CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Landscape characteristics and socio-ethnic factors influencing farmers' attitudes towards adopting agroforestry in Nepal

MASTER'S THESIS

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DIPLOMA THESIS ASSIGNMENT

Bachelor of Science Mitchell Collins, BS

International Development and Agricultural Economics

Thesis title

Landscape characteristics and socio-ethnic factors influencing farmers attitude towards Agroforestry adoption

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Objectives of thesis

1. Farmers' perspectives on factors that affect their decisions on Agroforestry
2. Effect of landscape characteristics on Agroforestry
3. Effect of socio-ethnic factors on Agroforestry

Methodology

Study Area:

Three different agroecological regions of Nepal. Mountain region (Mustang District), Hilly Region (Baglung District), and Terai/Plain region (Chitwan District)

Data Collection:

Data will be collected through a questionnaire survey from three different agro-ecological regions of Nepal. The expected sample is 350-400 within all three regions. The development of the questionnaire will be derived from literature reviews and related theories.

Sampling Technique:

Our data will be collected in the multistage sampling method. The three agro-ecological regions are selected purposively and 350-400 smallholder farmers will be interviewed randomly.

Data Analysis

Econometrics analysis such as logit and multinominal model will be used. Data will be analyzed via Excel and SPSS.

The proposed extent of the thesis

50

Keywords

Nepal, climate change, farmers, agroforestry, landscape

Recommended information sources

Adoption of agroforestry practices in Bangladesh as a climate change mitigation option: Investment, drivers, and SWOT analysis perspectives. Environmental Challenges 7.

Bruck SR, Kuusela OP. 2021. How health and market access associate with agroforestry adoption decisions: evidence from Tabora, Tanzania. Agroforest System 95:1073–1086.

Dhungana N, Silwal N, Upadhaya S, Khadka C, Regmi SK, Joshi D, Adhikari S. 2020. Rural coping and adaptation strategies for climate change by Himalayan communities in Nepal. Journal of Mountain Science 17:1462–1474.

Karki S, Burton P, Mackey B. 2020. Climate change adaptation by subsistence and smallholder farmers: Insights from three agroecological regions of Nepal. Cogent Social Sciences 6: 1-23..

Tiwari KR, Rayamajhi S, Pokharel RK, Balla MK. 2014. Determinants of the Climate Change Adaptation in Rural Farming in Nepal Himalaya. International Journal of Multidisciplinary and Current Research 2:234-240.

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Declaration

I hereby declare that I have done this thesis entitled *"Landscape characteristics and socio-ethnic factors influencing farmers' attitudes towards adopting agroforestry in Nepal"* independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 21 April 2023

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Mitchell Collins

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Abstract

The global scenario of climate change is a pressing issue that continues to worsen. Climate change has increased the frequency and intensity of extreme weather events. This affects agriculture. In Nepal, food insecurity and vulnerability have increased for many rural communities as water temperatures have dropped, reducing yields of key staple crops. This study examines the determinants of agroforestry adoption in all three regions of the topographically diverse nation of Nepal. A multistage sampling technique and structured and unstructured interviews were used to answer the survey, resulting in 400 questionnaires used for data collection. IBM SPSS Statistics version 28 software was used for data analysis. Binary Logit Model was used to examine the effects of household (socio-demographic and socio-economic), institutional, landscape, and information access characteristics on agroforestry adoption. The results exposed ten statistically significant variables that have an impact on agroforestry adoption: study region (p-value <0.001); household age (p-value 0.017); education (p-value 0.022); marital status (p-value 0.026); labor access (p-value 0.100); land owner (p-value 0.003); farm income (p-value <0.001); access to formal credit (p-value <0.001); irrigation as a sustainable farming practice (p-value <0.001); and information access to weather via the internet (p-value 0.004). Based on the results of the study, recommendations for the Nepalese government and stakeholders alike mentioned in this study include educational investments and training programs, income diversification to increase profitability, affordable credit provisions be put in place, and incentivized provisions for landowners to engage in agroforestry practices.

Key words: Nepal, climate change, farmers, agroforestry, landscape

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List of the abbreviations used in the thesis

ANOVA	Analysis of Variance
BCR	Benefit Cost Ratio
BLM	Binary Logit Model
CDKN	Climate & Development Knowledge Network
DOI	Diffusion of Innovation
FAO	Food and Agriculture Organization
GHG	Greenhouse gas
HH	Household
ICRAF	International Council for Research in Agroforestry
IRR	Internal Rate of Return
IPCC	Intergovernmental Panel on Climate Change
NDC	Nationally Determined Contributions
NGO	Non-Governmental Organization
NPV	Net Present Value
OR	Odds Ratio
SALT	Sloping Agricultural Land Technology
VIF	Variance Inflation Factor
YOY	Year-Over-Year

1. Introduction

The global scenario of climate change is a pressing issue that continues to worsen. Scientists have observed rising average temperatures and extreme weather events, largely attributed to human activities such as burning fossil fuels and deforestation. The Intergovernmental Panel on Climate Change (IPCC) released its Sixth Assessment Report (AR6) in 2021, which highlighted the increasing severity of climate change impacts on natural and human systems. The report emphasized that human-induced climate change is unequivocal and that immediate, rapid, and large-scale reductions in greenhouse gas emissions will be required to limit global warming (IPCC 2021).

Climate change has increased the frequency and intensity of extreme weather events such as heat waves, floods, droughts, and heavy precipitation events, as well as changes in temperature. These events can have impacts on infrastructure, human health, water resources, and most devastatingly agriculture; affecting plant growth and development (IPCC 2021; FAO 2016). The Paris climate agreement, a 2015 treaty signed by 196 countries and in force since 2016, aims to limit global warming to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C (UNFCCC 2015). However, current Nationally Determined Contributions (NDCs) are not sufficient to achieve these goals. More ambitious action is needed to avoid the worst impacts of climate change (UNEP 2020).

Climate change has had significant impacts on global agriculture, leading to a reduction in crop yields (which has shown a 1% decline YOY since the 1980s) and changes in farming practices (IPCC 2019).This has significantly affected food security and the livelihoods of farmers who depend on farming for their income (IPCC 2019).

In addition, climate change has also resulted in changes in farming practices, as farmers adapt to new weather patterns and seek to mitigate the effects of climate change (FAO 2016). For example, some farmers have switched to more drought-resistant crops or introduced new irrigation methods to cope with reduced rainfall. However, these changes can be costly and may require significant investment in new equipment and infrastructure (IPCC 2019).

Climate change is having a significant impact on agriculture in Asia. The sector is facing a number of challenges. These specific challenges also include the aforementioned severe weather events, changes in water availability, temperature, and precipitation patterns

(Hijioka et al. 2014; ADB 2009). These effects are particularly pronounced in Nepal due to its limited adaptive capacity, reliance on subsistence agriculture, and diverse topography (Paudyal & Regmi 2009). Temperature and precipitation changes have resulted in shifts in the growing season and altered crop productivity. Nepal has seen a drop in water temperatures which has led to a decrease in the yield of major staple crops like wheat, maize, and rice. Similarly, irregular precipitation patterns, including increased intensity of rainfall events, have led to landslides, soil erosion, and flooding, which negatively impact agricultural production (Shrestha et al. 2012). Further exacerbations include the spread of pests and diseases, degradation of soil fertility, and the loss of agrobiodiversity. Combined with the direct impacts of climate change, these challenges have heightened food insecurity and vulnerability for many rural communities in Nepal (FAO 2016). Addressing these challenges will require targeted adaptation and mitigation strategies, along with broader efforts to reduce global greenhouse gas emissions. A promising solution to many of these challenges would be to introduce farming systems such as agroforestry. Agroforestry contributes to the advancement of sustainable agriculture. Nair (1993) describes it as a land-use management system that integrates crops with trees and sometimes livestock on the same land in a way that provides economic, environmental and social benefits. Agroforestry has been used in many parts of the world for thousands of years and is a widely recognized and promoted approach to sustainable land use (Leakey 1998).

The world's population is expected to grow from 7.7 billion today to 9.7 billion in 2050 (United Nations 2022). Sixty-one percent of the world's population lives in Asia (4.7 billion). The next most populous continent is Africa with 17% (Worldometer 2022). Therefore, it is imperative that we continue to innovate in the way we feed ourselves, while maintaining a complete nutritional profile for every human being. The United Nations' thirty-year Sustainable Development Goals (SDGs) for 2015 aim to leave no one behind, including our planet, and promote peace and prosperity.

1.1. Research Problem

Nepal is on the Global Climate Risk Index list of countries most vulnerable to weather-related loss events due to climate change, which is frightening given Nepal's disproportionate contribution of 0.025% to the world's total greenhouse gas emissions. In

Nepal, approximately 75% of employment and 25% of gross domestic product is derived from agriculture (CDKN 2016).

The research problem of this study is that farmers are experiencing adverse effects on their farms due to climate change, resulting in a loss of productivity. This poses a risk to the quality of their land, abandonment of the land through mass rural-urban migration, and livelihoods, among many others. There is limited research specifically addressing the attitudes of Nepalese farmers towards agroforestry. For example, a study by Adhikari et al. (2007) found that Nepalese farmers perceived agroforestry as a way to increase agricultural productivity, enhance soil fertility, and provide additional sources of income through the sale of tree products. The study also found that farmers valued the environmental benefits of agroforestry, such as reduced soil erosion and improved water quality. However, it is uncertain whether Nepalese farmers understand how their perspective on the factors that influence their decisions to adopt agroforestry can improve their livelihoods, such as topography and socio-ethnic factors.

To fill this gap, we investigated the perspective of farmers on agroforestry adoption. In all three topographical regions, we examined variables that influence farmers' households, and of these, landscape characteristics and socio-ethnic factors were the most novel in relation to agroforestry.

Nepal is important to global agriculture for several reasons, including its diverse agro-ecological zones, genetic diversity, traditional agricultural practices, and potential for climate change adaptation. The country's genetic diversity can serve as a valuable source of knowledge for developing climate-resilient crops and farming systems (Gentle & Maraseni 2012).

2. Literature Review

Agroforestry is a concept growing in popularity given its many agroecological, environmental, economic, and societal benefits. In agroforestry there is a remarkable potential economic and ecological interaction between the trees and agricultural components. Agroforestry has alternatively been defined as an approach aimed to optimize the benefits of ecological interactions among different components, such as wildlife habitat, soil fertility improvement, and crop yield increases (Garrity 2004).

Nepal has experienced widespread land abandonment as a result of climate change hindering the ability to adopt agroforestry.

For sustainable agroforestry practices, intentionality is also a critical factor. Prior seeds being sown, sometimes trees or crops can be shared within a certain plot of land but it may not have been intentional of the land owner, thus not be utilized as such to foster sustainable and biodiverse agro-ecological growth of the land. In other words, not managing or maximizing the potential benefits of trees and crops/livestock on shared land. There are many benefits, complexities, and drivers of agroforestry, which we will explore in this literature review after understanding how agroforestry came into existence.

2.1 Inception of agroforestry

Agroforestry has a long and diverse history spanning cultures and millennia, through the integration of trees and shrubs into livestock and crop production systems. For centuries, many traditional societies have practiced some form of agroforestry, making it difficult to pinpoint the beginning of agroforestry (Nair 1993). However, it was not until the 1970s that the term "agroforestry" was coined. Thus, the formal recognition and research on agroforestry began in the 1970s. This marked the beginning of its modern recognition and study as a distinct field (Nair 2007).

The inception of agroforestry as a scientific discipline can be attributed to the establishment of the International Council for Research in Agroforestry (ICRAF) in 1978, which later became the World Agroforestry Centre. This organization has played a pivotal role in promoting agroforestry research, education, and policy advocacy around the globe. Throughout the world, ancient agroforestry systems have been documented. Ancient Roman writings such as those of Varro, Cato the Elder, and Columella, who described the use of trees in Mediterranean agriculture, provide the first recorded evidence of agroforestry practices (Garrity 2004). In Central America, the Mayans practiced a form of agroforestry as early as 1000 B.C., using tree crops such as avocado and cacao as part of their agricultural systems (McNeil 2012).

Similarly, indigenous communities in the Amazon have long used agroforestry practices, including multispecies home garden cultivation, to conserve biodiversity and improve soil fertility (Miller & Nair 2006).

In Africa, evidence of agroforestry systems dates back to at least the first millennium CE. In the Sahel region, farmers have traditionally integrated Faidherbia albida trees into their crop fields to provide nitrogen fixation, fodder, and soil improvement (Reij & Garrity 2016). Additionally, in West Africa, the parkland agroforestry system, characterized by scattered trees within cultivated fields, has been practiced for centuries (Mokgolodi et al. 2011).

2.2 Agroforestry benefits

Agroforestry is actively promoted as an important strategy for subsistence farmers (those who consume more than 50% of their productive output) in developing countries to manage environmental risks, increase income and food security, and provide environmental services (Franzel et al. 2001; Garrity 2004).

Agroforestry benefits include improved human nutritional intake, increased soil productivity and nutrient cycling, and alternative fuelwood sources, according to Bruck & Kuusela (2021). For subsistence farmers who rely on home gardens for the majority of their food intake and on open land for fuelwood, the direct and indirect benefits of agroforestry systems may become increasingly important.

Agroforestry practices are being promoted to help farmers adapt to the effects of climate change and reduce CO2 emissions into the atmosphere (Jahan et al. 2022). - It can improve soil fertility, protect crops and livestock from wind, restore degraded land, promote water conservation, limit pests, and minimize soil erosion, among other benefits such as carbon sequestration, water and air purification, and recreation. Agroforestry systems can contribute to biodiversity conservation and climate change adaptation and mitigation if properly designed and managed. Agroforestry also includes links to the following areas.

