The Role of Agroforestry on Food Security and Climate-friendly Farming in Nepal and its Challenges and Approaches

Mr. Rudra Nath Dahal
Ph.D. Scholar of Prince of Songkla University, Thailand
Research Coordinator, PRMC, Barun Multiple Campus,TU
dahalrudra18@gmail.com

Abstract

The integration of forestry with agriculture, known as agroforestry, is a longstanding practice that incorporates trees into farming systems and landscapes. Unlike a substitute technique, agroforestry complements traditional agricultural methods. Climate change presents global challenges, particularly impacting the agricultural sectors of developing nations. Climate Smart Agriculture (CSA), introduced by the Food and Agricultural Organization (FAO) in 2010, offers a sustainable alternative to conventional farming by aiming to reduce greenhouse gas emissions while enhancing agricultural productivity, resilience, and efficiency. This review explores the role of agroforestry in promoting food security and climate-friendly farming, identifies challenges hindering its adoption, and proposes strategies to enhance implementation. By fostering sustainable development and improving rural livelihoods, agroforestry contributes significantly to climate change resilience. The study employs a qualitative research design, synthesizing secondary sources to analyze agroforestry practices, challenges, and contributions. Agriculture accounts for up to 14 percent of greenhouse gas emissions, while deforestation and erosion contribute an additional 17 percent. Climate-friendly agriculture, rooted in sustainable practices, focuses on increasing agricultural production and income sustainably, adapting to climate change, and reducing greenhouse gas emissions. By promoting climate-friendly agriculture in Nepal, local knowledge and resources can be effectively utilized, generating self-employment opportunities, reducing production costs, and promoting sustainable agricultural ecosystems. Implementing climate-friendly agriculture is crucial for achieving sustainable development goals and mitigating the adverse effects of climate change in agricultural systems.

Keywords: *Agroforestry, Climate Friendly, Climate Change, Food Security, Sustainability*

Introduction

Combining forestry and agriculture, agroforestry integrates trees into farms and in the agricultural landscape (Paudel et al., 2017; Brandt et al., 2013; FAO/The World

Bank, 2015). It is a strategy of managing natural resources'-forestry has been around for as long as people have engaged in agriculture; it is not a substitute technique (Sahoo et al., 2020). But only in the last 30 years has it attracted sufficient scientific attention and been thoroughly investigated. According to common definitions, agroforestry is "a collective name for land-use systems and technologies where woody perennials are intentionally used in some manner, either in placement or temporal sequence, on equivalent land-management units as agricultural crops and/or animals" (Sobola et al., 2015). Agro-forestry may support Forest and Landscape Restoration (FLR) in several ways, including by promoting sustainable agricultural intensification, reducing poverty, and realizing its under appreciated potential to reduce climate change and conserve biodiversity (FAO, 2013). Trees are included into farming systems by farmers worldwide. (Dhakal et al., 2012) These practices are new in some regions, while they are traditional in others (Campbell et al., 2014).

Agriculture is the most significant economic sector in many developing nations (Branca et. al., 2011). One of the most divisive socio-ecological and economic issues of the twenty-first century is climate change (Singh & Singh, 2017). Agriculture, both now and in the future, is seriously threatened by climate change (Tong et. al., 2019). Crop yield and distribution, along with the associated hazards, will be impacted by climate change. Since crop yields have already suffered, it is imperative that adaptable actions be taken (Scherr et al., 2012). A framework known as "climate-smart agriculture" has emerged to represent the concept that agricultural systems may be created and put into practice to improve food security, rural people's quality of life, help adapt to climate change, and offer mitigation advantages. In many parts of the world, millions of people's livelihoods depend on agriculture, and food security is being increasingly threatened by climate change (Dwivedi et al., 2017). Climate Smart Agriculture (CSA) was first presented by the Food and Agricultural Organization (FAO) in 2010 as a creative, cleaner alternative to conventional farming. The goal of CSA was to reduce greenhouse gas emissions while increasing the productivity, resilience, and efficiency of agricultural production systems with respect to natural resources. The detrimental effects of climate change on cotton output at the farm and regional levels can be lessened with the use of CSA technology and practices (Imran et. al., 2018). "CSA is agriculture that protects the environment from climate change, reduces climate change vulnerability, and reduces emissions that cause climate change" (FAO, 2017).

Climate change has become a global burning issue these days (Malla, 2008). This has created worldwide problems, which has badly affected the agricultural sector of developing countries. There are many environmental changes that occur due to climate change, such as long periods of dry and drought in summer, floods,

floods and landslides due to excessive rainfall in rainy season and global warming (Mc Karthy et al., 2011). Because of this, our local (*Raithane*) crop species and livestock have not been able to produce as much as before, so the main challenge is to adapt to climate change in agriculture (Scherr et al., 2012). Due to the lack of sufficient resources, the farmers of developing countries have less ability to fight the problems that appear in agriculture due to climate change compared to developed countries (Singh, 2017). Therefore, the future direction for agriculture in a country like Nepal is to simultaneously reduce climate change, reduce the damage caused to agriculture due to the effects of climate change, and increase agricultural production in view of the growing population (Branca et al., 2011). Promotion of climate-friendly agricultural techniques and good practices is one option to reduce the negative effects of climate change and adopt adaptation measures (FAO, 2013).

