tree branches near home to protect maize seed for next year.

Figure 3: Protection of food grains and seed in a container made up of mud and thatch and maize seed kept in tree branches.

**4.1.12 Evaluate the effectiveness of EbA measures in flood affected area.**

4.1.12.1 Effectiveness of planting near the field, irrigation canal, home

The effectiveness of ecosystem-based adaptation results found by regression analysis (agricultural field, near home, irrigation canal) has given below:

Table 5: Regression analysis of plantation as independent variable and benefits as dependent variable

| Dependent variable | Independent variable | R Square | F | Sig. (F) | B | Beta | Sig. (t) |
|---|---|---|---|---|---|---|---|
| Improve soil health/quality | Trees | 0.047 | 9.174 | 0.003 | 0.206 | 0.216 | 0.003 |
| Improve soil health/quality | Shrubs | 0.000 | 0.054 | 0.817 | -0.042 | -0.017 | 0.817 |
| Improve soil health/quality | Herbs | 0.011 | 2.087 | 0.150 | 0.164 | 0.105 | 0.150 |
| Improve soil health/quality | Grasses | 0.005 | 0.868 | 0.353 | 0.136 | 0.068 | 0.353 |
| Reduce soil erosion | Trees | 0.087 | 17.939 | 0.000 | 0.297 | 0.295 | 0.000 |
| Reduce soil erosion | Shrubs | 0.012 | 2.372 | 0.125 | 0.294 | 0.112 | 0.125 |
| Reduce soil erosion | Herbs | 0.000 | 0.009 | 0.923 | -0.012 | -0.007 | 0.923 |
| Reduce soil erosion | Grasses | 0.003 | 0.613 | 0.435 | 0.121 | 0.057 | 0.435 |
| Reduce run off | Trees | 0.000 | 0.002 | 0.962 | 0.001 | 0.004 | 0.962 |
| Reduce run off | Shrubs | 0.001 | 0.195 | 0.660 | -0.027 | -0.032 | 0.660 |
| Reduce run off | Herbs | 0.027 | 5.222 | 0.023 | 0.088 | 0.164 | 0.023 |
| Reduce run off | Grasses | 0.002 | 0.313 | 0.577 | -0.028 | -0.041 | 0.577 |

Improve Soil Health/Quality

Planting trees shows a statistically significant positive effect on improving soil health and quality. With $R^2$ of 0.047, F=9.174, B=0.206, Beta=0.216, sig(t)= 0.003) of the variance in improving soil health and quality. Shrubs has no significant effect ($R^2$ = 0, F=0.054, B=-0.042, Beta=-0.017, sig(t) = 0.817) on improving soil health and quality. This suggests shrubs do not contribute to soil quality improvement. Herbs have a non-significant positive effect on improving soil health ($R^2$ = 0.011, F=2.087, B=0.164, Beta=0.105, sig(t) = 0.15). Grasses do not show a significant relationship with improving soil health and quality ($R^2$ =

0.005, F=0.868, B=0.136, Beta=0.068, sig(t) = 0.353), indicating minimal impact in this context.

Reduce Soil Erosion

Trees have a strong and significant positive effect on reducing soil erosion ($R^2$ = 0.087, F=17.939, B=0.297, Beta=0.294, and sig(t)= 0.001). Shrubs show a weak, non-significant positive effect on erosion reduction ($R^2$ = 0.012, F=2.372, B=0.294, Beta=0.112, sig(t) = 0.125). Herbs have no measurable effect on soil erosion ($R^2$ = 0, F=0.009, B=-0.012, Beta=-0.007, sig(t)= 0.923), indicating that herbs do not significantly impact reducing erosion. Grasses do not show a significant effect ($R^2$ = 0.003, F=0.613, B=0.121, Beta=0.057, t = 0.435), role in reducing soil erosion.

Reduce Runoff

Trees show no significant effect on reducing runoff ($R^2$ nearly 0, F=0.002, B=0.001, Beta=0.004, t = 0.962); trees in this analysis do not strongly influence surface water flow or runoff reduction. Shrubs similarly show no significant influence on runoff reduction ($R^2$ = 0.001, F=0.195, B=-0.027, Beta=-0.032, sig(t) = 0.660). Herbs stand out as the only vegetation type with a statistically significant positive impact on reducing runoff ($R^2$ = 0.027, F=5.222, B=0.088, Beta=0.164, sig (t) = 0.023). Although the effect size is small, it is reliable, indicating that herbs might play a specialized role in controlling surface water movement, perhaps via ground cover or influencing water infiltration. Grasses show no significant contribution to runoff reduction ($R^2$ = 0.002, F=0.313, B=-0.028, Beta=-0.041, sig (t) = 0.577).

Table 6:Summery table of above findings

| **Dependent variable** | **Independent variable** | **Sig(t)** | **Significance/Remarks** |
|---|---|---|---|
| Improve soil health/ quality | Tree | 0.003 | Significantly effective |
| Reduce soil erosion | Tree | 0.000 | Highly significant effective |
| Reduce runoff | Herbs | 0.023 | Significant effective |

Planting trees shows significance in improving soil health and quality and effectively reduces soil erosion, while shrubs, herbs, and grasses generally show no significant impact on these outcomes. Herbs uniquely have a small but significant positive effect on reducing runoff, unlike trees, shrubs, and grasses which do not significantly influence runoff reduction.