Biodiversity

Agroforestry provides several benefits linked to biodiversity. These benefits include increased habitat provision, species richness, enhanced genetic diversity, and improved ecosystem services (Jose 2009; Garrity 2004).

On the one hand, agroforestry systems promote biodiversity by providing a wide range of habitats for fauna and flora (Bhagwat et al. 2008). The presence of shrubs and trees in agricultural landscapes increases heterogeneity and supports different ecological niches (Jose 2009).

Agroforestry also helps provide habitat for various wildlife species, including those that are threatened or endangered (Schroth et al. 2004). Resource availability and structural complexity in agroforestry systems provide breeding, shelter, and foraging for many species (Garrity 2004).

Agroforestry also enhances ecosystem services directly linked to biodiversity, including pollination, pest control, and nutrient cycling (Nair 2012). For example, increased tree diversity supports crop production by attracting more pollinating insects and natural pest predators (Pimentel et al. 2001).

Environmental

Agroforestry as a sustainable land management practice provides a range of advantages that contribute to both the well-being of humans and ecological benefits. Namely, as mentioned above, biodiversity conservation, carbon sequestration, water management, soil conservation, and also, as mentioned above, pollution and pest control. Carbon sequestration agroforestry practices can contribute to climate change mitigation through carbon sequestration in biomass and soil (Montagnini & Nair 2004). Shrubs and trees in agroforestry systems absorb atmospheric carbon dioxide and store it as carbon, reducing overall GHGs (Nair et al. 2009). In terms of soil conservation, agroforestry can prevent soil erosion and degradation through the provision of vegetative cover and the improvement of soil structure (Young 1997). The roots of the trees stabilize the soil and help to maintain soil fertility by recycling nutrients, while the leaf litter contributes to the organic matter of the soil (Jose 2009). Regarding water management, trees in agroforestry systems have the potential to improve water infiltration, reduce runoff, and enhance the recharge of groundwater (Bargués Tobella et al. 2014). This can contribute to the maintenance of water quality and the reduction of the negative impacts of agricultural practices on water resources (Garrity 2004).

For pollination and pest control, agroforestry systems can support diverse pollinator communities and natural pest predators, reducing the need for agricultural chemicals (Bianchi et al. 2006). As a result, crop productivity increases and ecological balance is maintained (Ricketts et al. 2008).

Food security and nutrition

According to FAO (2013), agroforestry provides numerous benefits that contribute to food security. The main benefits include diversification of food production, improved soil fertility, erosion control and water conservation, resilience to climate change, and income diversification. Agroforestry systems encourage diverse crop production, thereby diversifying food production and increasing food security (Nair et al. 2010). Trees in an agroforestry system contribute to the improvement of soil fertility through the fixation of nitrogen, the recycling of nutrients, and the addition of organic matter (Nair 2012). The result is an increase in crop productivity and thus a contribution to food security. Tree cover in agroforestry systems also helps reduce soil erosion and runoff, resulting in better water conservation and improved water quality (Nair et al. 2010). This can have a positive impact on agricultural productivity and food security. Regarding climate resilience, agroforestry systems can support farmers to adapt to climate change by buffering extreme weather events like floods, droughts, and storms (Garrity 2004). In the face of changing environmental conditions, this resilience helps to ensure food security. Agroforestry provides farmers with multiple streams of income from a variety of crops, wood, and non-wood forest products, and makes them less vulnerable to market fluctuations and crop failure (Nair 2012). At the household level, this economic stability can contribute to food security.

Regarding improved dietary diversity, agroforestry systems provide a variety of nutritious foods such as nuts and leafy vegetables, fruits, contributing to balanced diets and improved health (Jamnadass et al. 2011). The integration of trees and shrubs into agricultural systems can also provide additional sources of income, which has had outcomes of enabling households to purchase other foods that are more rich in nutrients (Mbow et al. 2014). Agroforestry plays a vital role in ensuring food security and nutrition by enhancing agricultural productivity, promoting diversity and resilience, and providing economic benefits which contribute to healthier, more sustainable communities and ecosystems.

Climate change risk mitigation

Agroforestry practices can also increase the resilience of agricultural systems to the effects of climate change, in addition to the carbon sequestration mentioned above. Through the aforementioned factors, such as promoting soil health and biodiversity, agroforestry can improve the ability of crops to withstand extreme weather events, such as droughts and floods, which are expected to increase in severity and frequency as a result of change in our climate (Lin 2011). Furthermore, agroforestry systems can contribute to the conservation of water resources by increasing infiltration rates, reducing runoff and promoting soil water holding capacity (Jose 2009). In addition, by diversifying income sources and improving food security for smallholder farmers, agroforestry practices can support adaptation to climate change. Agroforestry systems can provide farmers with additional income and reduce their vulnerability to climate-induced crop failures through the inclusion of trees that produce fruits, timber, and nuts and other valuable products (Garrity 2004). Integrating trees with crops may also improve nutrient cycling and soil fertility, resulting in increased agricultural productivity and food security (Nair, 1993). Ultimately, agroforestry can play a critical role in addressing climate change challenges by providing multiple benefits for climate risk mitigation through carbon sequestration, increased agricultural resilience, and livelihood support (Mbow et al. 2014).

2.3 Agroforestry complexities

While agroforestry has been identified as an approach that aims to create a more productive, diverse, and sustainable ecosystem (Jose 2009), the integrated system involves multiple complexities, including ecological interactions, temporal and spatial arrangements, and socioeconomic factors. For the success of agroforestry systems, spatial and temporal arrangements play a critical role. Crop and tree arrangements must be carefully designed to maximize nutrient, light, and water availability (Jahan et al. 2022; Nair et al. 1993). Disease and pest and dynamics can also be influenced by the choice of density, species, and arrangement of trees and crops (Lin 2011). In addition, the temporal aspect of agroforestry takes into account the life cycles of the different components of the system, including the rotation of trees and crops, and different management intervention times (Torquebiau 2000). Another complexity in agroforestry is ecological interactions.

Depending on factors such as competition for allelopathy, resources, or facilitation, trees can have both negative and positive effects on crops (Jose 2009). For instance, trees can reduce soil erosion, shade, and improve nutrient cycling through leaf littering and nitrogen fixing (Schroth et al. 2004). However, (Schroth et al. 2004) also found trees also compete with crops for resources such as nutrients, water, and light. In order to design effective and sustainable agroforestry systems, understanding these ecological interactions is essential.

Agroforestry is further complicated by socio-economic factors. Cultural preferences, local knowledge, and market dynamics affect how farmers adopt and manage agroforestry systems (Ajayi et al. 2011). Furthermore, agroforestry requires more labor and expertise than conventional farming systems, limiting adoption (Mbow et al. 2014). Policy and institutional support to provide training, incentives, and market access are needed to promote the widespread adoption of agroforestry (Leakey 2012). It is a complex and diverse approach to land management that requires careful attention to spatial and temporal organization, ecological interactions, and socioeconomic factors. For successful implementation and sustainability of agroforestry systems, understanding and addressing these complexities is essential.

2.4 Factors influencing agroforestry adoption

Altitude

Due to differences in indigenous knowledge, soil type, climate, biodiversity, and accessibility, altitude has a significant impact on agroforestry adoption in Nepal. With increasing altitude, precipitation patterns change and Nepal's climate cools (Pandey et al. 2014). The type of agroforestry system adopted by farmers may be affected by these changes in moisture availability and temperature. The characteristics of the soil change with altitude, which affects the types of trees and plants that can be grown (Lin 2011). In order for agroforestry practices to be successful, they need to be adapted to these soil conditions. In terms of accessibility, it can be difficult for farmers to transport agricultural outputs and inputs in the high altitude regions of Nepal. This may have implications for agroforestry practice adoption in these areas (Pandey et al. 2015).

Nepal's heritage agroforestry systems evolve based on local knowledge and the specific needs of the community at different altitudes (Atreya et al. 2021). These traditional systems may have shaped the agroforestry practices adopted in different altitude zones.

Therefore, developing agroforestry systems that are well-suited to different altitude zones is essential for successful implementation and sustainable management.

Extension services

In influencing agroforestry adoption, the offering of extension services and training can play an important role. Participation in extension programs was found to have a significantly positive effect on the chances of adopting agroforestry practices in Malawi by Coulibaly et al. (2014). In a similar study in sub-Saharan Africa, exposure to training and extension services was a significant predictor of agroforestry adoption, according to Meijer et al. (2014). This suggests that education, combined with training and targeted extension services , may help to increase adoption (Franzel et al., 2001).

Economic benefit

In a comprehensive study done in Bangladesh, researchers Jahan et al. (2022) found that when farmers engaged in agroforestry, their main purpose was to sell the wood and fruit from the trees rather than to subsist (consume most of their own products) in order to generate more economic output for other activities. Future analysis found that agroforestry had a comparatively higher NPV (Net Present Value), BCR (Benefit Cost Ratio), and IRR (Internal Rate of Return) on all accounts compared to single tree plantation, providing significant economic benefits.

Demographic factor - Household size

Using a binary logistic test, it was found that household size made quite the difference; which showed a greater likelihood of adopting agroforestry the larger the family size was observed. The reason being that it is burdensome to combine farming practices; thus, the larger the labor force, the family members, the more encouraged and likely farms are to diversify (Jahan et al. 2022).

Demographic factor - Age

Younger farmers (between twenty-one and forty years of age) were more likely to adopt agroforestry practices than older farmers (which is consistent with several other findings). Risk taking appears to be higher among younger farmers as well when it comes to "risky investments" since agroforestry is a nuance of a production system for many farmers. Therefore, it is pivotal to properly educate, encourage, and provide resources to younger farmers to create a more promising, economical and food secure future for smallholder farmers (Jahan et al. 2022).

Demographic factor - Gender

A widely studied unfortunate factor, mostly found in developing countries and a common truth, is that female heads of households are usually not as likely to advance as their male counterparts on a global scale. It has been found that in this case female heads of households do not have adequate access to support such as financial assistance (access to credit), extension services and community support. The reason for this is that women are generally not as educated which causes them to be less attractive, especially to financial intuitions, to provide support. Another analysis that lends itself to why women farmers do not adopt agroforestry practices is that women receive lower extension visits and most importantly they are still very influenced by male heads. When the frequency of extension visits is higher, farmers have a higher adoption rate of agroforestry (Jahan et al. 2022).

Socio-economic factor - Education

Many studies have reported that the more education a household has, the likelihood of agroforestry adoption increases, unless government agencies or NGOs provide training, education, and capacity-building resources, e.g., extension programs, to emphasize how critical it is to implement new production systems like agroforestry (Jahan et al. 2022).

Socio-economic factor - Market access

Greater access to markets means a higher rate of adoption of agroforestry practices as found in both Tanzania and Bangladesh. As market access becomes less accessible, transaction costs rise to levels that are inefficient and unprofitable. Production and logistics costs rise due to higher cost for transportation, less labor market access, and lower access to inputs. As a result, output markets that could contribute to revenue generation are limited and opportunities to sell desired goods are eliminated (Jahan et al. 2022).

2.5 Farmers perspective on agroforestry

What's a farmer's job? To harness nature's resources (soil, rain, sun, and most importantly indigenous and local goods) and transform them into animal feed, crops, and an abundance of additional nutritional value for animal and human consumption. Most farmers have been acclimatized to understand and prefer intensive monocultures.

Typically, monocultures grow about 1 cm below and above the soil. Through agroforestry and better soil and water use, crops can grow as high as 10 m above the ground, improving nutrient and root distribution and decreasing leaching. According to Mbow et al. (2014), most farmers' biggest common concern was lack of knowledge that is sufficient enough to learn how to properly plant agroforestry systems perennial components. Another author identified that a lack of government support is one of the biggest barriers mentioned by farmers, which is followed by a lack of training, lack of technical ability and knowledge, and lack of information and motivation (Jahan et al. 2022). All of which play a role in developing the perception of farmers to adopt the system.

Depending on factors such as resources, local context, and individual experience, farmers' perspectives on agroforestry can be quite diverse. Here are some perspectives from real-life stakeholders. The income diversification and increased resilience offered by agroforestry is valued by some farmers. Through the integration of trees and crops, farmers can protect themselves from market fluctuations and diversify their sources of income (Jose 2009). The potential labor and resource requirements of agroforestry systems are of concern to other farmers. They may be concerned about the increased load of work associated with maintaining, planting, and managing trees on top of their existing activities within agriculture (Mbow et al. 2014). Due to lack of access to training or information, some farmers may be skeptical about the benefits of agroforestry. When this is the case, they may hesitate to adopt agroforestry practices because they do not have proper support or guidance (Bishaw et al. 2022). Many farmers have found agroforestry to be beneficial and want to share what they learn. Farmers frequently report improved water retention, soil health, and pest control, resulting in yields of crops being increased and overall sustainability (Garrity 2004).

These perspectives highlight the complexity involved in adopting agroforestry systems and the different ways in which they affect farmer livelihoods. When assessing the potential benefits and challenges of agroforestry systems, it is important to consider the local context, available resources and individual experiences.

2.6 Aspects of agroforestry in Nepal: types, benefits, challenges and future development potential

Several types of agroforestry systems have been identified in Nepal, according to Pandey et al. (2015), who found that Nepal has been practicing agroforestry as a traditional land management system for centuries. Some of the most common ones are home gardens, silvopastoral systems, alley cropping, and sloping agricultural land technology (SALT). Home gardens in Nepal are a combination of herbs, shrubs, trees and herbs, usually grown around the household, that provide fuel, fodder, food, and medicine (Gautam et al. 2003). Nepalese people are also known for using silvopastoral systems, which integrate fodder, tree, and livestock uses, often with shrubs on rangelands, fodder trees planted, and/or livestock grazed under forest canopy (Adhikari et al. 2007). Indigenous people use intercropping by planting annual crops between rows of trees. This provides nutrient cycling, shade, and soil stabilization (Roshetko et al. 2007). When utilized domestically, SALT is implemented by establishing contour hedgerows of nitrogen-fixing trees and shrubbery along the contour of sloped land, helping to improve soil fertility and control soil erosion (Partap & Watson 1994).