Figure 1

Agroforestry and Food Security

Source: https://www.google.com/search?q=conventional+agriculture+image+of+ agroforestry+ for+food+security+in+Nepal-4/25/2024

The current agricultural sector of Nepal has to address two major challenges, food insecurity and climate change. About 64% of Nepalese are mainly engaged in agriculture, but it is becoming difficult to earn a living from it (Subedi et al., 2015). Due to the impact of climate change in the agricultural sector, the migration of the youth abroad and the declining interest of farmers towards the agricultural profession, the situation in this sector is becoming more and more worst. If this situation continues, it will have a big negative impact on the country's economy. There is an urgent need to transform the agricultural sector (Scherr et al., 2012). For the transformation of the agricultural sector, food security and sustainable agricultural development, there is a need for such a technology that can produce more, is climate friendly and depends on less resources and tools (FAO, 2013). According to various studies and researches, climate change, poverty and food security problems can be addressed if mixed agricultural systems (agroforestry,

integrated forestry and fish systems, agriculture based on biological diversity, organic farming, etc.) are adopted instead of the traditional single crop system (Imran et al., 2018). To solve these problems in the agricultural sector, one of the methods mentioned above, the agroforestry system can be a good solution (Bhagat et al., 2024). Reviewing the role of agroforestry, it has been discussed how this type of agricultural system can contribute to food security (Dhakal et al., 2012).

Statement of the Problem

The agricultural sector in Nepal faces significant challenges in ensuring food security and sustainability in the face of climate change. Agroforestry has been proposed as a potential solution, yet its adoption and effectiveness remain understudied. This research seeks to address this gap by examining the role of agro-forestry in enhancing food security and promoting climate-friendly farming practices in Nepal. Specifically, it aims to identify the challenges that farmers and stakeholders encounter in implementing agroforestry, explore the factors influencing its adoption, and propose effective approaches to maximize its benefits for both farmers and the environment.

Objectives of the Study

The main objectives of the study were to

i. Assess the role of agroforestry on food security and climate-friendly farming.

ii. Identify the challenges and barriers of agroforestry adoption.

iii. Develop approaches to enhance agroforestry implementation, food security, and climate-friendly farming.

Research Methodology

The research design of this study is qualitative based on content analysis and desk review. The data has been gathered from the review and synthesis of secondary sources; articles and reports related to agroforestry practices, challenges, and contributions to food security and climate-friendly farming. Scanning, Skimming, Screening, and Sorting were adopted during reviewing and related sources were searched and identified. For these forty-five research articles were through Google Scholar, Research Gate, Microsoft Academic, and Educational Resources Information Center. No additional articles were identified through other sources. Nineteen duplicate articles were identified and such nineteen full-text articles have been excluded. Only Twenty-one articles were screened and fourteen articles were excluded among them. Nine full-text articles have been assessed for eligibility. No full-text article was excluded. Nine studies have been included for review and qualitative synthesis.

Significance of the Study

The significance of the study consists of fostering foster sustainable development; enhance resilience to climate-change, and improving the well-being of rural communities (Paudel et al., 2014). Likewise, increase agricultural production diversification to improve food security, reduce the effects of climate change by storing carbon and taking adaptive steps, advocate for the conservation of bio-diversity and sustainable land management, reduce poverty and diversify rural livelihoods and encourage Nepal to develop evidence-based policies for resource management and sustainable agriculture (Malla, 2008).

Result and Discussion

1. Present Status of Agriculture

The agricultural system of Nepal is subsistence oriented. 64 percent of the labor force of the total population depends on this sector, while 32 percent of the total domestic product is occupied by the agricultural sector (CBS, 2013; Paudel et al., 2014). More than 50 percent of arable land does not have irrigation facilities, so such arable land has to depend on rain for irrigation. Government investment in agriculture, which is called the backbone of the nation's economy and is dependent on so many human resources, is low (CBS, 2013; Ghimire et al., 2024).

The arable land is also fragmented and scattered due to the landforms. Due to this situation, it is not easy to modernize and commercialize the agricultural sector (Khanal, 2009). Three-point one percent of farmers do commercial farming while the remaining farmers are engaged in traditional farming system. If we evaluate the current rural situation, there is a situation where only women, old people and children have to farm. Due to the attractiveness of foreign employment, the agricultural profession has not been given priority among the youth and the manpower required for farming is migrating abroad (Ghimire et al., 2024).

Figure 2 Agriculture System in Hilly Region

Source:https://www.google.com/search?q=image+of+agriculture%2C+climate+friendly +farming+Nepal-4/25/2024

Statistics show that more than 3 million Nepalese have emigrated for various purposes so far (Ghimire et al., 2024). Due to this, there is a shortage of agricultural manpower and the arable land has become sterile. Not only this, due to lack of manpower to work at home, it is difficult to collect the grass required for cattle from the forest, and the practice of keeping cattle is also decreasing (Dhakal et al., 2012). Thus, when the number of cattle decreases, on the one hand, there is a lack of nutrients needed by humans, on the other hand, the fertility of the soil is reduced, and the production and productivity are reduced (Khanal, 2009). Apart from this, the quality of the soil has decreased, and the environment has also been negatively affected. In this way, farmers will gradually flee from agriculture, arable land will become barren due to lack of manpower, the existing land will also be of poor quality, and settlements will increase in the outskirts of the city and on uncultivated fertile land. If the trend continues, it seems that there will be a big negative impact on the rural economy and food security in the future (Ghimire et al., 2024).