4.1.12.2 Effectiveness of planting near bank of river

Table 7:Regression analysis of Plantation near agricultural field, bank of river, irrigation canal (co benefit)

| **Independent Variable** | **Independent Variable** | **R Square** | **F** | **Sig(F)** | **B** | **Beta** | **Sig(t)** |
|---|---|---|---|---|---|---|---|
| Trees | reduced soil erosion | 0.014 | 2.687 | 0.103 | 0.120 | 0.119 | 0.103 |
| Trees | less waterlogging | 0.000 | 0.043 | 0.836 | 0.006 | 0.015 | 0.836 |
| Trees | reduced flood impact | 0.140 | 30.696 | 0.000 | 0.319 | 0.375 | 0.000 |
| Trees | improve crop production | 0.013 | 2.531 | 0.113 | 0.055 | 0.115 | 0.113 |
| Shrubs | reduced soil erosion | 0.009 | 1.762 | 0.186 | 0.255 | 0.096 | 0.186 |
| Shrubs | less waterlogging | 0.010 | 1.828 | 0.178 | 0.105 | 0.098 | 0.178 |
| Shrubs | reduced flood impact | 0.002 | 0.286 | 0.593 | -0.087 | -0.039 | 0.593 |
| Shrubs | improve crop production | 0.002 | 0.443 | 0.507 | -0.060 | -0.048 | 0.507 |
| Herbs | reduced soil erosion | 0.062 | 12.493 | 0.001 | 0.415 | 0.250 | 0.001 |
| Herbs | less waterlogging | 0.000 | 0.057 | 0.811 | 0.012 | 0.017 | 0.811 |
| Herbs | reduced flood impact | 0.033 | 6.316 | 0.013 | -0.251 | -0.180 | 0.013 |
| Herbs | improve crop production | 0.000 | 0.011 | 0.918 | -0.006 | -0.008 | 0.918 |
| Grasses | reduced soil erosion | 0.048 | 9.463 | 0.002 | 0.468 | 0.219 | 0.002 |
| Grasses | less waterlogging | 0.003 | 0.509 | 0.476 | -0.045 | -0.052 | 0.476 |
| Grasses | reduced flood impact | 0.006 | 1.218 | 0.271 | -0.144 | -0.080 | 0.271 |
| Grasses | improve crop production | 0.004 | 0.713 | 0.400 | -0.061 | -0.061 | 0.400 |

Relationship between type of vegetation (Trees, Shrubs, Herbs, or Grasses) and their effectiveness in reducing soil erosion, less waterlogging, reducing flood impact, and improving crop production. The analysis reveals that trees are highly significant positive predictors of reduced flood impact, i.e., (R square=0.14, F=30.696, B=0.319, Beta=0.375, t=0.000) and (R square =0.14, t=0.001), B=0.12, beta=0.119, t=0.103), indicating that trees have a positive effect on reducing soil erosion but not a statistically significant effect. Trees do not significantly reduce waterlogging (R square=0, F=0.043, B=0.006, Beta=0.015, sig t=0.836). Trees also do not show significance on improvement of crop production (R square=0.013, f=2.531, B=0.055, Beta=0.375, sig (t)=0.113).

In case of Shrubs, all R-squares, F values are lower, B and Beta values are also low, and significance has not been shown for all independent variables, reducing soil erosion, less waterlogging, reducing flood impact, and improving crop production.

And in case of herbs for reducing soil erosion, it shows a strong positive significant effect (r square=0.062, F=12.493, B=0.415, Beta=0.25, sig(t)=0.001). And for reducing flood impact on agricultural land and near irrigation canal, it shows (R square=0.033, f=6.316, B=-0.251, Beta=-0.18, sig(t)= 0.013) a significant negative effect. And it shows no significance for less waterlogging, where (R square= 0.0, F= 0.057, B=0.012, Beta=0.017, sig(t)=0.811) also has no significance on improving crop production (R square=0.0, F=0.011, B=-0.006, Beta=-0.008, sig(t)=0.918)

Grasses have a significant positive effect on reducing soil erosion (R square=0.048, F=9.463, B=0.468, Beta=0.219, sig (t)=0.002). Other variables (less waterlogging, reduced flood impact, improved crop production) show a very low R-squared value and are statistically insignificant.

Trees play an important role in reducing the impact of floods, but they don't significantly help with preventing soil erosion, waterlogging, or improving crop growth. Shrubs don't show any clear benefit or effectiveness. Herbs are good at preventing soil erosion but do not show effectiveness in reducing flood impact, with no notable effect on waterlogging or crop yields. Grasses also help reduce soil erosion, but they don't have a strong effect on waterlogging, floods, or crop production. In short, trees and grasses are useful for controlling soil erosion and flooding, while shrubs and herbs have less consistent effects.