Agroforestry in Nepal provides multiple benefits to farmers and the environment, including: Soil conservation, which helps to increase soil organic matter, reduce soil erosion, and improve soil fertility (Gautam et al. 2003); Biodiversity conservation, which contributes to the conservation of agrobiodiversity and overall ecosystem health (Pandey et al 2014); mitigate climate change through carbon sequestration, reducing greenhouse gas emissions and mitigating climate change (Adhikari et al. 2007); and diversify livelihoods through multiple sources of income, including non-timber forest products, timber, and livestock, that can reduce poverty and improve rural livelihoods (Garrity 2004).

Despite its many benefits, agroforestry in Nepal faces several challenges. These include land tenure insecurity, lack of access to markets and extension services, and limited knowledge of agroforestry practices (Pandey et al. 2014). Several actions are needed to address these challenges and promote agroforestry, such as Policy support, to strengthen institutional frameworks and policies that support agroforestry and its integration into national agricultural and environmental strategies; Research and extension, to increase research on agroforestry systems and improve farmers' access to extension services to facilitate adoption of appropriate practices; Market development, to develop market linkages and value chains for agroforestry products to incentivize farmers to adopt agroforestry practices; Capacity building, to strengthen the capacity of extension workers, farmers, and researchers in agroforestry practices and techniques through education and training.

2.6.1 Information access, landscape characteristics, and socio-demographics of farmers in Nepal

The livelihoods and agricultural practices of the country's farmers are influenced by Nepal's unique landscape. Nepal's diverse geography and rich cultural heritage shape the landscape and socio-demographic characteristics of its farmers. Located between India and China, Nepal is a landlocked country in South Asia. It ranges in altitude from 60 meters lowland Terai region to the Hilly region, to 8,848 meters in the high mountainous Himalayas above sea level, (Babel et al. 2013) and is known for its diverse topography, which is optimal for farming systems such as agroforestry. This presents unique opportunities and challenges for agroforestry implementation. Agroforestry adoption in Nepal is influenced by altitude in several ways. Factors such as stunted growing seasons, less fertile and thinner soils, and cooler temperatures, which usually result from being located at higher altitudes (Atreya et al. 2021), limit the amount of crops being grown. The reason for this is that higher altitudes are characterized by harsher environmental conditions and an increased reliance on subsistence farming. This can reduce the potential success of implementing agroforestry practices (Adhikari et al. 2007). However, there are several successful cases of agroforestry adoption despite higher altitude challenges. For example, in Nepal mid-hills region there is a tradition of growing fodder trees which provide benefits like carbon sequestration and soil conservation (Atreya et al. 2021). Lower-altitude regions tend to have a wider range of climatic conditions. Increased soil fertility, extended growing seasons, improved accessibility, market and transportation access are many of the ways that can serve to promote agroforestry adoption and enable farmers to have diversified incomes (Adhikari et al. 2007). Ultimately, with the appropriate agroforestry adoption practices, resources, tools, and techniques, the practice can result in success in both low and high altitude regions. Ultimately, agroforestry can be successful in both low- and high-altitude regions with the right practices, resources, tools, and techniques.

Information access has been known to play a significant role in agroforestry adoption in Nepal. Several ways include social network influence, knowledge dissemination, and extension services. In the diffusion of agroforestry practices, social networks play a crucial role as farmers usually rely on neighbors and other peers to advise on farming practices (Gautam & Andersen 2016). When farmers see their neighbors succeeding with agroforestry practices, they are more likely to begin adopting what has worked. Ultimately contributing to agroforestry adoption.

Dissemination of knowledge is another important aspect of promoting agroforestry adoption. This is because farmers have the opportunity to become better informed about how to use and benefit from the techniques (Mbow et al. 2014). In addition, access to information through a variety of channels such as educational materials, mass media, and training programs helps farmers bridge knowledge gaps to encourage agroforestry adoption (Garrity 2004).

Sociodemographic characteristics of Nepalese farmers reveal an overwhelmingly male workforce, with women making up 43 percent of agricultural workers (FAO 2021). Nevertheless, women are crucial in livestock management and farming, especially when men are absent due to migration for employment opportunities (Gartaula et al. 2012). The age distribution of farm workers is ageing, with younger workers increasingly choosing to work outside of agriculture or to migrate (Sugden 2013). Nepal is a diverse country in terms of caste and ethnicity. There are more than 100 ethnic castes and groups. Farmers' socioeconomic status and agricultural practices vary by caste/ethnicity (Gurung et al. 2005). Generally, high-caste groups have larger holdings of land, while indigenous and marginalized communities often have smaller landholdings and limited services and resource access (Gurung et al. 2005).

2.7 Agroforestry on a global scale

Here, we will examine some key examples of agroforestry practices worldwide.

Latin America

In countries such as Mexico, Colombia, and Nicaragua, silvopastoral systems-the combination of forage, trees, and livestock-described earlier in this review appear to be the most widely implemented practice (Murgueitio et al. 2011). The system has had a positive impact on biodiversity, livestock productivity, and carbon sequestration in the region (Murgueitio et al. 2011).

Sub-Saharan Africa

Alley cropping is a common agroforestry practice in sub-Saharan Africa. Alley cropping is defined above as the practice of growing crops between rows of trees. By intercropping nitrogen-fixing trees like Faidherbia albida with cereals, farmers can increase yields and improve soil fertility (Garrity et al. 2010).

Southeast Asia

In addition to Nepal, countries such as Thailand, Indonesia, and the Philippines (Kumar & Nair 2004) are home gardens, which integrate a variety of trees, crops, and at times livestock in a small-scale, household-managed system. Among other benefits to the region as also noted by Kumar & Nair (2004), these systems contribute to income generation and household food security.

Europe

In Europe, agroforestry for biomass production, silvopasture, and the integration of nut and fruit trees into agricultural landscapes are common practices (Eichhorn et al. 2006). Such methods can support wildlife, enhance biodiversity landscapes and offer opportunities for farmers to diversify their income (Eichhorn et al. 2006).

2.7.1 Climate change and agroforestry

Agroforestry and climate change are inextricably linked, as agroforestry systems can help mitigate the effects of climate change, while climate change can also affect how agroforestry succeeds and works. There are several ways in which climate change affects agroforestry. Erratic rainfall patterns, rising temperatures, and increasingly frequent extreme weather events can have negative impacts on agroforestry systems and reduce tree and crop productivity (Lin 2011). For example, an increase in evapotranspiration due to higher temperatures can lead to a decrease in soil moisture and affect the growth of trees and crops (Luedeling et al. 2014). While on the other hand, agroforestry can help mitigate climate change. It can reduce greenhouse gas emissions and sequester carbon. Agroforestry systems store carbon in soil and tree biomass, which helps to offset land transformation, deforestation emissions, and the burning of fossil fuels (Nair et al. 2009). In addition, trees in agroforestry systems reduce irrigation requirements and conserve water resources by shading crop plants (Kumar and Nair 2004). Furthermore, agroforestry has the potential to improve the resilience of agricultural systems to the impacts of climate change. Through the enhancement of biodiversity and the creation of micro-climates, agroforestry systems can help maintain the stability and productivity of agricultural ecosystems under challenging and changing climate conditions (Mbow et al. 2014). For example, integrating trees and crops can enhance nutrient cycling, and reduce soil erosion, resulting in more sustainable agriculture (Jose 2009).

2.7.2 Importance of agroforestry to researchers

Agroforestry is a topic of great importance to researchers for a number of reasons, including all the aforementioned potentials for the enhancement of ecosystem services and the improvement of farmers' livelihoods (Nair 1993; Jose 2009). Most important, however, in the present social climate of climate change, the long-term resilience and sustainability of agriculture is paramount. From climate change mitigation to improved water and air quality, the ecosystem services provided by agroforestry systems can be both intangible and tangible (Jose 2009). Agroforestry is also important to researchers due to its potential to bring social and economic benefits to local communities and farmers. Agroforestry not only diversifies agricultural production, but also helps to increase income opportunities for farmers and reduce the risks associated with monoculture systems (Nair 1993). Ultimately, in the current social climate surrounding the issue of climate change, the importance of agroforestry for researchers stems from its potential to provide a resilient and sustainable agricultural system that addresses economic, environmental, and social challenges at the same time.

2.8 Agroforestry in theory vs. practice

Several theoretical frameworks for optimizing resource use efficiency and productivity (Mead & Willey 2008), such as the Land Equivalent Ratio (LER), exist for agroforestry. However, due to various factors such as social, economic, and environmental constraints, theoretical expectations may not always match actual implementation.

Alley cropping

In theory, alley cropping is supposed to improve soil fertility, nutrient cycling, and crop productivity while reducing erosion (Jose 2009). In practice, a study conducted in Kenya on alley cropping with maize and Leucaena leucocephala showed a significant increase in maize yield (Mugendi et al. 1999); however, farmers faced challenges such as limited knowledge on tree management, lack of access to inputs such as tree seedlings, and not enough demand from the market for tree products (Franzel et al. 2001).

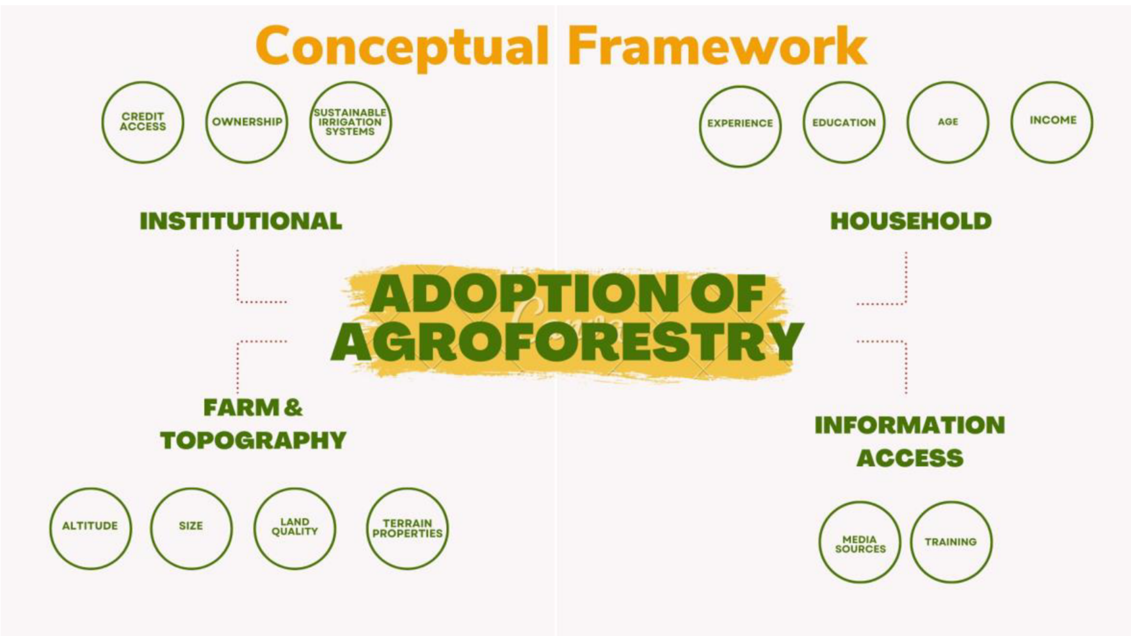
Silvopasture

Theoretically, silvopastoralism should increase biodiversity, improve animal welfare and enhance nutrient cycling (Nair 2012). A study in Colombia showed that in practice, livestock productivity increased in silvopastoral systems compared to traditional grazing systems (Murgueitio et al. 2011), but it has been strongly influenced and constrained by factors such as lack of technical support, high initial investment, and cultural barriers (Calle et al. 2009).

2.9 Conceptual framework

The conceptual framework for agroforestry adoption and how the four key factors are interrelated is shown in Figure 1. Climate change indicators (atmospheric changes such as changes in greenhouse gas levels and erratic weather), household (education, age, income), institution (access to credit, tenure, information access, and sustainable irrigation systems), and farm and topography (altitude, size, soil quality, and terrain) all influence how and whether farmers adopt agroforestry.

Figure 1 Conceptual Framework



2.10 Theoretical framework

2.10.1 Diffusion of Innovation

Diffusion of Innovation (DOI) is a theory that explains how, why, and how quickly new technologies, ideas, and products spread through social systems or a population. This theory was first developed in 1962 by sociologist Everett M. Rogers. The central tenet of the theory is that diffusion occurs with innovation over time through communication channels in a social system, with different groups of adopters adopting at different speeds. According to Rogers (1962), five key factors influence innovation adoption: relative advantage, compatibility, complexity, trialability, and observability (as shown in Figure 3). Adoption becomes more likely if they have limited experimentation, are relatively easy to understand and apply, and have tangible outcomes which are easy for others to observe. Diffusion is influenced by adopter characteristics, which can be divided into five categories depending on their willingness to adopt: innovators, early adopters, early majority, late majority, and laggards (Rogers, 1962) - as shown in Figure 2.