2. Impact of Climate Change on Agriculture

Many scientific studies show that the climate is changing rapidly with industrial development in the world. Mainly due to the widespread use of mineral energy, carbon dioxide, methane, nitrous oxide, ozone, etc., are emitted due to the increase in the amount of greenhouse gases in the atmosphere (Koirala et al., 2010). Due to these effects, the number and duration of climatic disasters such as floods, landslides, storms, hailstorms, droughts, etc. are increasing in Nepal every year. Due to this, natural resources, biological diversity, and livelihood resources have started to have a direct impact (Imran et al., 2018). As shown by various studies, the effects of climate change are directly visible in agriculture, such as reduction in agricultural production and productivity, decline in agricultural biodiversity, drying up of water sources, reduction in soil fertility and impact on crop cycle and calendar, etc. are some examples. Among these, two main topics, agricultural production and productivity and the impact of climate change on agricultural biodiversity and crop calendar, are discussed in this article Koirala et al., 2010; Malla, 2008). Climate Change Effects on Nepal and Nepalese Agriculture (Subedi et al., 2015)

- Changes in precipitation patterns such as late or early pre-monsoons, decreased rainy days, and intense rainfall leading to more runoff and lower groundwater recharge.
- Unusual extreme fog conditions in the terai regions have been observed.
- Traditional rainfall patterns in Kathmandu during Jestha and Ashar have shifted to Shrawan and Bhadra, negatively impacting paddy production.

- Receding snowfall and glacier retreat due to rising atmospheric temperatures in mountainous areas.
- In Kathmandu Valley, frost days are decreasing, with winter cold arriving a month later than usual, and a rare snowfall occurred in February 2007 after 60 years.
- Darchula district experienced unusual snowfall, affecting the collection of precious medicinal herbs like Yarsa Gumba.
- Mosquitoes from the Terai and Mid-hills are now surviving in higher elevations such as Ilam, Mustang, and Helambu.
- In 2005/06, the Eastern Terai faced rain deficits from an early monsoon, leading to a 12.5% reduction in crop production nationally. Meanwhile, the mid-western Terai experienced heavy rains and floods, reducing production by 30%.
- Crops are maturing earlier due to increased temperatures, potentially allowing for more crops in the same cycle.
- There is evidence of shifting climatic zones within the country, leading to the extinction of natural vegetation like local basmati rice varieties, certain wheat and maize varieties, and other agricultural crops.
- The cold wave in Nepal during 1997/98 had significant negative impacts on agricultural productivity, resulting in reductions of 27.8%, 36.5%, 11.2%, 30%, 37.6%, and 38% in potato, toria, sarson, rayo, lentil, and chickpea production respectively.

a. Impact of Climate Change on Agricultural Production and Productivity:

Agricultural work is based on the environment, agricultural production and animal husbandry which depend on the local climate. Changes in weather due to climate change, manipulation of the rainfall calendar, and increase in temperature, drought, floods and landslides have a negative impact on agricultural production. The agricultural sector depends on monsoon rains and winter rains (Malla, 2008). Due to the irregularity and fluctuations in the rainfall, the traditional crop cycle of agriculture is becoming unbalanced - due to which it is difficult to plant the crops on time and the productivity of the local species is increasing.For example, due to the lack of monsoon, there has been a change in the farming system due to changes in the time of paddy planting, faster ripening of fruits, increased use of drought-tolerant seeds, etc (Subedi et al., 2015). As the temperature rises with the changing climate, the water sources dry up and the crop does not get the moisture it needs, the growth and development of the crop is affected and the production is

reduced (FAO, 2017).Likewise, if the temperature increases, the organic matter in the soil will decrease and the soil's nutrients will change due to the leakage of the soil's physical condition, and there is a possibility of an increase in acidification and desertification. Not only this, when the temperature increases, evaporation and transpiration increase and when the water and other liquids in the plant come out, pressure is created on the plant and crop production decreases. If the temperature is high, various diseases and insects will attack and the use of pesticides to control it will also reduce the fertility of the soil (Ghimire et al., 2024).

Figure 3

Agroforestry Contribution to Food System/modified nexus framework of food system in Nepal

Source: https://www.researchgate.net/figure/Contributions-of-forest-and-trees-to-food-systemshttps://www.mdpi.com/2073-4395/10/8/1129-*4/25/2024*

Figure 4

Impact of Climate Change on Agriculture in Nepal

Source: https://www.google.com/search?q=image+of+impact+of+climate+change+on+*Agriculture+in+Nepal-4/25/2024*

b. Agricultural Biodiversity and Crop Calendar

Biodiversity plays an important role in agricultural production. Biodiversity provides various environmental services associated with the agricultural production system such as: soil nutrient cycle helping to decompose organic matter, pollination, soil fertility, carbon storage, etc (Sobola et al., 2015). Therefore, biological diversity also reduces the negative effects and risks on human health and the environment (Singh et al., 2015). According to studies, climate change also affects agricultural biodiversity (Scherr et al., 2012). Increased use of pesticides and chemical fertilizers along with climate change is another major cause of biodiversity loss (Subedi et al., 2015). The use of pesticides harms not only the harmful insects in the environment but also the beneficial insects that protect the environment and reduces diversity (Swodesh, 2019). Increasing use of chemical fertilizers affects soil bacteria and biological diversity by increasing soil acidity. It has been observed that the crop calendar adopted by the farmers has changed due to climate change in the last few years (Wreford et al., 2017).