Table 8: Summery table of above findings

| **Dependent Variable** | **Independent Variable** | **Sig(t)** | **Significance/Remarks** |
|---|---|---|---|
| Reduced flood impact | Trees | 0.000 | Highly significant effective |
| Reduced soil erosion | Herbs | 0.001 | Highly significant effective |
| Reduced soil erosion | Grasses | 0.002 | Highly significant effective |

4.1.12.3 Effectiveness of Biodykes in irrigation canal and agricultural field

Table 9: Effectiveness of wood used to make wall (Bamboo) to reduce risk and cost effectiveness.

| **Dependent variable** | **Independent variable** | **R Square** | **F** | **Sig. (f)** | **B** | **Beta** | **Sig. (t)** |
|---|---|---|---|---|---|---|---|
| Risk Reduction | Biodykes (wall) | 0.125 | 26.94 | 0.000 | 0.393 | 0.354 | 0.000 |
| cost effective | Biodykes (wall) | 0.03 | 5.737 | 0.018 | 0.118 | 0.172 | 0.018 |

A simple linear regression was conducted to examine the effect of the independent variable Wall /(biodykes) on two dependent variables: risk reduction and cost effectiveness. For risk reduction, the model was statistically significant, (R square=0.125, f=26.94, B=0.393, Beta=0.354, sig(t)=0.00) and explained the variance in risk reduction (R square =0.125). Cost-effectiveness, the regression model was also significant, but shows a smaller portion of the variance (R square=0.03, F=5.737). The B coefficient was 0.118 (B = 0.018, Beta=0.172, sig(t)=0.018), showing a weaker but still positive relation between Wall and cost effectiveness.

Biodykes are effective in reducing risk of erosion and bank cutting and they are also cost effective as they can be prepared by locally available materials.

**4.1.13 The role of women in EbA practice**

4.1.13.1 Head of family

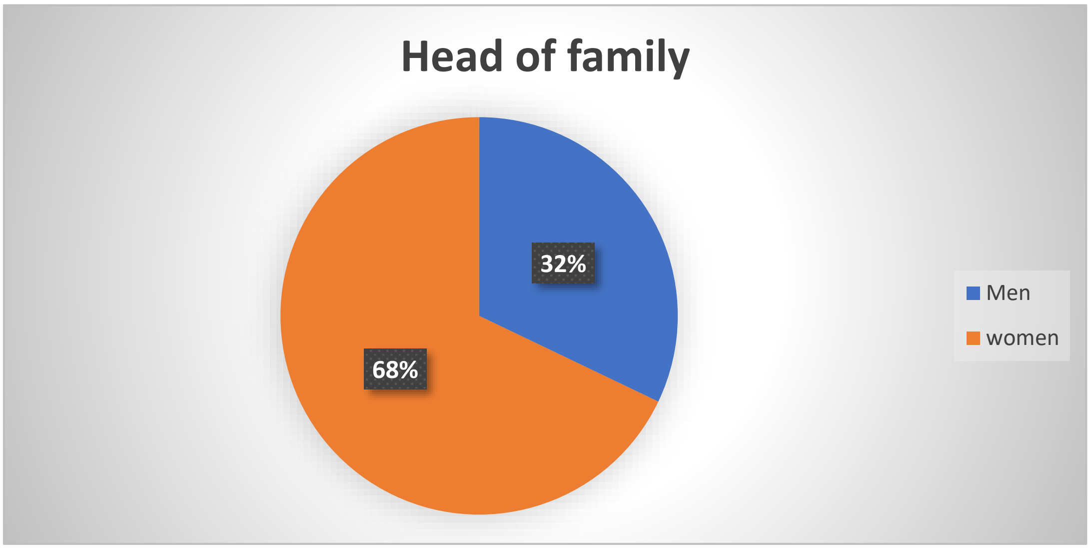


*Figure 16: Head of family*

The pie chart illustrates the gender distribution of the head of the family, where 68% of the families have women as head of the family, and 32% of the households have men as head of the family.

Besides that, 100% the respondents said that women have the decision-making power in the home same as men. They both discuss and make decisions for the betterment of their family. And 99% household respondents agreed that women have distinct knowledge, traditional knowledge, natural resource management, resource management etc.

**4.1.13.2 Regression analysis of Women and livelihood**

Table 10: Regression analysis of Women and their livelihood

| **Dependent Variable** | **Independent Variable** | **$R^2$** | **F** | **Sig. F** | **B** | **Beta** | **Sig. t** |
|---|---|---|---|---|---|---|---|
| Farming | Women | 0.021 | 4.126 | 0.044 | -0.126 | -0.147 | 0.044 |
| Employment | Women | 0.023 | 4.374 | 0.038 | 0.084 | 0.151 | 0.038 |
| Others | Women | 0.003 | 0.632 | 0.428 | 0.041 | 0.058 | 0.428 |

For the dependent variable farming, ($R^2 = 0.021$, $F = 4.126$, sig $f = 0.044 < p = 0.05$), indicating a statistically significant relationship between women's livelihood and farming activities. The regression was negative and significant (B=-0.126, Beta=-0.126, sig (t) = 0.044), suggesting that higher values of women's livelihood were associated with a slight decrease in farming involvement.

Regarding employment the variance ($R^2 = 0.023$, F = 4.374, sig f = $0.038 < p = 0.05$) showing a statistically significant relationship. The coefficient for women's livelihood was positive and significant (B=0.084, Beta=0.151, sig t = $0.038 < p = 0.05$), indicating that increases in corresponded to higher employment engagement.

For the dependent variable others, which include (fishing, having a grocery shop, tailoring, etc), the model was not significant ($R^2 = 0.003$, F = 0.632, f = $0.428 < p = 0.05$), and the women's livelihood did not significantly influence this outcome (sig t = $0.428 < p = 0.05$).

This statistical result shows women have farming as their primary livelihood, they have employment as another positive and significant livelihood but others, which include (fishing, having a grocery shop, tailoring, etc.), shows no significance.