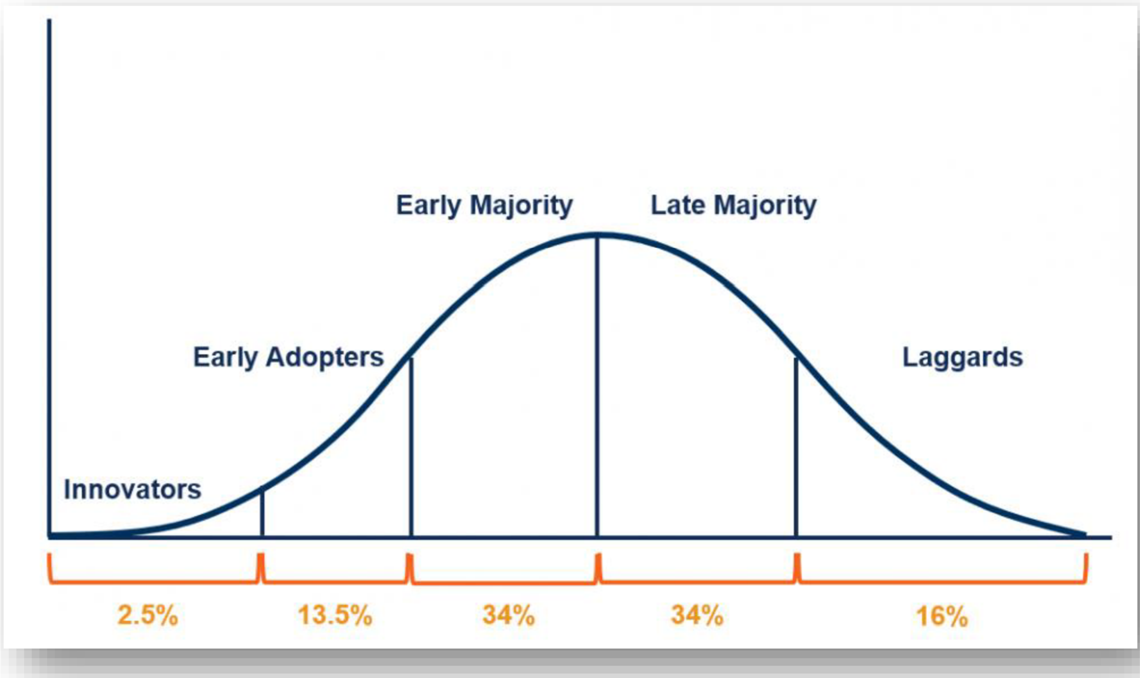


Figure 2 Diffusion of Innovation by Everett Rogers
Source: Rogers 1962

Innovators, often seen as opinion leaders, are the first to adopt new ideas, who are then followed by early adopters. Then there is a chasm that develops between early adopters and early majority. This is because after some point of selling to the early adopters, the sales plateau is reached and the product has to be taken to the mass market. Laggards are the last to adopt innovations, while early majority and late majority comprise the majority of the population and are typically more cautious. In addition to innovation and adopter characteristics, diffusion rates are influenced by the communication channels used to circulate information about the nature of the social system, the innovation, and the efforts of change actors (Rogers 1962). DOI theory has been widely used to predict and understand the spread of practices and new ideas in fields as diverse as public health, marketing, and technology adoption.

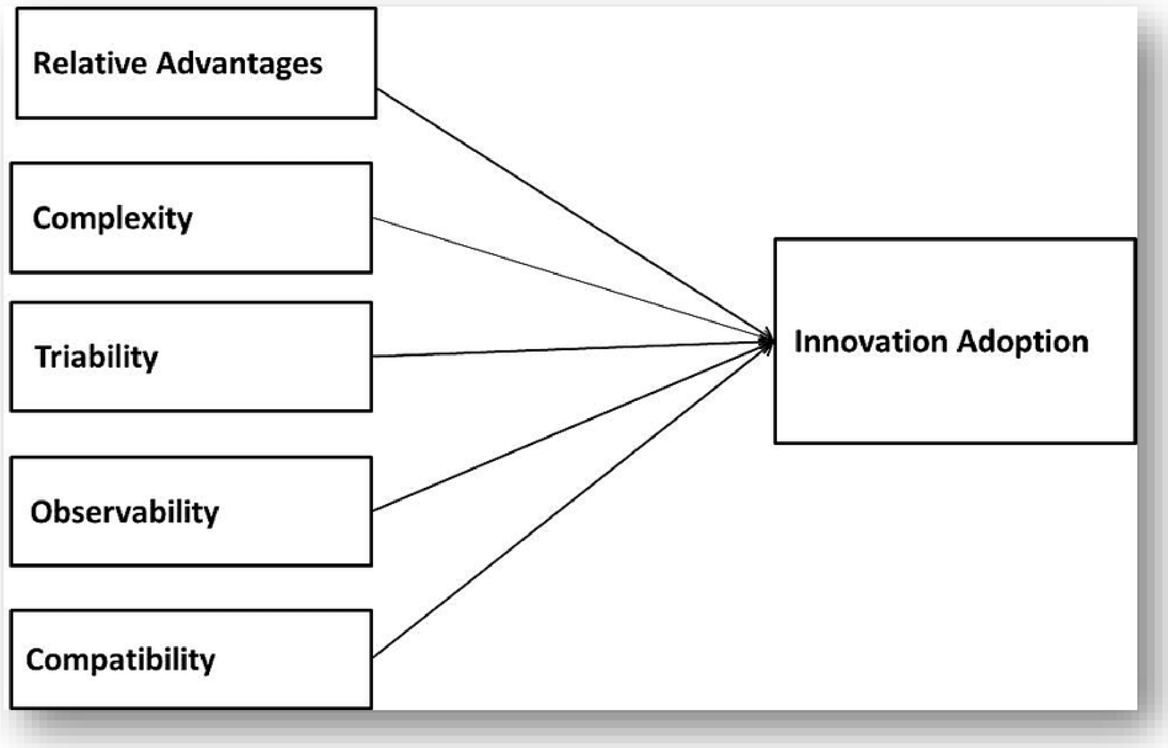


Figure 3 Attributes of innovation: Variables determining the Rate of Innovation Adoption
Source: Rogers 1962

As far as Nepal is concerned, this theory is of utmost relevance to the agricultural sector in Nepal, as new technologies and agricultural practices can have a significant impact on the livelihoods of rural communities.

The agricultural sector in Nepal is largely made up of small-scale subsistence farmers who face a number of challenges, including limited access to resources, climate change, and socio-economic constraints (Shrestha et al. 2012). The diffusion of innovation theory can help to understand how these farmers adopt new agricultural innovations that can improve their incomes, their productivity, and their resilience to climate change.

The DOI process consists of five main stages: knowledge, persuasion, decision, implementation and confirmation, according to Rogers (1962). Factors such as the characteristics of the innovation, the communication channels, the social system, and the efforts made by the change agent to promote the innovation influence these stages.

In the Nepalese context, several studies have applied DOI theory to understand the adoption of a range of agricultural practices. For instance, factors like compatibility with existing practices, perceived relative advantage, and observable nature of the innovation positively influenced the adoption of integrated pest management (IPM) by farmers in Nepal, as found by Khanal et al. (2020). Similarly, extension services, social networks, and training programs played an important role in the adoption of climate-smart agricultural practices in Nepal, as demonstrated by Shrestha et al. (2012).

However, there are also challenges to the diffusion of agricultural innovations in Nepal. Inappropriate infrastructure, lack of awareness, limited access to resources, and cultural attitudes may impede adoption (Devkota et al. 2014). Therefore, it is crucial that these barriers are taken into account in the design and implementation of agricultural interventions in the country.

Diffusion of Innovation theory provides a valuable framework for understanding agricultural innovation adoption in Nepal. Practitioners and policymakers can design targeted interventions to promote the dissemination of new practices and technologies, and ultimately improve the livelihoods and resilience of the farmers in Nepal, by addressing the factors that influence the adoption process.

3. Aims of the Thesis

The primary objectives of this study are to investigate and understand which of the many landscape characteristics and socio-ethnic factors in Nepal influence farmers to adopt agroforestry as a mixed farming practice. The three objectives outlined are as follows:

1. To explain farmers' perspectives on the factors that influence their decisions about agroforestry;

2. To determine the effect of landscape characteristics on agroforestry;

3. To determine the effect of socio-ethnic factors on agroforestry.

3.1 **Research questions**

Similar to the outlined objectives, the questions that this research focuses on also stem from the review of previous researchers and the identification of discrepancies within the topic in order to capitalize on the novel aspects of this topic.

1. What are the farmers' perspectives on the factors that influence their decisions about agroforestry?

2. What are the effects of landscape characteristics on agroforestry?

3. What are the effects of socio-ethnic factors on agroforestry?

3.2 Research hypothesis

Based on the literature review, the hypothesis is derived from the research questions as follows:

1. H_1: Human and social capital affect the adoption of agroforestry;

2. H_2: Access to financial capital affects agroforestry adoption;

3. H_3: Access to land affects the adoption of agroforestry.

4 Methodology

4.1 Study Area

Most Nepalese (approximately 81% in 2021) depend on agriculture to make ends meet, and most live in rural regions (World Bank 2021). Agricultural systems in Nepal are classified into three major agro-ecological zones based on the country's topography: Terai, Hilly, and Mountain (Paudel et al. 2018). The Terai, the most southerly part of the country, has fertile soils and flat terrain, and is a major agricultural area, where wheat, rice, and corn are the main crops (Gautam & Andersen 2016). The Hill zone, located in the center, is characterized by mixed farming systems including vegetables, staple crops from terrace farming, and fruit trees (Paudel et al. 2018). The Mountain area, at the highest elevation, is characterized by animal husbandry and subsistence farming, with limited cropland and severe climatic conditions (Gentle & Maraseni 2012).

Nepalese agriculture is overwhelmingly small-scale, with 71% of agricultural households farming less than one hectare (CBS 2011). This has been driven by various factors, including land subdivision, population growth, and hereditary practices (Paudel et al. 2018).

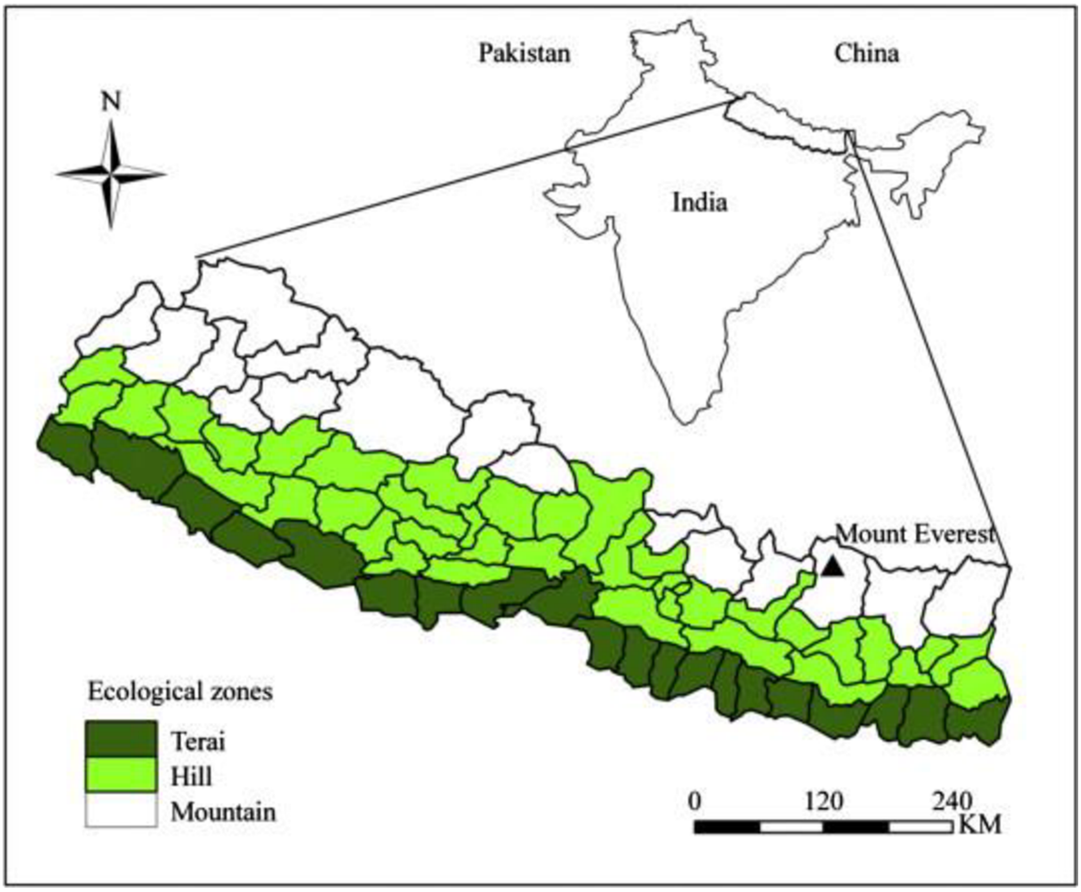


Figure 4 Study area Source: Applied Geography 2012

4.2 Data Collection

The data collection was carried out from March to July 2021 in all the three different agro-ecological regions of Nepal. The sample size of the survey was quite large, with a total of four hundred surveys being completed. In the Terai region, Chiwan district, Ratna-Nagar and Bharatpur municipalities, 70 surveys were collected. In the Hilly Region, Baglung District, Tarakhola municipality, 150 surveys were collected. In the

Himalayan region, Mustang district, Gharapojung, Baragung Muktichhetra and Thasang municipalities, 180 surveys were collected. The method used to collect data derived from primary sources (interviews, focus groups, questionnaires, and observation). The interviews were structured as well as non-structured. The interviews were conducted face to face and the interviewees (the head of the household or whomever was next in line as an informed proxy) were informed about the objective of the study and that the data collected would be used for academic purposes only. Observations were carried out on voluntary farmer participants.