In fact, due to changes in rainfall, farmers have changed the timing of cultivation and this has affected the entire crop calendar. According to the study done by Koirala and Bhatta in central Nepal, the farmers have quoted the statement that the sowing time of grain crops has been delayed by 15 to 30 days (Koirala & Bhatta 2010). A study conducted in Siraha district has also shown that climate change has changed the timing of planting and flowering and fruiting of various food crops (Table 2) and fruit crops (Table 3) (Subedi et al., 2015).

Table 2

Changes in grain crop timing due to climate change in Siraha district

Grain	Time to Plant Crops		Cause
	In Past	In Present	
Potato	November-December	October-November	Chilling in Nov-Dec
Paddy	May-June/June-July	July-August/Aug-Sep	Decrease in Rainfall
Wheat	November-December	December-January	Although there is a delay in rice planting, it also affects wheat
Onion	First Week of Dec-Jun	Last of the Dec-Jan	Chilling and Less Sunlight

Source: Subedi et al., 2015

Table 3

Changes in budding and flowering time of fruits and crops due to climate change in Siraha district

Fruit	Budding Time		Flowering Time	
	In Past	In Present	In Past	In Present
Mango	Jan-Feb	Feb-March	Feb-March	Mar-Apr/Apr-May
Coconut	Nov-Dec	Dec-Jan	Dec-Jan	Jan-Feb
BeBerries	Mar-Apr	Last of Mar-Apr	Apr-May	Last of Apr-May
Guava	May-Jun	Last of May Jun	Jun-July	Last of Jun-July
Jackfruit	Jan-Feb	Feb-March	Mar-Apr	Apr-May

Source: Subedi et al., 2015

3. Relevance of Climate-friendly Agriculture and Agro-forestry

Although the agricultural sector itself is at risk of climate change, experts say that it emits up to 14 percent of greenhouse gases. Similarly, deforestation and erosion contribute to another 17 percent of greenhouse gas emissions, according to the study, and the current agricultural system needs to be developed and promoted to make it climate-friendly (Subedi et al., 2015). Climate-friendly agriculture is not a new method; it is based on sustainable agriculture. Climate-friendly agriculture mainly has three dimensions: one: sustainably increasing agricultural production and income, two: climate change adaptation and timely adaptation, three: reduction in greenhouse gas emissions from traditional agricultural systems (Karki et al., 2012). Apart from agroforestry, this agricultural system includes protected agriculture, integrated forestry, crop fish system, etc. Apart from this, permaculture, organic farming, ecological farming, farming based on biological diversity etc. can also be considered as climate friendly farming. Agroforestry is a farming system in which food crops, woody perennials such as grass, fruits, vegetables, spices, ground grass etc. are planted together in one place. It also includes animal husbandry, beekeeping, and fish farming (Koiral, et al., 2010). The benefits of this type of farming technique are numerous. Multiple products can be obtained from agroforestry. Multiple products can be obtained from agroforestry. Trees are produced along with grass, crops, and animal husbandry; agroforestry maximizes the use of land and increases production and productivity (Campbell et al., 2014). As agroforestry is a mixed cropping technique, farmers can get income from food crops and tree products and the household income is diversified. And if one of the crops is unable to produce due to climate change or any other environmental impact, it protects the farmer from losses as it can be taken from others. Multi-purpose trees in agroforests help reduce the impact of climate change by absorbing carbon dioxide gas from the

atmosphere and storing carbon in the wood. In addition, tree planting plays a major role in soil erosion control, water source enhancement, and wildlife habitat and biodiversity conservation (Subedi et al., 2015). Daily essential resources such as grass, firewood, apples, sawdust are easily available from the agricultural forest, so the pressure on the community forest and national forest is reduced. Also, since the farmers will get firewood near their homes, the time required to collect the forest produce will be saved and time will be saved for another household work (Branca et al., 2011). In addition, it helps to reduce deforestation by reducing the pressure for collection of forest products. Since cereal crops and perennial tree plants are planted together in the agricultural forest, the roots of the tree plants can take nutrients from the soil from the lower surface of the ground where the roots of the cereal crops cannot reach, and the leached mineral elements are reused (Scherr et al., 2012). In addition, leaves and residues of tree plants fall and increase the organic matter in the soil. Also, tree plants help to make the climate favorable by protecting the moisture in the soil from evaporation by providing shade (Pandit et al., 2018).

Figure 5

Climate-friendly Agriculture and Agro-forestry

Source: https://www.google.com/search?q=image+of+climate+friendly+farming+Nepal-*4/25/2024*

4. The Role of Agroforestry in Food Security

People always have access to food, and all people, with physical and financial access, can eat adequate amounts of safe, nutritious food - that is called food security (FAO, 2017; Ghimire et al., 2024)). There are four dimensions of food security.

i. Availability of food elements,

ii. Economic and physical access to food elements,

iii. Food utility and

iv. Food stability

Agroforestry maximizes the use of land and increases production and productivity. According to studies, agroforestry techniques increase production by 42 to 137 percent. In order to increase the production, it is necessary to either do agriculture on more land or to adopt an intensive farming system. Currently, it is difficult to increase the arable land in the perspective of plotting the arable land and changing to the city. Agroforestry helps to maintain food security as it can produce more from less land by making maximum use of land (Subedi et al., 2015).