#### 4.1.13.3 Women participation in EbA

Table 11:Regression analysis between women participation in afforestation and sustainable agricultural practices

| Dependent Variable | Independent Variable | R square | F | Sig. F | B | Beta | Sig. t |
|---|---|---|---|---|---|---|---|
| Afforestation | Women participation | 0.554 | 224.605 | 0.000 | 0.738 | 0.738 | 0.000 |
| Sustainable agriculture practices | Women participation | 0.084 | 17.321 | 0.000 | 0.000 | 0.176 | 0.000 |

The coefficient of determination, R-square is 0.554, indicating the variance in afforestation can be explained by women's participation. The model is highly significant, as evidenced by an F-statistic of 224.605 and a Sig. F value of 0.000. The unstandardized regression coefficient (B) for women's participation is 0.738, suggesting that for every unit increase in women's participation, afforestation efforts are predicted to increase by 0.738 units. The standardized beta coefficient (Beta) is also 0.738, signifying a substantial positive impact. The significance t value of 0.000, further confirming the statistical significance of this relationship.

Regarding sustainable agriculture practices, the regression analysis also indicates a statistically significant positive relationship with women's participation, albeit with a more modest explanatory power. The R square value is 0.084, implying that the variability in sustainable agriculture practices can be attributed to women's participation. Despite the lower R square, the overall model remains statistically significant, with an F-statistic of 17.321 and a Sig. F value of 0.000. The unstandardized regression coefficient (B) for women's participation is 0.000, and the standardized beta coefficient (Beta) is 0.176. The t-value is 0.000, indicating a statistically significant result.

Participation in different programs like afforestation and sustainable agricultural practices was highly significant.

**4.1.13.4 Women gets participate in EbA program.**

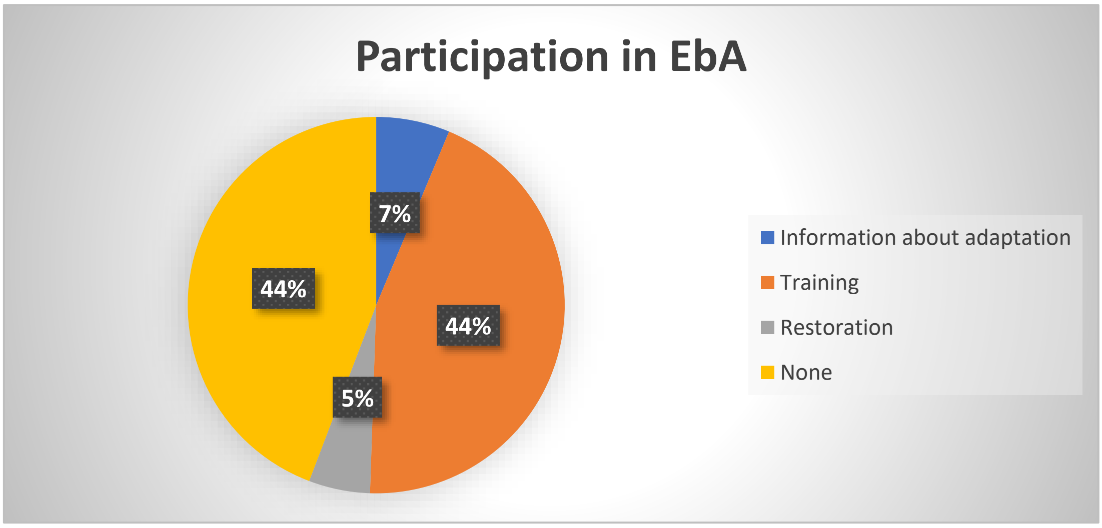


*Figure 17: Women participation in EbA program*

The bar chart illustrates the distribution across: Information about adaptation, training, restoration, and none. The data show that training is the most prominent category, with 44%. In contrast, information about adaptation and restoration has much lower values of 7% and 5%, respectively, and 44% of them reported that they participated in none of the above programs.

FGD has done in the presence of Budgars and local people. From FGD it has been found that they work as a team to reduce impact of flood. In the pre monsoon period they practice mock drill activity to save and rescue elderly people, pregnant women, small children, domestic animals and grains from flood. In many works or programs like trainings, free Laboure to make biodyke, skill development activities and plantation done in community level the participation of women is equal to men.