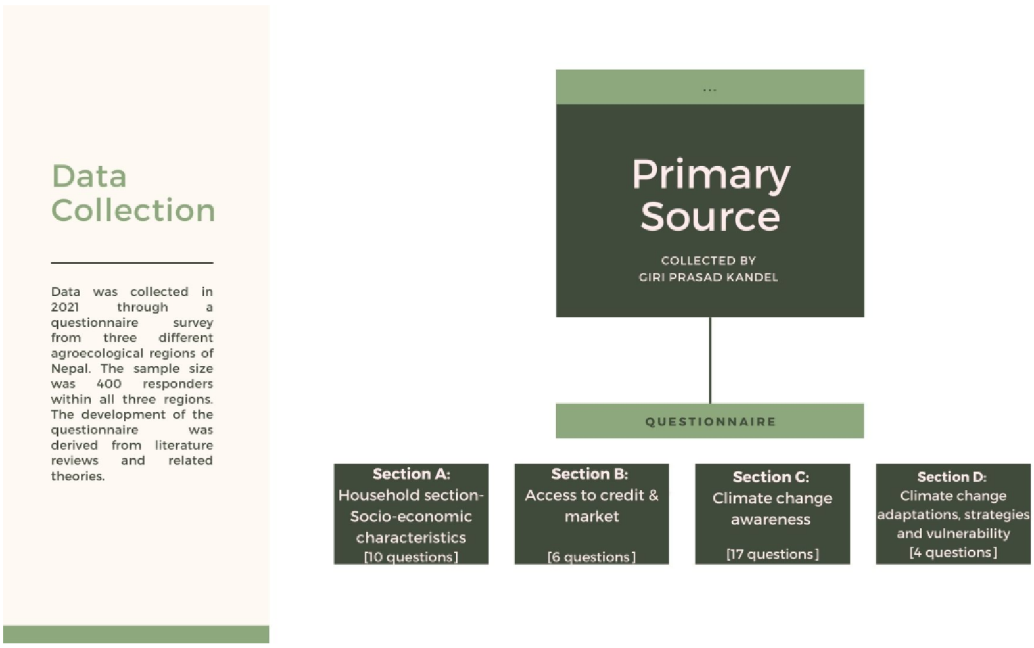


Figure 5 Data Collection

4.3 Questionnaire design

The seven-section questionnaire consisted of both open ended and closed ended questions. The development of the questionnaire derived from literature reviews and related theories. Likert scale, continuous, and categorical questions were asked. For this study only the first four sections were utilized:

A. Household section - socio-economic characteristics (10 questions including ethnicity, education, marital status, land ownership to name a few)

B. Access to credit and markets (6 questions including off-farm income, investment financing, household income shares, buy from/sell farm products to markets, market distance)
C. Climate change awareness (17 questions including heat intensity, seasonal duration changes, rainfall amount, avalanches, harvesting and plantation changes etc.)
D. Climate change adaptation, strategies, and vulnerability (4 questions including adoption strategies, information access etc.)

4.4 Sampling technique

A multistage sampling technique was used for data collection. The three agro-ecological regions were purposively selected. The reason for this is because there was in-depth knowledge of the study area and topic as the lead researcher is a Nepalese native, and through literature review. Since the aim of the study was to gain knowledge from farmers who could potentially benefit from agroforestry practices, purposive sampling was used. Thus, the sample was the most appropriate for the answering of our research questions and the determination of the significance of the hypothesis. For the primary data collection - collected by Nepalese native, Giri Prasad Kandel - purposive sampling was used for regional sample selection in the first stage. At the district level, convenience sampling was used for the second stage, and for the final stage of sampling, random sampling was used to select the farmers to be interviewed within the distinct municipalities.

4.5 Data Analysis

IBM SPSS Statistics version 28 software was used for data analysis, as well as Microsoft Excel. Microsoft Excel was used for data entry and cleaning of the survey data. Charts, descriptive statistics, and graphs were used for data analysis. Binary logistic regression (otherwise known as Binary Logit Model) was performed in SPSS to determine significance levels of 0.1, 0.05 and 0.01 between our dependent variable of agroforestry adoption and socio-demographic and landscape factors. The Binary Logit Model (BLM) was crucial because we needed to identify how strong the impact of the independent variables were on the dependent variable, and at which significance level.

In a similar manner, this type of test and analysis has also been used in the research work of Jahan et al. (2022).

4.5.1 Definition of model variables

The variables used in this study were obtained by means of cross-sectional data obtained from the questionnaire.

The dependent variable used is the adoption of agroforestry.

The independent variables included farm and topographic, institutional, household and climate change indicators based on previous literature. High altitude and low temperature areas are limiting factors for the adoption of agroforestry practices, according to Jara-Rojas et al. (2020). In their study, characteristics of the farmer (age, education, etc.), biophysical and financial characteristics of the farm (income, use of credit, etc.), and environmental factors (altitude, etc.) influence the adoption factors of agroforestry.

4.5.2 Binary Logit Model specification

In this study, we propose a binary logit model for the prediction of factors influencing agroforestry adoption in three different regions of Nepal. The set of predictor variables shown in Table 1, is used to predict the dependent variable, agroforestry adoption. The explanatory variable is dichotomous, 1=yes, the farmer adopted agroforestry practices. The logit model, which is designed to model the probability of an event occurring given a set of explanatory variables, is well suited for this task.

$$\text{Logit}(Y) = \log(\frac{pi}{1 - pi}) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon$$

Where:

- Y is the dependent variable, agroforestry adoption (1 = yes, 0 = no)
- pi represents the likelihood of the dependent variable, agroforestry adoption (1 = success, 0 = failure)
- $log(\frac{pi}{1 - pi})$ is the logit function, which is the natural logarithm of the odds ratio
- β_0 is the intercept term
- $\beta_1, \beta_2, \ldots, \beta_k$ are the coefficients, estimated parameters, for each predictor variable ($x_1, x_2, \ldots, x_k$)
- ε is the error term

Also note, the predictor variables ($x_1, x_2, \ldots, x_k$) can be continuous, categorical, or a combination of both. All variables, their specific descriptions, and their measurement type are listed in Table 1 below. From this insightful interpretation and estimation of the model we gain insight into the factors that contribute to success of agroforestry adoption and can potentially use this information to suggest effective interventions and policies.

Table 1 Variable selection and description

Variables	Description	Type	Measurement
Dependent variable			
Agroforestry Adoption	Whether farmer adopts agroforestry practices	Dichotomous	0=no, 1=yes
Independent variable			
Study Region	Three topographical study area regions	Categorical	1=Chitwan, 2=Baglung, 3=Mustang
Climate change awareness	Farmer aware of environmental climate change	Dichotomous	0=no, 1=yes
Gender	Gender of respondents	Dichotomous	0=Female, 1=Male
HH age	Average household age	Ordinal	1=less than 20, 2=21-30, 3=31-40, 4=41-50, 5=51-60, 6=61 and more
Education	Level of schooling reached	Ordinal	1=nonformal, 2=primary, 3=secondary, 4 Higher Secondary, 5=Undergraduate, 6=Postgraduate
Marital status	Marriage status	Nominal	1=single, 2=married, 3=divorced, 4=widow, 5=other
Household size	average persons in household	Continuous	
Working on farm	Number of years working on a farm	Continuous	
Labor access	Access to labor the past 5 years	Ordinal	1=never, 2=rarely, 3=sometimes, 4=often, 5=always
Landowner	Does the farmer own the land	Dichotomous	1=yes, 2=no
Irrigation	Whether irrigation was used as a farming practice	Dichotomous	0=no, 1=yes
Access to formal credit	Did the income come from a bank	Dichotomous	0=no, 1=yes
Farm income	How much income from on-farm activities	Ordinal	1=0-25%, 2=26-50%, 3= 51-75%, 4=76-100%
Info access (internet)	Monthly access to weather info from internet	Ordinal	1=Never, 2=Once a year, 3=Once a month, 4=Once a week, 5=Everyday

Info access (radio)	Monthly access to weather info from radio	Ordinal	1=Never, 2=Once a year, 3=Once a month, 4=Once a week, 5=Everyday
Info access (TV)	Monthly access to weather info from TV	Ordinal	1=Never, 2=Once a year, 3=Once a month, 4=Once a week, 5=Everyday
Info access (farmers group)	Monthly access to weather info a farmers group	Ordinal	1=Never, 2=Once a year, 3=Once a month, 4=Once a week, 5=Everyday
Info access (research institution/university)	Monthly access to weather info a research institution/university	Ordinal	1=Never, 2=Once a year, 3=Once a month, 4=Once a week, 5=Everyday
Info access (print media)	Monthly access to weather info from mobile	Ordinal	1=Never, 2=Once a year, 3=Once a month, 4=Once a week, 5=Everyday
Info access (mobile)	Monthly access to weather info from print media	Ordinal	1=Never, 2=Once a year, 3=Once a month, 4=Once a week, 5=Everyday

5 Results

5.1 Descriptive analysis

Agroforestry adoption - As illustrated in Figure 8 Agroforestry adopters vs non-adopters 39% of respondents have indicated that yes, they have adopted some form of agroforestry, and the remaining 61% indicating they have not adopted any agroforestry practices. Meaning that a majority of farmers are not practicing this form of sustainable farming. Table 2 Descriptive statistics - agroforestry adoption drivers, exhibits the descriptive statistics of all the drivers.

Study Region - A majority of the respondents (45.5%) came from the Mustang-highland region, then Baglung-midland (37.5%), and Chiwan-lowland region (17%). As seen in Table 3 Adopter vs non-adopter characteristics, the Baglung-midland region holds the highest number of non-agroforestry adopters; and the Mustang-mountainous region holds the highest amount (37.3%) of agroforestry adopters.

Gender - For gender, most of the respondents identified as male, which were usually the head of the households.

Household age - The average person in the household of surveyed respondents was 50.3 years of age. This is a growing concern in Nepal, as several factors are contributing to an ageing agricultural population, including younger generations migrating to urban areas or abroad and declining interest in farming among youth (Acharya 2016). It is also common for households with older members to be less likely to adopt new technologies.

Education - The sample population had an average level of education of primary school, which shows that most farmers stop attending school before they reach adolescence. Farmers only attend school until they are less than ten years old. According to Table 3 Adopter vs non-adopter characteristics, the majority of non-adopters have no formal education or only primary education (77% combined). We can then see that the higher a respondent's level of education, the smaller the gap between adopters and non-adopters.

Marital status - Most respondents reported their marital status as married (85%). The next most common statuses were single (6.8%) and widowed (7.2%).

Household size - In this study, the average farm household size is 5.8 people.

Experience as a farmer - Respondents indicated that on average they had been working as farmers for 23.8 years. Rahman (2009) cited that in Bangladesh, farming is often a lifelong occupation, usually starting at a young age, as seen now in this study in Nepal. Adger et al. (2003) further confirmed this by noting how climate change is creating additional challenges for these lifelong farmers and how long they will actually be able to work due to the increasingly inadequate farms.

Land ownership - 92.3% of the farmers indicated that they were the owners of their land, while the remaining 7.7% of the farmers indicated that they were not the owners of their land. Land ownership is important when considering the adoption of agroforestry because not owning one's own land would not give a farmer the freedom to implement new technological practices on the farm. Therefore, in Nepal, farmers have a much greater degree of free will to do as they please when it comes to adopting sustainable practices on their farm.

Irrigation - Irrigation as a sustainable farming practice is used by 50% of the farmers. This is crucial because, as we learned from this study, the average farm site is considered to be at high altitude, which makes access to water for agriculture difficult and the use of irrigation systems necessary.

Income source (bank) - According to our respondents, loans from government institutions or a bank are the second lowest source of income for a Nepalese farmer (3.2%), after non-profit organizations (0.4%). The leading source of financing for farmers in this study was family savings (74.9%) and borrowing from a friend or relative (9.9%). This factor is important as global inflation continues to rise and climate change affects farmers' livelihoods, potentially reducing their ability to rely on family savings and/or relatives.

Farm income - Twenty-six to fifty percent of the income of 42.8% of the farmers comes from their farms. So, once again, a reduction in productivity due to loss of labor (rural-urban migration, climate change) could be detrimental not only to farmers, but to a significant portion of the Nepalese population.

Labor access - Respondents were asked how often their household had to deal with a lack of available labor for working in agriculture in the past five years. The response options were never (22%), rarely (14%), sometimes (30%), often (22%), to always (14%). Most respondents can only get access to agriculture sometimes, then never or always quite equally.

Information access - Respondents were asked to choose from never receiving weather information, receiving weather information once a year/month/week, to receiving weather information daily, using an ordinal Likert scale. As seen in Figure 7 Overall weather information access most (49%) of respondents never receive any weather information at all. The frequency breakdown of where respondents get their weather information is shown in Figure 6 Weather information source. The leading source of information daily is via mobile (238 respondents), then internet (176 respondents), and television (135 respondents). The second most frequent source (with a drastic decrease in respondents) of information weekly is via radio (52 respondents), then television (45 respondents), and mobile (38 respondents).