In order to be safe from the point of view of food security, the food we eat should have a sufficient amount of variety of nutrients. Agricultural forests are considered to be a good source for food diversity as grains, fruits, vegetables, vegetables, fish and meat etc. are obtained (Singh et al., 2017). Leaves, seeds, flowers, fruits, mushrooms obtained from tree plants have been popular as food in rural communities for a long time (Regmi, 2007). Medicines and medicinal materials are also obtained from trees. Therefore, agroforestry will provide food and nutritional security directly (Malla, 20011). Nowadays, the promotion of agroforestry encourages the increase in animal husbandry when the farmers are gradually reducing animal husbandry due to lack of grazing area, lack of manpower to collect grass from the forest and raise livestock (Singh et al., 2017). Grass for animal husbandry is obtained from the trees of the agricultural forest. As the availability of grass and ground grass is good, livestock production will increase (Sobola et al., 2015). Meat, milk and other sources of nutrients from animal husbandry are good sources. Similarly, when there is an increase in animal husbandry, income can be obtained through selling and when the source of income is good, the purchasing power of the farmers will increase and the situation of food security will be better. In addition, the firewood obtained from the agroforestry is used as energy for cooking at home. This also reduces the energy crisis (Singh et al., 2017).

The household income increases from the sale of various wood and non-timber forest products of the agricultural forest. This makes the farmer financially independent and increases the farmers' access to the market (Branca et al., 2011). In the agroforestry system, as the trees develop a microclimate, in this system the crops grow well and the yield is high. Thus, crops grown in a good climate have sufficient nutrients and the availability of quality food can address malnutrition and food insecurity (Magcle et al., 2009). The following figure also tries to show the interrelationship between agro-forestry and food security.

Figure 6

Agroforestry and Organic Farming in Nepal

Source: https://www.chitlang.com/organic-farming-in-nepal-4/25/2025

5. The Role of Agroforestry in Climate Friendly Farming

1. Carbon Sequestration:

- Agroforestry systems, which combine trees with agricultural crops or livestock, help sequester carbon from the atmosphere. Trees absorb carbon dioxide during photosynthesis, storing it in their biomass and in the soil (Campbell et al., 2014).

- This process helps mitigate climate change by reducing the amount of greenhouse gases in the atmosphere, making agroforestry a valuable tool in climate change adaptation and mitigation strategies (Branca et al., 2011).

2. Soil Health and Water Management:

- Trees in agroforestry systems contribute to improved soil health. Their roots help bind soil particles, reducing erosion and improving soil structure (Dove, 1992).

- Agroforestry can enhance water infiltration and retention in the soil, reducing the risk of soil erosion and improving water availability for crops, especially important in areas prone to droughts or erratic rainfall (Karki et al., 2012).

3. Biodiversity Conservation:

- Agroforestry promotes biodiversity by creating diverse habitats for various plant and animal species. The combination of trees, crops, and sometimes livestock creates a more complex and resilient ecosystem (Mulatul et al., 2019).

- This biodiversity can provide natural pest control, pollination services, and overall ecosystem stability, reducing the need for synthetic inputs and enhancing farm resilience to climate change impacts (Bekele, 2018).

4. Diversification and Resilience:

- Agroforestry systems provide farmers with diversified sources of income and food. Trees can yield fruits, nuts, timber, and other products alongside traditional crops (Norgrove et al., 2016).
- This diversification enhances resilience to climate-related risks such as crop failure or market fluctuations. If one crop fails due to climate extremes, other components of the agroforestry system can still provide income and food (Bekele, 2018).

5. Adaptation to Climate Change:

- With climate change leading to more frequent and intense weather events, agroforestry offers a way for farmers to adapt. The diverse nature of agroforestry systems helps buffer against extreme temperatures, floods, and droughts (McCarthy et al., 2011).
- Trees in agroforestry can also serve as windbreaks, reducing the impact of strong winds on crops, and provide shade, which is particularly beneficial during heatwaves (Sobola et al., 2015).

Similar to this, Nepal's agroforestry has enormous potential for climate-friendly farming since it can absorb carbon, improve soil health, support biodiversity, boost resilience, and offer solutions for adaptation. Farmers, the environment, and attempts to mitigate and adapt to climate change can all benefit from agroforestry when obstacles are addressed and suitable strategies are used (FAO, 2017).

6. Challenges of Agroforestry

The main challenges for the development, expansion and promotion of agroforestry are as follows:

Policy Problems: There is no separate national policy for agroforestry yet. Due to the lack of a separate policy and institutional structure, this sector has been neglected (Regmi et al., 2023). Although this sector will be linked to both the Ministry of Forestry and Agriculture, the policies and structures to adequately address it are lacking. Not only that, some of the issues that have been addressed are also conflicting with each other due to which such policy rules are not being

fully implemented. Timber and other herbs which are produced both in forest and private land are difficult to sell and distribute. Nepal's land policy has also affected agroforestry (Paudel et al., 2022). Therefore, this area has not been developed sufficiently.