#### 4.1.13.5 Support needed to enhance women participation on EbA activities.

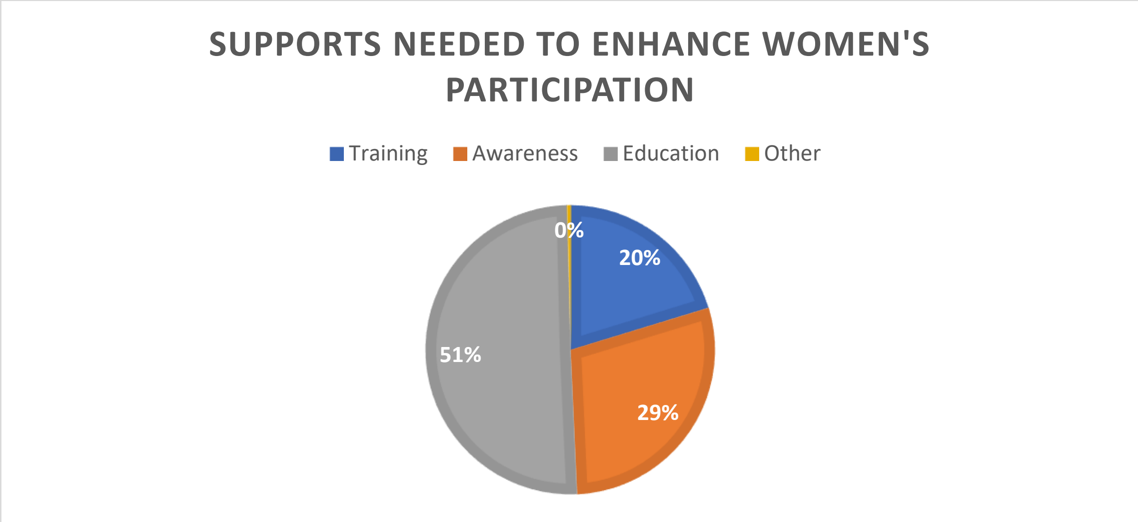


*Figure 18: Support needed to enhance Women participation on EbA activities.*

More than half of the respondents said that education is most important to enhance women in EbA practices (51%). Awareness campaigns that are related to EbA are also important, making up 29%. Training programs like (community forest management, choosing the best plants for plantation with multiple benefit, and sustainable agricultural practices) that is 20%. This means most of the help women need comes from education, awareness, and training to enhance their participation.

Besides that, KIIs from different wards of Rajapur (1,3,4,7 and 10) found that women of Rajapur take part in (EbA) afforestation program, community awareness program, sustainable agricultural practices trainings, etc. In ward no 1, women's participation in all activities is 35%, ward number 3 is more than 70%, ward no 4 is above 50%, ward no 7 is 55% and ward no 10 is 80%. This shows a huge increase in the participation of women over few years.

## 4.2 Discussions

### 4.2.1 Ecosystem Based Adaptation Employed by Indigenous Community

The result of this study provides valuable insights on ecosystem-based flood adaptation employed by indigenous community.

The people of Rajapur have various indigenous practices, especially ecosystem-based adaptations, to control erosion and flooding also including water channel management.

Plantation of trees, herbs, shrubs, and grass is a common flood impacts prevention EBA practice adopted by Rajapur indigenous community as in locations like Ksedi river watershed, Ajgada, Udayapur (Phuju 2019). Saplings received from Sub-DFO are planted in riverbanks as well as near irrigation canal and agricultural fields. Species used for plantation depends on location planted species included Bamboo, Sisam, Simal, Jamun, eucalyptus etc. Near river, other trees like near their houses, like ipil ipil, Bakaino, Guava, Mulberry, Jackfruit, sitafal, etc. some of the plants like Asuro, Laptis, khus, and khas khas near irrigation canal, where as in Ajgada Bamboo, Simal, Sal, Kans, broom grass were planted.

Making a (Biodyke) wall of wood and tree branches along with sand filled sacks, mud, and small stones, in which the wood logs are tied with a strong rope on the riverbank to stop erosion is a temporary solution through community participation, is another common practice. Use of Zhaala Paata (made using branches of trees, various sticks) for reducing the impact of floods. Using wood to build walls to prevent erosion is practiced reducing the impact of floods. These are common traditional practices in western terai district like Bardiya (Dhungel, 2011). According to locals, it is a very affordable method and was greatly used by their ancestors. However, it is only effective for three months as it dries up. When the timing of the monsoon could be anticipated, it was sufficient to prevent floodwaters from reaching the village.

Local people are generally associated in forest management. Each ward has a community forest, and most people actively participate in programs such as tree plantation and other forest-related activities. Activities are supported by the Sub DFO by providing saplings. Plantation is done mainly near the river and the irrigation canal. Similar practices were also reported from Lake Naivasha, Kenya (Isindu et al., 2024). Also, EBA strategies like afforestation and agroforestry through government support, other structural EbA strategies like soil and water conservation, terraces and rainwater harvesting structure were developed.

A primary concern, especially during the monsoon season, has been protecting seeds from flood damage. Local communities have developed several indigenous practices to safeguard their seeds, often drawing on traditional knowledge. One common method involves using a special container known locally as a "Dhehari." This pot, crafted from mud and straw, provides a secure storage solution. To further protect the seeds from both flood and pests, they are often mixed with neem leaves and other medicinal herbs. These Dheharis are typically placed in elevated locations to keep them safe. Other adaptation practices include, Storing seeds in cotton clothes or sacks.

Flood waterlogged areas are used to grow fish and Mollusca (edible snails), and seasonal vegetables and fruits are cultivated on the bank of the river, which gives people the opportunity to grow a good amount of fruits and vegetables. They grow onions and watermelons mostly in such areas. Farmers living close to the riverbanks in the Terai region often experience recurring floods, which lead to land deterioration and disrupt their means of living, since the deposited sand prevents them from growing crops Bagar farming fits well in this context. In the riverbed area of Kapilvastu, farmers sow watermelon and sweet potato seeds during January and February (FAO, 2014).