Figure 6 Weather information source

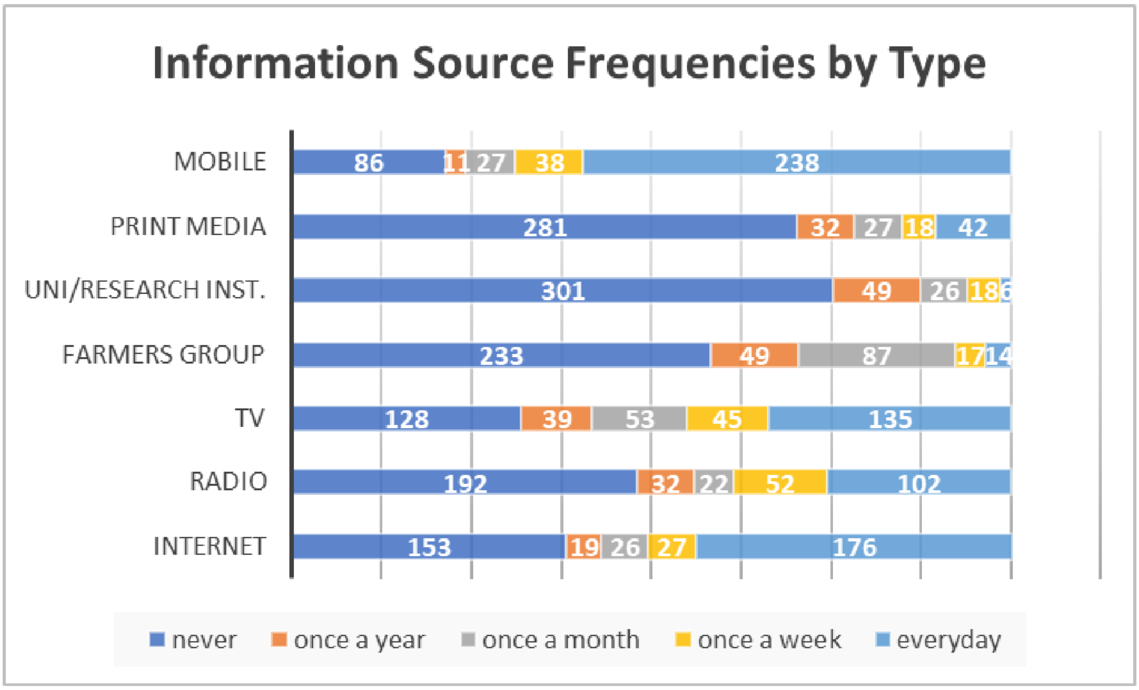


Figure 7 Overall weather information access

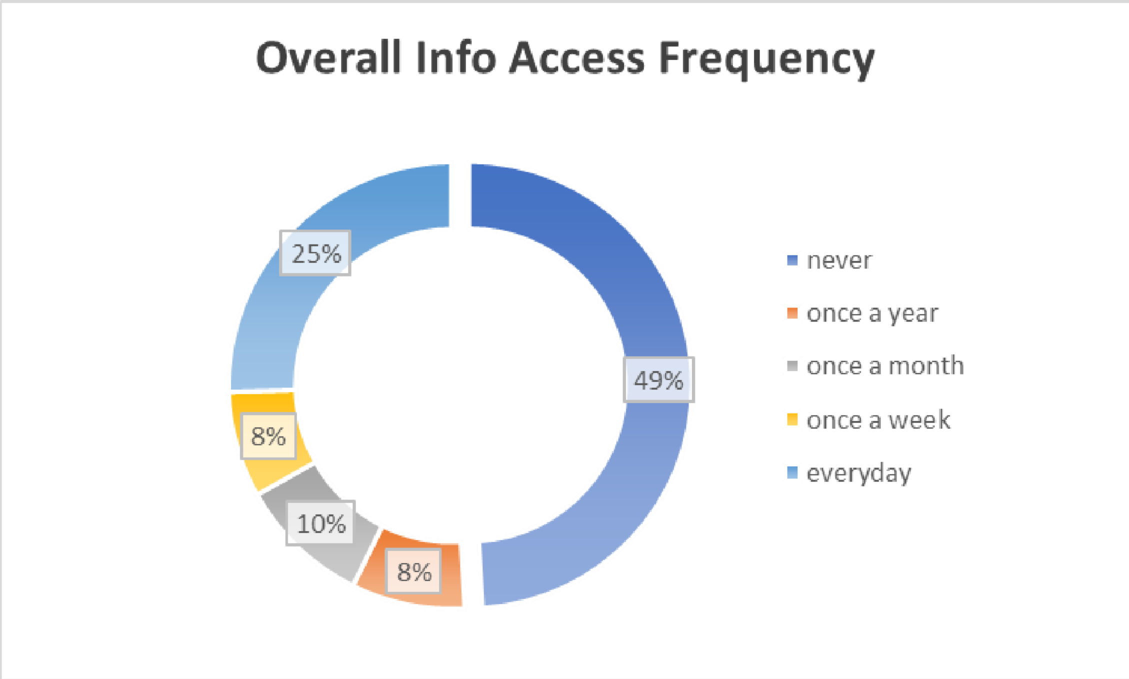


Table 2 Descriptive statistics - agroforestry adoption drivers

Variables	Minimum	Maximum	Mean	Std. Deviation
Dependent variable				
Agroforestry Adoption	0	1	0.39	0.49
Independent variable				
Study Region	1	3	2.29	0.74
Climate change awareness	0	1	0.92	0.27
Gender	0	1	0.72	0.45
Household Age (in years)	20	88	50.32	13.99
Education	1	6	2.06	1.03
Marital status	1	4	2.09	0.60

Household size	1	20	5.80	2.88
Working on farm (years)	1	70	23.78	14.29
Labor access (past 5yrs)	1	5	2.93	1.31
Landowner	1	2	1.08	0.27
Irrigation as a sustainable farming practice	0	1	0.50	0.50
Access to formal credit (bank)	0	1	0.04	0.19
Farm income	1	5	1.76	0.99
Info access to the weather (internet)	1	5	3.14	1.84
Info access to the weather (radio)	1	5	2.60	1.73
Info access to the weather (TV)	1	5	3.05	1.69
Info access to the weather (farmers group)	1	5	1.83	1.12
Info access to the weather (research institution/university)	1	5	1.45	0.91
Info access to the weather (print media)	1	5	1.77	1.36
Info access to the weather (mobile)	1	5	3.83	1.64

N=400

Figure 8 Agroforestry adopters vs non-adopters

N=400

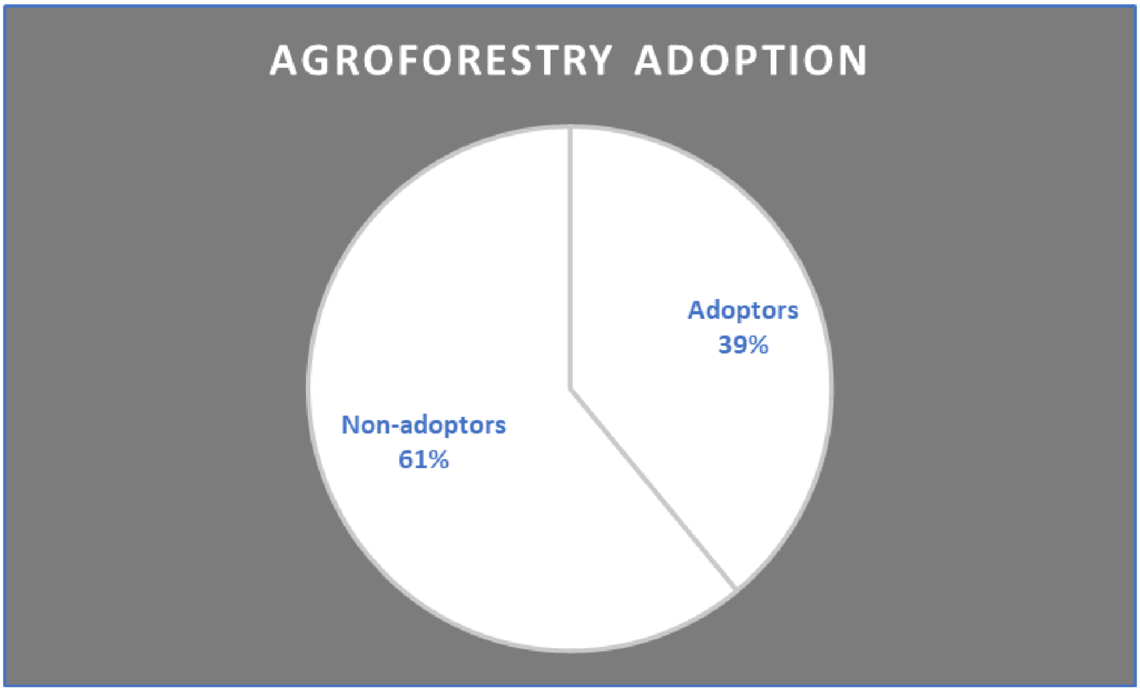


Table 3 Adopter vs non-adopter characteristics

Variables	Adopter % (n = 156)	Non-adopter % (n = 244)	Total % (n = 400)
Dependent variable			
Agroforestry Adoption	39	61	100
Independent variable			
Study Region			
Mustang-highlands	37	8	45
Baglung-midlands	0	37	38
Chitwan-lowlands	2	16	17
Climate change awareness			
Yes	35	57	92
No	4	4	8
Gender			
Male	27	45	72
Female	12	16	28

Education			
Non-formal	12	23	35
Primary	12	24	36
Secondary	11	10	21
Higher secondary	3	3	6
Undergraduate	1	1	2
Graduate	0	0	0
Marital status			
Single	5	1	7
Married	30	55	85
Divorced	1	1	1
Widow	4	3	7
Labor access (past 5yrs)			
Never	10	11	21
Rarely	4	10	14
Sometimes	10	20	30
Often	9	12	21
Always	6	8	14
Landowner			
Yes	33	59	92
No	6	2	8
Irrigation as a sustainable farming practice			
Yes	28	21	50
No	11	40	50
Access to formal credit (bank)			
Yes	2	2	4
No	37	59	96
Farm income			
<50,000	12	39	52
50,001 to 100,000	16	15	31
100,001 to 150,000	6	5	10
150,001 to 200,000	3	1	4

5.2 Drivers of agroforestry adoption - Binary Logit Model

A total of 20 variables were analyzed as shown and described in the methodology section. Table 6 Binary Logit Model, illustrates the results of all explanatory variables at the 90% confidence level or higher highlighted in color. The chi-squared value of the model was 28.50. The Wald χ^2 outcome was 19.040, -2 log-likelihood value was 185.04. These all show good results as an assessment of the quality of the model. Additionally an ANOVA test was performed to determine the effect of the independent variables on the explained variable (agroforestry adoption). Table 4 ANOVA Results shows us that the p-value is significant at $0.001<0.5$. This means the predictor variables have a strong influence on the dependent variable and that they help to determine the effect on agroforestry adoption.

In order to determine the overall performance of the entire model Table 5 Model Summary Results, a model summary test was performed, resulting in an $R2 = 0.65$ (adjusted $R2 = .63$), which is satisfactory. This indicates that the variation between the explained and explanatory variables is 65% (the closer to one hundred percent the better).

These results all confirm the model as a goodness of fit for this study. A multicollinearity test was also performed on all variables. The only two variables above 2 were household age (VIF of 2.53) and experience working as a farmer (VIF of 2.63). Therefore, all variables were under the 10, 5, and 3 thresholds indicating there is no variable that is redundant with other variables. So this means no multicollinearity exists within any of the independent variables. Therefore, all variables are okay to remain in the model and it is okay to proceed with the BLM.

Table 4 ANOVA Results

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	61.685	20	3.084	34.903	<.001[b]
Residual	33.485	379	0.088		
Total	95.16	399			

a. Dependent variable: Agroforestry adoption

b. Predictors: (constant)

Table 5 Model Summary Results

Model Summary[b]

Model	R	R Squared	Adjusted R Squared	Std. Error of the Estimate
1	.805a	0.648	0.630	0.297

The model resulted in ten independent variables with significance as explained below; most within socio-demographic and institutional aspects.

5.2.1 Socio-demographic aspects

Many socio-demographic characteristics show significance in this model. Household age (greater than 95% significance, p-value .017**), Education (greater than 95% significance, p-value .022), Marital status (greater than 95% significance, p-value .026**). Gender did not show a statistical significance level with a p-value of 0.365, and of the overall model gender showed the third lowest odds outcome of 0.657. This means that there was a 66% decrease in the odds of a farmer adopting agroforestry practices as the ratio of gender (males) increased. All other remaining socio-demographic aspects also did not have any statistical significance level. The remaining variables were household size (p-value 0.866), and experience working on a farm (p-value 0.143).

5.2.2 Socio-economic aspects

On-farm income showed a significance level greater than 99% confidence interval at <0.001*** p-value.

5.2.3 Institutional characteristics

Of the 20 variables, all of the institutional characteristics included in the model showed statistical significance, with two showing two of the four highest levels of significance in the entire model. In total, four variables fell into this category. The factors were labor access (90% significance, p-value .100*), land owner (p-value 0.003), access to formal credit through a bank or government institution (p-value <0.001), irrigation systems (p-value <0.001).

5.2.4 Landscape characteristics

Study region showed one of the strongest levels of significance with a significance of more than 99% confidence interval and a p-value of <0.001. And with regard to the odds ratio (OR), it showed a result of 61.943, which shows the strongest positive impact on adoption. An odds ratio (OR) indicates the change in the odds of the outcome (dependent) variable will occur when the predictor (independent) variable changes by one unit, holding all other variables constant. This means that because the higher the odds ratio (greater than 1) means that the odds of the outcome occurring increase as the predictor variable increases, the study region has an extremely high impact, representing a 61.9-fold increase in odds. In other words, a higher OR value of the predictor variable is associated with a higher probability of occurrence of the outcome (adoption of agroforestry practices). Conversely, an OR less than one indicates a lower probability of adopting agroforestry practices.