Institutional Problems: Due to the absence of its own organizational structure of agroforestry, some aspects of this sector are under the Ministry of Forestry and Agriculture, but due to lack of inter-ministerial and interdepartmental coordination/ combination, promotion of agroforestry has not been possible (Atreya et al., 2021). As both agricultural and forest products are included in the production of agroforestry, their marketing processes are different. Therefore, some goods can be sold and distributed in a simple and easy way like agricultural products, while some have to be sold as forest products only after going through a complicated legal process - which has caused problems for the farmers. In addition to this, due to the inability to produce in large quantities, the inability to maintain the quality of the products produced, and the lack of access to external exports, this sector has not been able to be developed as an enterprise (Amatya et al., 2018). Due to the limited production, most of the farmers have to find the market by themselves, have to transport themselves and have to settle for the price set by the traders and the farmers have not been able to get a fair price for their produce. Moreover, the activity of many types of middlemen has made the problem worse (Atreya et al., 2021).

Limited Traditional Knowledge: Although agroforestry has traditionally been practiced in villages in Nepal, there is a lack of sufficient knowledge about it. Farmers are not fully prepared for agroforestry because they do not have sufficient knowledge of the benefits and opportunities of agroforestry and the belief that agroforestry reduces production (Atreya et al., 2021).

7. The Approaches of Agroforestry in Nepal

For reasonable development of agroforestry, the following approaches can be adopted.

- In this perspective of making a national agroforestry policy soon, there is a need to formulate a small farmer-friendly agroforestry policy with the participation of related stakeholders and organizations.
- Due to the impractical aspects of the Forest Act and regulations, agroforestry can be promoted on private land.
- Farmers could sell firewood produced from their private land.

- Dismiss the complicated and impractical permit system.
- Farmers want to get a fair price for their products.
- In the current situation, there is a need for a separate structure and department for the institutional development of agroforestry rather than linking the agricultural forest to any existing department; it can be promoted as an independent department.
- Complicated and impractical policy rules seen in the sale and distribution of agroforestry products should be thoroughly considered and made farmer-friendly.
- Forest products produced in agricultural forests should also be developed in an environment where they can be sold and distributed as easily as agricultural products.
- Due to the lack of coordination and cooperation between the Ministry of Agriculture and Forestry, a separate structure is necessary for the institutional development of agroforestry.
- For the development, promotion and priority of farmers, it is necessary to have a good market management for the simple and easy sale and distribution of the produced goods.
- In partnership with the community, private and cooperative sectors, there must be a situation to increase the quantity of agricultural forest products, to reduce the land of middlemen by building necessary infrastructure such as collection centers, transportation materials and storage, and farmers can get the maximum reasonable price for their products.
- By promoting agroforestry as an enterprise and increasing industry and business, there is a need to maintain the country's economic prosperity, poverty reduction and food security.
- It is important that study, research and dissemination of agroforestry policies should be farmer-friendly and community-based.
- Farmers should be directly involved in the research.
- In the future, it is necessary to develop the sustainable development of this area by expanding the relationship between the forest and the agricultural system through the agricultural forest.

- To reduce the negative effects of climate change, the development of climate change adaptation and mitigation friendly agricultural systems is necessary.
- Raising public awareness among farmers about the impact of climate change on the agricultural sector, making them realize that climate-friendly agricultural systems are the next necessity.

(Kumar et al., 2012; Subedi et al., 2014; Sharma et al., 2023

Implications

Studying The Role of Agroforestry for Food Security and Climate Friendly Farming in Nepal and its Challenges and approaches can hold the following implications:

1. **Increased Food Security:** By incorporating trees into agricultural systems, agroforestry adds fruits and nuts to the mix of traditional crops. By expanding resilience to shocks brought on by climate change and diversifying food sources, an understanding of its practices can increase food security.
2. **Adaptation and Mitigation of Climate Change:** Carbon dioxide is sequestered by agroforestry systems, which reduces climate change. Researchers can contribute to climate-friendly farming practices by examining these activities in order to find strategies to improve agricultural systems' resilience to climatic variability and optimize carbon sequestration.
3. **Sustainable Land Management:** Deforestation, soil erosion, and unsustainable farming methods are the main causes of land degradation in Nepal. Agroforestry increases soil fertility, decreases soil erosion, conserves water, and increases tree cover all of which contribute to a sustainable approach to land management. Policymakers and farmers can be guided toward sustainable land management practices by having a clear understanding of the opportunities and problems associated with implementing agroforestry.
4. **Livelihood Diversification:** By selling lumber, fruits, and other tree products, agroforestry gives farmers access to alternate revenue streams. By diversifying their sources of income, households can become less reliant on a particular agricultural product and become more resilient to shocks to the economy.
5. **Biodiversity Conservation:** By offering homes to a variety of plant

and animal species, agroforestry systems can aid in the conservation of biodiversity. Developing conservation techniques that support agricultural production and biodiversity conservation requires an understanding of the relationships that exist between trees, crops, and biodiversity in agroforestry environments.