**4.2.2 Evaluate the effectiveness of EbA measures in flood affected area.**

The tree shows effective significance (B=0.206, Beta=0.375) in enhancing soil health/quality and preventing soil erosion (B=0.297, Beta=0.294) due to extensive root systems, leaf litter, and canopy cover, which improve soil structure and protect soil surfaces. In contrast, herbs appear to have shown significance (B=0.080, Beta=0.164) effectiveness in reducing runoff, perhaps providing effective ground coverage, and increasing soil infiltration capacity; their influence on soil quality or erosion is limited. Shrubs and grasses do not demonstrate statistically significant impacts on any of the three measured outcomes (improving soil health/quality, reducing soil erosion, and reducing runoff), though some weak positive trends suggest that conditions or contexts might influence their potential effects in respondent' agricultural fields, near irrigation canal, and their home. Erosion control supported by vegetative measures such as plantations for conservation of soil, disaster prevention, and reduction of vulnerabilities of local communities through water-induced hazards, which was initiated by the Ecosystem-based Adaptation-EbA Project as in

Panchase area, by ecosystem restoration through the plantation of multipurpose trees and other forest products (Adhikari et al., 2018).

Trees stand out for their positive effectiveness in reducing flood impacts. With high statistical significance (B=0.319, Beta=0.375) ($p < 0.001$), trees play a vital role in reducing flood risks, possibly through root system stabilization, and enhancing soil infiltration. Statistically, they show limited impact on erosion control or no significant impact on waterlogging, and crop production improvement, but in reality, due to the strong root system, they strongly hold the ground or soil, which decreases the erosion caused by flood or heavy rainfall, and also help in reducing waterlogging, but it may be correct in the case of improving crop production because trees do not directly influence crop production. Shrubs' contribution to reducing erosion, waterlogging, or flood impact or improving crop productivity appears very low, suggesting that they are not significant for effectiveness in reducing flood risk because a smaller number of shrubs have been planted or they are not naturally built to stop erosion and flood impact. But grasses (B=0.468, Beta=0.319) and herbs (B=0.415, Beta=0.250) plantation has shown significant effectiveness in reducing soil erosion. This may be due to the dense root system binds soil, surface cover reduces the impact of rainfall, slows down water flow, and promotes vegetation recovery. Compared with riparian reforestation/rehabilitation along riverbanks to slow run-off and capture sediment before it reaches the water course, thus limiting downstream flood damage to property and livelihoods, reforestation/forest restoration to stabilize slopes and prevent landslides, mud flows, and debris flows, thus limiting risks to life, property, and livelihoods. Measures of flood damage (infrastructure, households, crops), frequency and severity of landslides, measures of damage from slope failure (loss of life, damage to property, impact on livelihoods), e.g., planting indigenous, climate-resilient, and multi-use species that benefit local communities (UNEP-WCMC and UNEP, 2019).The effectiveness of temporary walls made on the bank of the river and, bank of the irrigation canal has a significant and positive impact on reducing risk, such as the impact of flood, reducing bank cutting, reducing inundation, and erosion control. This suggests that using biodykes is moderately effective in enhancing safety or resilience, likely due to its inherent strength and flexibility. Biodykes (walls) also play an important role in enhancing cost efficiency. This indicates that although the material might offer some economic benefits, other factors likely play a more substantial role in determining overall cost efficiency.

### 4.2.3 The role of women in EbA practice

In many families, women often take on the role of the primary decision-maker and leader. They can decide with a family member for the betterment of their livelihood. Another reason for this is that men usually go outside of their home for work and earning purposes. Usually, women have distinct knowledge than men, this is because they know resource management better, which is due to experience by working in such environments where the utilization of resources is primary due to a lack of proper resources, either economic or other things that are used in daily life for living.

The regression results indicate that women's livelihood has a statistically significant but modest predictive effect on both farming and employment. Specifically, a higher presence or involvement is associated with a decrease in farming-related activities or outcomes, whereas their influence positively impacts employment-related outcomes. The relationship between women's livelihood and farming reflects underlying social, economic, or cultural dynamics statistically, but in reality, most of the women were involved in agricultural farming to cultivate and grow food for a year. Conversely, the positive association with employment suggests that women's involvement may be facilitating or contributing to employment sectors, possibly indicating successful participation in agricultural as well as non-agricultural labor. The lack of a significant relationship between women livelihood and the others (fishing, having grocery shop, tailoring, painting shop etc.) indicates that in this context, women's involvement does not meaningfully predict outcomes categorized under Others (fishing, having grocery shop, tailoring, painting shop, etc.) it may be due to a smaller number of women's involved in fishing, having grocery shop, tailoring in household survey area. In comparing with, the relationship between women's status within the family and environmental conservation was positive and statistically significant ($\beta = 0.256$; C.R. = 4.324; $P = 0.000$). Similarly, the influence of the husband's behavior on environmental conservation showed a positive and significant effect ($\beta = 0.160$; C.R. = 2.647; $P = 0.008$). Women's active participation also had a meaningful positive association with environmental conservation ($\beta = 0.248$; C.R. = 3.841; $P = 0.000$). However, the connection between women's social protection and environmental conservation was positive but not statistically significant ($\beta = 0.053$; C.R. = 0.856; $P = 0.392$) in the Chaharmahal and Bakhtiari Province, located in southwestern Iran (Ghasemi et al., 2021), Most of the women take part in programs like Information about adaptation, training, restoration, but they need more awareness and education programs to enhance their role in adapting EbA activities and learn about such programs will give huge benefits to conduct programs like afforestation, in their village, in collaboration with the ward and municipality. Rajapur municipality has a huge number of women participating, mostly women stay in the house and do all the activities of the home, and they participate in EbA programs such as afforestation, sustainable agricultural practices, which have shown high significance in regression analysis, making of temporary walls(biodykes), etc. Ranjitkar (2020) previously highlighted that community-based program involvement in Rajapur was traditionally seen as a responsibility for men. However, a feminization of participation roles, which was encouraged by male outmigration, shifts in addressing traditional gender roles for women, has increased women's access to CCA programs. Women have also been motivated to participate in CCA programs as an opportunity to expand their network and enhance their skills. Despite participation, leadership opportunities were largely seen as male-dominated. Although, increase in women's participation indicates elasticity of norms, leadership positions being reserved for men indicate the opposite.