5.2.5 Information access

Information access came in with the most factors with significance levels. Monthly information access to internet (greater than 95% significance, p-value .021**), radio (greater than 90% significance, p-value .066*), television (just over 90% significance, p-value .094*), farmers group (over 90% significance, p-value .076*), and print media (just over 90% significance, p-value .088*). These results are important because they've been shown to influence behavior. The two that were not significant in this area were monthly access from mobile (p-value .213) and the other category (p-value 22.76). Although it is interesting that the category of "other" did not show statistical significance, considering that, as we mentioned earlier, it was the most widely used source, accounting for 32.9% of the information gathered on a monthly basis.

Taking all significant variables into account, these results tell us that when considering adoption approaches to agroforestry solutions, household and landscape characteristics, and as in an article published by Muench et al. 2021 on Nepalese tea farmers, information sources and institutional factors have a positive impact on agroforestry adoption.

Table 6 Binary Logit Model

Variables in the Equation	Coef.	S.E.	Sig.	Odds Ratio
Study Region	**4.126*** **	0.513	<.001	61.943
Climate change awareness	-0.842	0.668	0.208	0.431
Gender	-0.42	0.463	0.365	0.657
Household Age (in years)	**0.056** **	0.023	**0.017**	1.057
Education	**0.562** **	0.245	**0.022**	1.754
Marital status	**-0.803** **	0.36	**0.026**	0.448
Household size	-0.014	0.086	0.866	0.986
Working on farm (years)	-0.034	0.023	0.143	0.967
Labor access (past 5yrs)	**-0.263* **	0.161	**0.1**	0.769
Landowner	**2.333*** **	0.785	**0.003**	10.306
Farm income	**0.962*** **	0.276	<.001	2.617
Access to formal credit (bank)	**3.531*** **	1.036	<.001	34.145
Irrigation as a sustainable farming practice	**1.791*** **	0.433	<.001	5.997
Info access to the weather (research institution/university)	-0.129	0.313	0.68	0.879
Info access to the weather (print media)	0.159	0.206	0.441	1.172
Info access to the weather (mobile)	-0.174	0.155	0.261	0.84
Info access to the weather (internet)	**0.422*** **	0.146	**0.004**	1.526
Info access to the weather (radio)	-0.09	0.133	0.500	0.914
Info access to the weather (TV)	0.089	0.135	0.508	1.093
Info access to the weather (farmers group)	0.17	0.209	0.414	1.186

N=400
R2 : 0.65
(Wald χ²) = 19.04, Hosmer and Lemeshow Test = <.001
-2 Log likelihood: 185.04
0.10* (1 chance in 10, 10%), 0.05 (1 chance in 20, 5%), and 0.01*** (1 chance in 100, 1%) - table is highly significant at <0.001**
Dependent variable: Agroforestry adoption

6 Discussion and Recommendations

This study, by fulfilling the research objectives stated in the aims of this thesis, provides more recent additional insights into how agroforestry adoption is influenced by Nepalese farmers. The final result of this study shows how farmers are influenced to adopt agroforestry practices by factors such as human capital, financial capital, social capital, and ownership and landscape characteristics. A study by Wijayanto et al. (2022) had a similar rate of adopters (41%) and non-adopters (59%); and found that as access to irrigation decreases and landscape characteristics vary, farmers are less likely to adopt agroforestry practices. This helps to explain why farmers tend to fall into the non-adopting category as also seen with the results of this study.

The Diffusion of Innovation (DOI) theory was used as a theoretical framework and provides a valuable context for understanding the adoption of agricultural innovations. Through a few of the statistically significant variables in this study, it was realized that this framework is highly relevant to the adoption of agroforestry practices in Nepal as it supports the identification of the rate at which farmers adopt sustainable agricultural practices and their influencing factors. Therefore, when designing and implementing agricultural interventions in the country, it is crucial to consider the barriers faced by non-adopters. The areas examined in this study that are relevant to DOI with statistical significance are social systems and communication channels through accessing weather information via the Internet. Our study shows that the average farmer works as a farmer for 23.78 years in terms of time as an element of DOI. Thus, considering how much time a practice like agroforestry takes to adopt as they need to learn new techniques, observe the results and adapt to new systems; a farmer's lifetime of work experience is sufficient enough to learn and implement such techniques within a household (the average HH age is 50.32 years in our study). This is an area that can be further explored in future research, as the rate of adoption depends on several factors, such as farmers' access to resources, the complexity of the innovation, and the perceived benefits and risks associated with the practice.

6.1 Human and social capital

This study's hypothesis states that human and social capital affect the adoption of agroforestry. This means that we can reject the null hypothesis. Statistically significant factors considered in this study show that education with 95% confidence interval (p-value 0.022) and access to weather information through internet with over 99% confidence interval (p-value 0.004) have positive effect on agroforestry adoption among Nepalese farmers. This finding is supported by a study from Ullah et al. (2023) which states that awareness increases with education, so educated farmers adopt the practice quickly due to higher expectations. Therefore, policymakers should invest in education and training programs that promote agroforestry practices, given the positive relationship between education and agroforestry adoption in this study as well. This could include agroforestry specific curricula in agricultural colleges and adult education programs. It could also include targeted capacity building for extension workers. Higher levels of education may enable farmers to acquire and process new information, leading to better decision-making on agroforestry adoption.

6.2 Financial capital

As stated in the second hypothesis that access to financial capital affects agroforestry adoption, farm income showed a strong positive relationship with agroforestry adoption ($p = 0.001$). This result is consistent with the idea that farmers who earn more have more resources to invest in agroforestry practices and more capacity to absorb potential risks associated with their adoption Cerdán et al. 2012. This underscores the need for policy interventions to diversify the sources of income of farmers and to increase the profitability of agroforestry systems in general.

Access to credit from a bank was significantly associated with adopting agroforestry ($p = .001$), supporting the argument that financial resources play a critical role in adopting new agricultural practices Wossen et al. 2017. With access to credit, farmers would be able to invest in the necessary inputs and technologies for the successful implementation of agroforestry practices. It is recommended that for agroforestry adoption, the provision of affordable credit to farmers is essential. Risk mitigation strategies and tailored credit products for agroforestry investments should be developed by policy makers and stakeholders in collaboration with financial institutions.

6.3 Land access

According to the third hypothesis of this study (H_3: Access to land and landscape characteristics influence agroforestry adoption), land tenure emerged as a significant predictor of agroforestry adoption ($p = 0.003$). This result lends support to the argument that the security of land tenure facilitates the adoption of sustainable land management practices, such as agroforestry (FAO & ICRAF 2019). Bavorová et al. (2020), also stated increased land ownership was exhibited by adopters than non-adopters, also showing that land ownership has a positive effect on sustainable farming practices. Secure land tenure provides farmers with the confidence to invest in long-term practices that pay off over time. Policies could consider the prioritization of secure land tenure and the provision of incentives for landowners to engage in agroforestry practices.

In this study, study region was found to be a significant predictor of agroforestry adoption ($p = .001$). This finding is in line with previous studies that highlight the importance of location-specific factors in the determination of agroforestry adoption (Mbow et al. 2014). Different regions may exhibit different agro-ecological conditions, institutional support, and cultural practices, which could influence the decision to adopt agroforestry.

One recommendation of this study would be for planners and policy makers to develop interventions that are region-specific to address local farmers' barriers and take advantage of additional opportunities such as financial incentives, investments in improved infrastructure and extension services.

6.4 Limitations of the study

Lack of contextual knowledge: Not being present during data collection can limit understanding of the local context, cultural nuances, or other factors that may influence the data.

COVID-19: Since the global pandemic was in full swing, limited access to participants posed as a limitation due to social distancing measures and lockdowns during the pandemic could impact the generalizability of the study results. In addition, psychological stress and impact on responses as the COVID-19 pandemic caused significant stress and anxiety, which might have influenced participants' responses or willingness to participate in the study.

7 Conclusions

The purpose of this study was to investigate the factors that influence the adoption of agroforestry among farmers. The binary logit model was used to analyze the relationship between the dependent variable (adoption of agroforestry) and twenty independent variables, ten of which were found to be statistically significant. Namely, study region (p-value <0.001); household age (p-value 0.017); education (p-value 0.022); marital status (p-value 0.026); access to labor (p-value 0.100); land ownership (p-value 0. 003); farm income (p-value <0.001); access to formal credit (p-value <0.001); irrigation as a sustainable agricultural practice (p-value <0.001); and access to weather information via the Internet (p-value 0.004). In addition, indicators such as differences between adopters and non-adopters led to the conclusion that 61% of non-adopters should be targeted with support to acquire means such as land, financial capital, and human and social capital. And incentives and support to invest in sustainable agroforestry practices should be provided to the 39% of adopters.

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Appendices

List of the Appendices:

Appendix 1: Questionnaire

Dear Sir/Madam,

Namaste,

I would like to ask you to fill in the following questionnaire. I am a Ph.D. student at the Czech University of Life Sciences Prague, Czech Republic. I am conducting this study to learn more about the "***Effect of climate change on food security of smallholder farmers in Nepal and on migration*** ". All the data are collected anonymously. I would appreciate it very much if you would fill in and help me to conduct this research. Thank You!

ID number (M/D/C ………. M= Mustang, B=Baglung, C= Chitwan)	…………………………………………………………………………
Name of the respondent	…………………………………………………………………………
Phone number/email	…………………………………………………………………………
Rural Municipality name and ward number	…………………………………………………………………………
Date of the interview	…………………………………………………………………………
Geographical coordinates/ Altitude	…………………………………………………………………………

Section A: Household section- Socio-economic characteristics

No.	**Questions**	**Responses**
1	Sex of the HH (Household Head)	Female ☐ =0 Male ☐ =1
2	Current age of HH (in years) Age Category, less than 20, 21-30, 31-40, 41-50, 51-60, 61 and more	……………
3	What is your highest education level?	Nonformal☐=1 Primary☐=2 Secondary☐ = 3 Higher Secondary☐ =4

		Undergraduate☐ = 5 Postgraduate☐ =6
4	What is your marital status?	Single☐=1 Married☐= 2 Divorced☐=3 Widowed☐=4 others ……..=5
5	What ethnicity do you belong??	Kshetri = 1 Brahmin = 2 Magar =3 Tharu=4 Tamang=5 Newar=6 Sherpa=7 Gurung =8 Thakali=9 Dalit=10 Rai=11 Madeshi=12 Others=13
6	What is your household size (in persons)?	………………
6a	Total number of Children (<15 years):	
6b	Total number of adults (16-59 years): active labor	
6c	Total number of adults (>59 years):	
6d	Total number of males in household	
6e	Total number of females in household	
7	How long have you been working as a farmer? (years)	
8	Are you involved in some farmers group (Krishi samuha)?	Yes☐=1 No ☐ =2
8a	If yes, what kind of group it is?	Producer☐=1 Processors☐=2 Marketing☐= 3 Multipurpose☐=4 Others (specify) ……=5
9	Do you own land?	Yes ☐=1 No ☐= 2
9a	What is the total amount of land your household owns now (ha)? (1 Ropani=0.050873704704 hectare)	………………
9b	What is the total amount of land your household cultivated (both owned & rented) (in ha) this year?	……………….
9c	What is the total amount of land your household use for pastoral (both owned & rented) (in ha) this year?	……………….
9d	What is the land you cultivated 5 years ago?	More than now=1 Less than now=2 Equal as now=3 N/A=99

10	What type of farming you have?	Arable farming (Crops) ☐= 1 Pastoral farming (Livestock) ☐ =2 Mixed farming (Arable & Pastoral) ☐=3	
10a	Please indicate what are the major crops you cultivated in last 2-3 years?	**Main crops**	**In %**
		Rice=1	
		Wheat=2	
		Maize=3	
		Millets=4	
		Barley=5	
		Buckwheat=6	
		Oats=7	
		Potato=8	
		Beans=9	
		Vegetables=10	
		Fruits=11	
		Others=12	
10b	How is your food production compared to 5 years ago?	Less now =1 More now=2 No difference=3 Don't know=4	
10c	Please indicate what are the major livestock you have?		**Number**
		Livestock	…………
		Cattle ☐=1	…………
		Yak/nak ☐=2	…………
		Horse/ Mule☐=3	…………
		Goat/Sheep ☐=4	…………
		Buffalo ☐=5	…………
		Pigs☐=6	…………
		Chicken☐=7	…………
		Others……..=8	

Section B: Access to credit & market

1	How do you finance investment in your farm in last year? (Multiple choice allowed)	Family saving ☐, =1 A loan from bank/Government ☐=2 Borrow from friends and relatives ☐=3 Farmers Group ☐=4 Non-profit organizations ☐=5 Remittances ☐=6 Family saving/ remittance= 7 family saving/Farmers group=8 Family saving/Borrow from friends and relatives=9 Family saving/ loan from the bank and government= 10 Others (please specify) Labor work= 11	
1a	What share of the household income do you get by your farm (in%)?	0-25% ☐ =1 26-50% ☐=2 51-75% ☐=3 76-100% ☐=4	
2	Do you have off-farm occupation?	Yes ☐=1 No ☐=2	
2a	**If yes, what are the major off-farm activities?**	**Activities**	**income share (%)**
		Self-employed (Permanent work) =1	……..
		Self-employed (temporary work) =2	……..
		Retailer=3	……..
		Labor work=4	……..
		Administrative(office) work=5	
		Others=6	……..