6. **Policy Formulation:** Studies on agroforestry techniques and their benefits can help in the creation of programs and policies that support Nepali food security, sustainable agriculture, and the preservation of natural resources. For agroforestry initiatives to be scaled up successfully and farmer issues to be addressed, evidence-based policy formulation is essential.

Conclusion

It has been more than several decades since there has been a public awareness discussion about climate change and its adaptation in Nepal at the national and district levels. However, the initiatives taken at the local level are not enough to adapt to climate change, especially for climate-friendly development of the agricultural sector. Although climate adaptation and low carbon emission-oriented development have been mainstreamed as a major part of the country's development at the policy level, access to climate change adaptation and the necessary technical knowledge, skills and capabilities at the local level has reached a very low level. It has become very necessary to develop the local agricultural system in a climate-friendly manner by supporting the capacity building of the farming community at the local level. Although Nepal emits very little greenhouse gas, Nepal is on the list of countries that are most vulnerable to the effects of climate change. As a matter of policy as well as practically, climate change adaptation programs are a priority area for Nepal. However, climate mitigation can also be co-benefited from the technologies promoted for climate adaptation, if special importance can be given to such technologies, a small contribution to climate mitigation can be made spontaneously by Nepal. For this, climate-friendly agriculture has great potential in the agricultural sector. Climate friendly agriculture helps to make agricultural production sustainable through climate adaptation and mitigation techniques and processes. Climate friendly agriculture is not a completely new method, but a method based on current good practices that include climate change adaptation and mitigation as a major agenda for the sustainable development of the agricultural sector through the promotion and expansion of climate-friendly agriculture in Nepal, local knowledge, skills and technologies can be properly managed, local resources can be properly and sustainably mobilized, local self-employment can be created, agricultural production costs can be reduced, and agricultural ecosystems can be managed sustainably. It can be put into practice.

References

Acharya, K.P. (2002). Twenty-four years of community forestry in Nepal, *The International Forestry Review 4*(2) 151-156.

Amatya, S. M. (1994). Agroforestry Systems and Practice in Nepal. *Forest Research and Survey Centre. Ministry of Forests and Soil Conservation,* Babarmahal, Kathmandu, Nepal.

Amatya, S. M., Cedamon, E., & Nuberg, I. (2018). Agro-forestry systems and practices in Nepal. *Revised Edition. Agriculture and Forestry University.*

Aryal, K., Thapa, P. S., & Lamichhane, D. (2019). Revisiting agro-forestry for building climate resilient communities: a case of packagebased integrated agroforestry practices in Nepal. *Emerging Science Journal, 3*(5): 303–311.

Atreya, K., Subedi, B. P., Ghimire, P. L., Khanal, S. C., Charmakar, S., & Adhikari, R. (2021). Agro-forestry for mountain development: prospects, challenges and ways forward in Nepal. *Archives of Agriculture and Environmental Science, 6* (1): 87–99. https://doi. org/10.26832/24566632. 2021.0601012

Bartlett, R., Bharati, L., Pant, D., Hosterman, H., and McCornick, P. (2010). Climate change impacts and adaptation in Nepal. *International Water Management Institute (IWMI) Working Paper no 139,* Colombo, Sri Lanka.

Bekele, Solomon Estifanos (2018). Parkland Agro-forestry of Ethiopia; Key to Production, Productivity, Biodiversity Conservation and Climate Change Mitigation: *A Review Open Journal of Forestry,* 2018, 8, 472-488 http://www.scirp.org/journal/ojf ISSN Online: 2163-0437 ISSN Print: 2163-0429,

Bhagat, Rakshit, Walia, Sohan Singh, Sharma, Kartik, Singh, Rajbir, Singh, Gurshaminder, Hossain, Akbar (2024). The integrated farming system is an environmentally friendly and cost-effective approach to the sustainability of agri-food systems in the modern era of the changing climate: *A comprehensive review, Food and Energy Security,* DOI: 10.1002/fes3.534

Branca G, McCarthy N, Lipper L, Jolejole MC. (2011). Climate smart agriculture: a synthesis of empirical evidence of food security and mitigation benefits from improved cropland management. *Mitigation of climate change in agriculture series,* 3, pp.1-42.

Campbell, B. M., Thornton, P., Zougmore, R., Van Asten, P., and Lipper, L. (2014). Sustainable intensification: What is its role in climate smart agriculture? Current Opinion in Environmental Sustainability, 8, 39-43.

CBS. (2013). National Sample Census of Agriculture Nepal 2011/12. *National Report. National Planning Commission Secretariat, Central Bureau of*

Statistics, Kathmandu. Government of Nepal.

Dhakal, Arun, Cockfield, Geoff, Maraseni, Tek Narayan (2012). Evolution of agroforestry-based farming systems: a study of Dhanusha District, Nepal, *Agroforest Syst* (2012) 86:17–33, DOI 10.1007/s10457-012-9504-x

Dhyani, Shiv Kumar, Rizvi, Javed and Nayak, Devashree (2019). Agroforestry: Traditions, Transformations and Prospects Focus on Asia and Africa, World Agro-forestry, *South Asia Regional Program (SARP), ICRAF, NASC Complex, PUSA,* New Delhi

District Agriculture Development Office (NA). Panchthar, Records of Extinct and Endangered Species of Grain in District, *GoN. Ministry of Agriculture Development. Agriculture Department, Regional Directorate of Agriculture,* Panchthar.