# CHAPTER 5: CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

People of Rajapur have adapted various EbA in which plantation or afforestation is higher. They have planted various plants on the bank of the river, near their agricultural field. Most of these plants help in reducing soil erosion and reduce flood impact as they have a fibrous root system and a deep root system.

People of Rajapur have knowledge about EbA, like afforestation, sustainable agricultural practices, community forest management, etc. They take part in EbA activities like tree plantation, awareness program, and local planning program.

Also use indigenous knowledge like using logs of wood, tree branches, sand, small stones, and mud on a sack and make a wall structure to reduce the impact of flood. The effectiveness of the traditional use of walls (biodykes) in Rajapur during the monsoon season has proven to be a highly effective and adaptable method for flood reduction. These structures are usually made on the bank of a river during the monsoon season. Promoting such indigenous practice can play a vital role in ecosystem-based adaptation.

They also use some method to preserve seeds for next year, like keeping them in an elevated house and hanging (maize) on branches of trees to protect them from floods.

This study concludes that the effectiveness of plantation (trees) plays a significant role in reducing flood-related risks, such as soil erosion, flood impact reduction, and improving soil quality and health. Especially when the plantation is done on the bank of the river, the irrigation canal is nearer to the agricultural land and the home. Herbs also show effectiveness in reducing runoff and soil erosion.

Grasses show effectiveness in reducing soil erosion. Therefore, promoting such plantation strategies is considered a practical and sustainable approach for ecosystem-based flood adaptation, although they do not directly contribute to crop production improvement.

Women play a vital role as leaders within their families, often making important decisions for their households. Their distinct knowledge and experience in natural resource management stem from daily involvement in sustainable resource use.

Women’s livelihoods have a significant but moderate effect on their involvement in farming and increased employment, reflecting their diverse roles in both agricultural and non-agricultural sectors. However, women’s participation in activities like fishing and small businesses remains low, limiting their impact in these areas.

Women also take part in afforestation and sustainable agricultural practices. Women actively engage in adaptation programs such as training and restoration but need more education and awareness to strengthen their role in EbA.
High participation rates in places like Rajapur municipality highlight women's commitment, especially where men migrate for work. Overall, empowering women through education and inclusive programs will enhance their contribution to sustainable resource management.

## 5.2 Recommendation

Launch awareness and education program in Rajapur to give them more knowledge and understanding about the ecosystem-based adaptation.

Encourage farmers and locals to move towards ecosystem-based solution. Bio engineering, more plantation along the riverbank and around the farmland might be some of the methods for flood risk management.

Rajapur municipality and community forest office should collaborate with each other to give technical knowledge to the people for plantation which encourage people to do plantation on their area and barren land.

More research like ecosystem-based adaptation, nature-based solution, bioengineering is required. So, like to recommend more researchers to do research more on those fields.

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# APPENDICES

## Appendix A: Sample calculation of Regression analysis

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .172[a] | .030 | .024 | .30392 |

a. Predictors: (Constant), Bamboo wall(biodykes)

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .530 | 1 | .530 | 5.737 | .018[b] |
| | Residual | 17.365 | 188 | .092 | | |
| | Total | 17.895 | 189 | | | |

a. Dependent Variable: cost effective

b. Predictors: (Constant), Bamboo wall(biodykes)

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | .019 | .042 | | .456 | .649 |
| | Bamboo wall | .118 | .049 | .172 | 2.395 | .018 |

a. Dependent Variable: cost effective

**Appendix B: Photographs**

Plant near river

Plantation near river

Plantation on agricultural field

Elevated handpump

Focus Group Discussion

KII with Focal Person and Chief Administration Officer of Rajapur Municipality


KII in Ward office (1,3,4,7 and 10) with ward secretariat, ward officer and ward chairperson

## Appendix C: Questionnaire

Questionnaire

**General**

GPS

X: Y:

Ward no:

**2.Age:**

a. Below 20

b.21-30

c.31-40

d.41-50

e.51 and above

**3.Major Occupation:**

a. Farmer

b. Labor

c. Student

d. Other(specify)