How often did this happen?		**Never =(1)**	**Rarely (once a year)=2**	**Sometimes (few times a year- 2-3 times a year)=3**	**often (monthly) =4**	**Very often (weekly) =5**
3	Do you sell your farm products to the market?					
3a	Do you buy farm products from the market?					
3b	What is the nearest distance to the next market (in km and in hour)	…….. km …………..hours				
4	How much total money did you earn from your farm in 2020 (in NPR)?	<50,000 ☐ =1 50,001 to 100,000 ☐ =2 100,001 to 150,000 ☐=3 150,001 to 200,000 ☐=4				

		>200,001 ☐=5

		Food	Water	Shelter	Cloths	Health
4a	How satisfied is your family with the satisfaction to cover the following needs from your income in last 2-3 years?	Very satisfied ☐ =1	Very satisfied ☐ =1	Very satisfied ☐ =1	Very satisfied ☐ =1	Very satisfied ☐ =1
		Satisfied ☐=2	Satisfied ☐=2	Satisfied ☐ =2	Satisfied ☐=2	Satisfied ☐=2
		Neutral ☐=3	Neutral ☐=3	Neutral ☐ =3	Neutral ☐=3	Neutral ☐=3
		Dissatisfied ☐=4	Dissatisfied ☐=4	Dissatisfied ☐=4	Dissatisfied ☐=4	Dissatisfied ☐=4
		Very dissatisfied ☐=5	Very dissatisfied ☐ =5	Very dissatisfied ☐=5	Very dissatisfied ☐ =5	Very dissatisfied ☐ =5

5	Which of the following sustainable farming practices do you use?	Yes=1 No=2 Rotating crops ☐, = Intercropping ☐ = Planting cover crops ☐, = Reducing or eliminating tillage ☐, = Applying integrated pest management ☐, = Integrating livestock and crops ☐, = Adopting agroforestry practices ☐, = Use of organic fertilizer ☐, = Irrigation ☐ =

		Seeds	**Irrigation system**	**Pesticides**	**Chemical fertilizer (eg.urea)**
6	How do you perceive the price of inputs? Not applicable =5	Extremely cheap ☐=1	Extremely cheap ☐=1	Extremely cheap ☐=1	Extremely cheap ☐=1
		Cheap ☐=2	Cheap ☐=2	Cheap ☐=2	Cheap ☐=2
		Affordable ☐=3	Affordable ☐=3	Affordable ☐=3	Affordable ☐=3
		High☐=4	High☐=4	High☐=4	High☐=4
		Extremely high ☐=5	Extremely high ☐=5	Extremely high ☐=5	Extremely high☐=5

Section C: Climate change awareness

1	Are you aware of climate change?	Yes ☐ =1 , No ☐= 2
In the last 10-15 years have you experienced the following changes?		
2	It is generally warmer these days,	Agree ☐ =1 , Disagree ☐ =2, No change ☐ =3 , Don't know ☐=4
3	Intensity of extreme heat	Higher =1, lower=2, unpredictable=3, don't know=4
4	The onset of summer these days occurs,	Earlier ☐= 1, Later☐=2 No change ☐=3, Don't know ☐=4
4	Duration of winter these days are,	Longer ☐=1, Shorter☐ =2 No change ☐=3, Don't know ☐=4
5	The amount of rainfall these days are,	Less ☐=1, More ☐= 2 Unpredictable ☐=3, Don't know☐= 4
5a	Intensity of Rainfall	Low=1, more =2, unpredictable=3, don't know=4
6	The onset of rainfall these days occurs,	Earlier ☐= 1, Later☐=2 No change ☐=3, Don't know ☐=4
7	Snowfall these days starts,	Earlier ☐= 1, Later☐=2 No change ☐=3, Don't know ☐=4
7a	Intensity of coldness	Low=1, more =2, unpredictable=3, don't know=4

8	Incidence of drought these days are,	Higher ☐=1 , Lower☐=2 No change ☐=3, Don't know ☐=4
9	Incidence of fire these days are,	Higher ☐=1 , Lower☐=2 No change ☐=3, Don't know ☐=4
10	Incidence of floods and landslides these days are,	Higher ☐=1 , Lower☐=2 No change ☐=3, Don't know ☐=4
11	Incidence of avalanches these days are,	Higher ☐=1 , Lower☐=2 No change ☐=3, Don't know ☐=4
12	Amount of forest area these days are,	Higher ☐=1 , Lower☐=2 No change ☐=3, Don't know ☐=4
13	Populations of wildlife species these days are,	Higher ☐=1 , Lower☐=2 No change ☐=3, Don't know ☐=4
14	Blooming time of common plants these days occurs,	Earlier ☐= 1, Later☐=2 No change ☐=3, Don't know ☐=4
15	Plantation of major crops these days occurs,	Earlier ☐= 1, Later☐=2 No change ☐=3, Don't know ☐=4
16	Harvesting of major crops these days occurs,	Earlier ☐= 1, Later☐=2 No change ☐=3, Don't know ☐=4
17	Increase of pest and disease outbreak these days are,	Higher ☐=1 , Lower☐=2 No change ☐=3, Don't know ☐=4

Section D: Climate change adaptations (1,2) strategies and vulnerability (3,4)

1	Which of the following strategies you have adopted so far?	How long are you using this strategy (in years)?
	Crop diversification (e.g., different cultivars) ☐=1	…………….
	Changing planting date ☐=2	…………….
	Changing of crop planted ☐=3	…………….
	Early matured varieties ☐=4	…………….
	Drought tolerant/resistant varieties ☐=5	…………….
	Irrigation system ☐=6	…………….
	Rainwater harvesting ☐=7	…………….
	reduced tillage ☐=8	…………….
	Mulching ☐=9	…………….
	Agroforestry ☐=10	…………….
	Off-farm income ☐=11	…………….
	Fallow land=12	
	Temporary migration ☐=13	…………….
	Organic fertilizer=14	…………….
	Other (Please specify) …………….=15	…………….

2	How often do you have access to the following information channels regarding weather information?				
Sources	**Never-1, Once a year-2, Once a month-3, Once a week-4, Everyday-5**				
Internet	1	2	3	4	5
Radio (e.g. weather forecast)	1	2	3	4	5
Television (e.g. weather forecast)	1	2	3	4	5
Farmers group (Krishi Samuha)	1	2	3	4	5
Research Institution/University	1	2	3	4	5
Print media (e.g. newspaper)	1	2	3	4	5
Mobile phone	1	2	3	4	5
Other (please specify):	1	2	3	4	5

3	How was the influence/impact of the following factors on your farm production in the last 5 years?
Factors	**Very negative-1, negative-2, no change-3, positive- 4, very positive-5**

Rise in temperature	1 2 3 4 5
Erratic rainfall	1 2 3 4 5
Drought	1 2 3 4 5
Windstorm	1 2 3 4 5
Overflooding	1 2 3 4 5
Hailstorm	1 2 3 4 5
Crop pest and disease outbreak	1 2 3 4 5
Livestock disease outbreak	1 2 3 4 5
Decrease in soil quality	1 2 3 4 5
Other (please specify) …………………………….	1 2 3 4 5

4	How often following consequences of climate change occurred in last 5 years?
Factors	**Never-1, Rarely (once in a 5 years)-2, sometimes (2-3 times in 5 years) -3, often (4-5 times in 5 years)-4, Always (more than 5 times)-5**
Reduce crop yield	1 2 3 4 5
shortage of livestock feeds	1 2 3 4 5
Dead of livestock	1 2 3 4 5
Crop pest and disease outbreak	1 2 3 4 5
Destruction of farmland	1 2 3 4 5
Destruction of habitat (human being & animal)	1 2 3 4 5
Physical injury to the family member/me	1 2 3 4 5
Dead of family member (except earthquake)	1 2 3 4 5
Lack of financial capital	1 2 3 4 5
Others (please specify) ………………………………	1 2 3 4 5
Others (please specify) ………………………………	1 2 3 4 5

Section E:

Food consumption and food sources (FCS)				
Who decides what will be eaten?			**Female☐ =1**	**Male ☐=2**
			Female	**Male**
1	How many meals did the adults (18+) in this household eat yesterday?		1.|__|	2.|__|
2	How many meals did the children between the age of 5-17 eat yesterday?		1.|__|	2.|__|
3	How many meals did the children between the age of 2-< 5 eat yesterday?		1.|__|	2.|__|
4	**Food items/groups**	**Examples**	**4.1. How many days over the last 7 days, did members of your household eat the following food items, prepared and/or consumed at home?**	**4.2. How was this food acquired?** **Write the main source of food for the past 7 days**
			Days	**Source**
1	Cereals or tubers=1	Rice, potato, naan etc.	……………	……………
2	Pulses and groundnuts=2	Beans, peas, Cashew nuts	……………	……………
3	Milk and milk products=3	Fresh milk, powdered milk, yogurt, cheese, other dairy products	……………	……………
4	Eggs, meat, fish, shells=4	Organ meat, flesh meat, fish, eggs, etc.	……………	……………
5	Vegetables=5	carrots, spinach etc.	……………	……………
6	Fruits=6	Apple, banana, etc.	……………	……………

7	Sugar=7	Sugar, honey, jam, cakes, pastries, (sugary drinks)	……………	……………
8	Oil=8	Vegetable/palm oil, butter, ghee, other fats	……………	……………
9	Condiments=9	Spices, tea, coffee, salt, spices, tomato / sauce	……………	……………

Food acquisition codes:

01 = purchase (cash)

02 = purchase (credit)

03 = food assistance (General Food Distribution)

04 = food assistance (food card)

05 = army distributing food

06 = support from relatives/friends

07 = barter and exchange

08 = borrowing

09 = begging/scavenging

10 = gathering of wild foods (plants/insects)

11 = hunting/fishing

12 = own production

HOUSEHOLD COPING STRATEGIES (rCSI)		
	During the last 7 days, were there days (and, if so, how many) when your household had to employ one of the following strategies (to cope with a lack of food or money to buy it)?	**Frequency (number of days from 0 to 7)**
1	Relied on less preferred, less expensive food=1	……….
2	Borrowed food or relied on help from friends or relatives=2	……….
3	Reduced the number of meals eaten per day=3	……….
4	Reduced portion size of meals at meals time=4	……….
5	Restrict consumption by adults in order for young children to eat=5	……….

Section F: Migration

1. Household size and migrants

Variable	Male =2	Female =1
Household size excluding migrants (current)		
How many have migrated internally (inside the country) for the past 10 years		
How many have internationally (outside of the country) migrated for the past 10 years		

3	Do you receive remittances or items from migrant members				Yes ☐=1 No ☐=2, N/A=99Liv	
3a	If yes, how often do you received the following items from migrants for the past 5-10 years					
		Never=1	**Rarely (once a year)=2**	**Sometimes (Few times a year)=3**	**Often (Monthly)=4**	**Very Often (Weekly)=5**
	Money					
	Farm input					
	Cloth & household belongings					
	Food items					
	Others……					
	Not applicable=x					
4	Please indicate the share of your livelihood which was covered by money or stuff sent by migrant members last year?				0-25 % ☐=1, 26-50% ☐=2 51-75% ☐=3, More than 75% ☐=4	
5	Please indicate the importance of remittances to cover the following (1 lowest importance, 5 highest importance)					
	Importance of remittances	**1-not at all importan t**	**2-slightly importan t**	**3-Neutral**	**4-very important**	**5-Extremely important**
	Buying food/ cloths					

	Education					
	Health expenses					
	Buying Seed/ fertilizer					
	Buying pesticides					
	Buying Agri tools					
	Repay debts					
	Financing migration costs of additional family members					
	House construction and maintenanc e					
	Others ……………					

6	Ideally, if you had the opportunity, would you like to move **Temporarily** to another place?	Yes ☐=1 No ☐=2
6a	Where do you want to move?	To the same/different village=1, to the urban area=2
6 b	Ideally, if you had the opportunity, would you like to move **Permanently** to another place?	Yes ☐=1 No ☐=2
7	If 6&6a is Yes, are you planning to move in the next 12 months?	Yes ☐=1 No ☐=2
8	If 7 is Yes, have you done any preparation for this move? (for eg; buy properties or making arrangements for the move)	Yes ☐=1 No ☐=2
9	If any questions from 6 to 8 is Yes, What is the primary reason you choose to move?	Education ☐ =1 Search for work ☐=2 , Job transfer/ opportunity ☐=3, Drought=4 , Flood ☐=5, landslides=6, Family problems ☐=7, Better livelihoods☐=8, Do not own Agri land to work here ☐=9

	(Multiple selection allowed)	Don’t have enough land ☐=10, Poor quality of land ☐ =11 Other (Please specify) =12……
10	How often do your household had to deal with the lack of labor available for work in agriculture in last 5 years?	Never ☐=1, Rarely ☐=2, Sometimes ☐=3, Often ☐=4, Always ☐=5

Section G: Covid-19 in food security

COVID-19 and Food security		
1	Which statement best reflects your food situation in this pandemic time?	I increased my food intake ☐=1 I had no difficulties eating enough food ☐=2 I ate less preferred foods ☐=3 I skipped meals or ate less than usual ☐=4 I went one whole day without eating ☐=5
2	Does your household had/have food stock?	Yes, less than 1 week ☐=1, Yes, 1 week ☐=2 Yes, 2-3 weeks ☐=3, Yes, 1 months ☐=4 Yes, more than 1 months ☐=5
3	What is the situation of your household income in this pandemic time?	Increased in salary/revenue ☐=1, No change ☐=2 Job loss ☐=3, Reduced salary/revenue ☐=4 Had to resort to alternative source of income☐=5
4	Looking ahead, how do you expect your livelihood will be impacted as result of disruptions from COVID-19?	No impact ☐=1, slightly impact ☐=2 Somewhat impact ☐=3, very impact ☐=4, Severe impact ☐=5

5	In this pandemic and the lockdown started, have you received any food, cash, or other support from anyone else that you do not usually receive?	Yes ☐=1 No ☐=2
5.1	If 5=yes, could you please indicate the source?	Government ☐=1 Relatives ☐=2 Neighbors ☐=3 Community leaders ☐=4 NGOs ☐=5 Other (please specify)=6 ……………………
6	Is someone in your family had to return home from abroad due to COVID-19?	Yes ☐=1 No ☐=2