Dove, M. R. (1992). Foresters' beliefs about farmers: a priority for social science research in social forestry, *Agroforestry Systems* 17: 13-41.

FAO (2008). An Introduction to the Basic Concepts of Food Security. Published by the EC - *FAO Food Security Programme.* Accessed on: www.foodsec.org/docs/concepts_guide.pdf

FAO (2011). Climate-Smart Agriculture Managing Ecosystems for Sustainable Livelihoods Rome, Italy: *Food and Agriculture Organization of the United Nations* (FAO).

FAO (2013). Climate-smart Agriculture Sourcebook. Rome, Italy: *Food and Agriculture Organization of the United Nations (FAO).*

FAO (2014). Statistical Year book 2014 Asia and the pacific food and agriculture. *Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific,* Bangkok.

FAO (2017). Strengthening Sector Policies for Better Food Security and Nutrition Results. *Food and Agriculture Organization.*

Ghimire, Manisha, Khanal, Ashish, Bhatt, Deepa, Daha, Dhiraj Datta, Giri, Suja (2024). Agroforestry systems in Nepal: Enhancing food security and rural livelihoods – a comprehensive review, *Food and Energy Security,* Weekly, DOI: 10.1002/fes3.524

Imran MA, Ali A, Ashfaq M, Hassan S, Culas R, Ma C. (2018). Impact of Climate Smart Agriculture (CSA) practices on cotton production and livelihood of farmers in Punjab, Pakistan. *Sustainability,* 10(6), p.2101. DOI: https://doi.org/ 10.3390/su10062101

Jha, Dinanath (2004). RudrakshaRahasya, India: *Bhagawati Pocket Books.*

Joshi, Suresh C and Jain K. Prativa (2014). A Review on Ethnomedicinal and Traditional Use of Elaeocarpus ganitrusRoxb. (Rudraksha). *Int J Pharma Bio Sci* 2014 Jan j 5(1): P 495-511 ISSN 0975-6299

Joshi, S., Gupta, P., Kumar, N., Rai, N., Gautam, P., & Thapliyal, A. (2012). A comprehensive report on the therapeutic potential of Elaeocarpus ganitrus Roxb. (Rudraksha). *Environment Conservation Journal,* 13(3), 147-150.

Karki, R. and Gurung, A. (2012). An Overview of Climate Change and Its Impact on Agriculture: a Review From Least Developing Country, Nepal, *International Journal of Ecosystem* 2012, 2(2): 19-24 DOI: 10.5923/j.ije.20120202.03

Khanal, R.C. (2009). Climate change and organic agriculture. *Journal of Agriculture and Environment.* 10(1), 100-10.

Koirala, M. and Bhatta. R. (2010). Communities Challenging Climate Change. Case Studies from Nepal. *NEFEJ.*

Kumar, B. Mohan, Singh, Anil Kumar, Dhyani, S. K. (2012). South Asian Agroforestry: Traditions, Transformations, and Prospects, DOI:10.1007/978-94-007-4676-3_19

Kumar N, Dubey M, Agarwal V, (2013). Rudraksha: A Review on Mythological, Spiritual and Medicinal Importance, *Global Journal of Research Medicinal Plants & Indigenous Medicine,* 2(1),

Kumar, Shiva (2020). Major Rudraksha: India: *Notion Press*

Magcale-Macandog, D. B., Rañola, F. M. (2009). Enhancing the food security of upland farming households through agroforestry in Claveria, Misamis Oriental, Philippines. *Agroforestry Systems* 79(3): 327-342.

Mahat, T.B.S. (1987). Forestry-Farming Linkages in the Mountains. Occasional Paper No. 7, *Kathmandu. ICIMOD*

Malla, G. (2008). Climate Change and Its Impact on Nepalese Agriculture. *The Journal of Agriculture and Environment* Vol:9, 62-71

Malla, Y.B. (2011). Impacts of Community Forestry Policy in Rural Livelihoods and Food Security in Nepal. *Unasylva* 200(38-45).

https://www.researchgate.net/figure/Contributions-of-forest-and-trees-to-food-systems

McCarthy, N., Lipper, L., and Branca, G. (2011). Climate-smart agriculture: smallholder adoption and implications for climate change adaptation and mitigation. *Mitigation of Climate Change in Agriculture Working Paper,* 3.

Mulatu1, Kassahun, Hunde, Debela (2019). Agroforestry: A Supplementary Tool for Biodiversity Conservation and Climate Change Mitigation and Adaptation, *Journal of Natural Sciences Research,* www.iiste.org ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online) Vol.9, No.19, 2019,

Nair, P.K.R. (1983). Agroforestry with coconuts and other tropical plantation crops. In: Huxley, P.A. (ed.), *Plant Research and Agroforestry,* pp. 79-102. ICRAF, Nairobi, Kenya.

Nair, P.K.R. (1993). An introduction to Agroforestry, DORDRECHT / BOSTON / LONDON, Kluwer *Academic Publishers,* ISBN 0-7923-2134-0

Norgrove, Lindsey, Beck Jan (2016) Biodiversity Function and Resilience in Tropical Agroforestry Systems Including Shifting Cultivation, *Curr Forestry Rep* (2016) 2:62–80 DOI 10.1007/s40725-016-0032-1,