**4.Education level**

a. No schooling

b. Functional literacy

c. Primary schooling

e. Secondary schooling

f. University

**5.Nature of house:**

a) Mud, stone, straw roof

b) Mud, stone, tin roof

c) Cement, stone/brick, tin roof

d) Concrete, bricks, concrete roofs

**6.How long have you been residing in the Rajapur Municipality?**

a) Born here

b) Less than 10 years

c) 10-20 years

d) More than 20 years

**7.Yearly Income**

**Flood**

**8. Have you experienced flood in recent years?**

a. Yes b. No

**9. If yes, how frequently?**

**10. When was the last flood?**

**11.What were the impacts of the most recent flood on your household?**

a. damage to property

b. loss of crops/livestock,

c. health impacts

d. displacement

e. erosion/ soil deposition

**12. In how many years the large flood occurs?**

**13.What did the last major flood affected in your area?**

**14. How did it impact in your house?**

a. house drowned b. house swept away c. only affect ground floor

**15. Due to flood, what changes occurred in your daily working activities?**

**16. By your farming practice, how many months it takes to finish all the food you harvested?**

**17.Which type of crops do you cultivate in your agricultural land?**

**18.How many times you cultivate crops in a year?**

**19.In which season you mostly cultivate crops?**

**20.What are the types of crop varieties do you cultivate?**

**21.What does the flood make change in process/method of agriculture?**

**22.Does it affect the food grains?**

**23. If it has affected the food grains soaked (get wet) by flood, how did you dry them?**

**24. What other work did you do when your agricultural land has been flooded?**

**25. Did you get financial as well as other support?**

**26.What type of work done in your village as preventive measures to flood resistance?**

**27. Did you use fertilizer or pesticide in farming?**

**EbA practices employed by Indigenous community.**

**1.What types of plants are planted near the agricultural land?**

a. Trees b. Shrubs c. Herbs d. Grasses

**2. Any specific plant do you planted in your agricultural field (earthen bud)?**

a. pigeon's pea plant b. black gram beans plant c. amriso d. others(specify)

**3. Which of the following EbA do you know?**

a. Afforestation/riverbank vegetation

b. community managed forest

c. reforestation of degraded land

d. sustainable agriculture practices (fertilizer, pesticide, tillage, crop type)

**4. Have you participated in local EbA program?**

a. Yes b. No

**5. If yes, what kind of program?**

a. tree planting program b. awareness program c. local planning/decision making program d. others.

**6. Do you plant flood resistant plants/crops in your field? If yes, which?**

**7.What indigenous practice did your community use to adapt?**

a. water channel management

b. using of plants to prevent from impact of flooding.

c. using woods to make walls to stop erosion.

d. forest management

**8. Has the implementation of EbA impact on traditional knowledge and practices?**

a. Yes b. no

**9. If yes how?**

**10. What type of plant do you use for the plantation?**

**11. Does wall with woods(biodykes) are made to stop soil erosion?**

**12. If yes, which tree wood you mostly prefer to use to make wall?**

a. bamboo b. Ipil Ipil c. sal d. other

**13. Are there any flood-resilient community shelters or storage structures built using traditional methods?**

a. mud b. bamboo c. thatch d. other

**14.Do agricultural or livestock practices change with the flood season?**

a. shifting grazing areas   b. changing crop types.

**15.Are there any traditional or indigenous knowledge related to flood management that you think should be promoted?**

**16. Are traditional seed exchange system or preserving grains till next year? If yes what?**

**17. What are the approaches done in this area to reduce soil erosion due to flood?**

**18. Are there any beliefs related to environment protection and adaptation practices?**

**To evaluate Effectiveness of EbA**

1. **What is the advantage or benefit of planting trees near agricultural land, irrigation canal?**
   a. improve soil health b. reduce soil erosion c. reduce runoff d. others.
2. **Is the plantation near the agricultural field, bank of river is effective(beneficial) rather than the area where plantation has not been done?**
3. **If yes, what benefits have you observed?**
   a. reduced soil erosion,
   b. less waterlogging,
   c. reduced flood impact
   d. improved water quality
   e. improves crop production.

4. **Have you notice any reduction in soil erosion after plantation?**
   a. Yes   b. No
5. **What are the main advantages of EbA (biodykes)?**
   a. Risk reduction b. cost effective c. promote community participation.
6. **Are EbA benefit to reduce flood impact in this area?**
7. **What are the measures to be taken in cultivated land to reduce erosion?**
8. **How many types of crops do you cultivate in your agricultural land in a season?**
   a. 1 b. 2   c. 3 d. 4
9. **Is there any benefit in cultivating multiple crops at a time?**

10. **If yes, what benefit?**
11. **In which season do you cultivate those crops?**
    a. Pre-Monsoon b. Monsoon c. Post Monsoon
12. **Did you observe better crop growth after EbA applied?**
13. **Has the presence of vegetative cover cause less waterlogging/less erosion in crop field after flood?**
14. **Has EbA helped to preserve indigenous seed varieties?**
15. **How has the effectiveness of traditional EbA practice changed over time?**
16. **What does the co-benefit arise from EbA in community?**
    a. Risk reduction b. sustainable water provision c. enhance of knowledge d. Mitigation measures.
17. **Do you find any disadvantage of implementing EbA?**
18. **What are the challenges of implementing EbA?**
19. **Is overall implementing EbA is cost effective?**

**Role of women in EbA studies**

**1.Who is leader of your house?**

a. Man b. Women

**2.Does women take part in decision making in your family?**

**3.What types of livelihoods do women have?**

a. Farming b. employment c. other

**4.Does women has distinct knowledge than man?**

a. Yes b. No

**5.Do women take part in EbA practices?**

**6.What type of work do women engaged in EbA practice?**

**7.Do women receive any training? If yes which one?**

**8.Do women and men have same role in community for EbA practice?**

a. Yes b. No

**9.What support will help to enhance women's participation in EbA?**

a. Training b. education c. community awareness d. other

**10.What do you think women are benefitted by EbA activities?**

**11.Which of the following women gained access through EbA practices?**

a. restoration

b. training

c. information about adaptation

d. none

**12. In your opinion how important is role of women in implementing ecosystem-based adaptation?**

**13.Give any suggestion for increasing role of women in EbA practices?**