Agroforestry Practices for Climate Change Adaptation and its Contribution to Farmers' Income

Article *in* Grassroots Journal of Natural Resources · September 2021

DOI: 10.33002/nr2581.6853.040305

Rajeev Joshi
Amity Global Education (Lord Buddha College)

Deepa Paudel
Tribhuvan University, Institute of forestry,Pokhara ,Nepal

Grassroots Journal of Natural Resources, Vol.4 No.3 (September 2021)
ISSN 2581-6853 | CODEN: GJNRA9 | Published by The Grassroots Institute
Website: http://grassrootsjournals.org/gjnr | Main Indexing: Web of Science

ISSN 2581-6853 | 4(3) Sep 2021

OPEN ACCESS Freely available online

M – 00242 | Research Article

Agroforestry Practices for Climate Change Adaptation and its Contribution to Farmers' Income

Raju Prasad Bhandari[1], Rajeev Joshi[*2], Deepa Paudel[3]

[1]Tribhuvan University, Institute of Forestry, Pokhara Campus, Post Box No. 43, Hariyo Kharka-15, Pokhara, Gandaki province, Nepal. Email: rajuprasad2080@gmail.com | ORCID: 0000-0001-6749-2490

[2]Forest Research Institute (Deemed to be) University, Dehradun-248195, Uttarakhand, India; Faculty of Forestry, Amity Global Education (Lord Buddha College), CTEVT, Tokha -11, Kathmandu-44600, Nepal. Email: joshi.rajeev20@gmail.com | ORCID: 0000-0003-1106-9911

[3]Tribhuvan University, Institute of Forestry, Pokhara Campus, Post Box No. 43, Hariyo Kharka- 15, Pokhara, Gandaki province, Nepal. Email: skt.deepa@gmail.com | ORCID: 0000-0002-6447-1026

**Corresponding author*

How to cite this paper: Bhandari, R.P., Joshi, R. and Paudel, D. (2021). Agroforestry Practices for Climate Change Adaptation and its Contribution to Farmers' Income. *Grassroots Journal of Natural Resources*, 4(3): 42-51. Doi: https://doi.org/10.33002/nr2581.6853.040305

Received: 24 June 2021
Reviewed: 18 July 2021
Provisionally Accepted: 24 July 2021
Revised: 03 August 2021
Finally Accepted: 12 August 2021
Published: 30 September 2021

Abstract

Agroforestry practices offer a unique opportunity to address climate change impacts while securing the livelihoods of the rural communities. This study was carried out in Tillotama municipality of Rupandehi district, Nepal. Agroforestry system practices at the study site were identified through reconnaissance survey and discussions with ward officials. With 10% sampling intensity, purposive sampling was adopted for the study using the structured questionnaire, key informant interview, and field observation. For mean comparison, one-way ANOVA and Least Significant Difference (LSD) as post-hoc tests were carried out. Local communities were adopting eight different types of agroforestry practices under four agroforestry systems, namely agri-silvicultural, silvo-pastoral, agro-silvopastoral and silvi-fishery. The agroforestry system shared up to 50.54% of total households' income, in which income from agriculture was the highest. Agroforestry income was dependent on the economic status of the households. Change in cropping calendar was found as a major adaptation strategy. Scaling up of agroforestry system and commercialization of agroforestry products were recommended.

Keywords

Adaptation; Agroforestry; Climate change; Impacts; Income

Doi: https://doi.org/10.33002/nr2581.6853.040305 OPEN ACCESS Freely available online

Introduction

Agroforestry is a climate-smart production system and is considered more resilient than mono-cropping (Charles *et al*., 2014; Haile *et al*., 2019). It is one of the most experimented land-use systems across landscapes and agro-ecological zones in Nepal (Nair, 2007; McCord *et al*., 2015). With food shortages and increased threats of climate change, interest in agroforestry is gathering for its potential to address various on-farm adaptation needs, and fulfill many roles in AFOLU (agriculture, forestry, and other land-use) related mitigation pathways (Mbow *et al*., 2014). It can play a crucial role in improving resilience to uncertain climates through micro-climate buffering and regulation of water flow (Stigter, 2015). When it provides assets and income from carbon, wood energy, improved soil fertility, and enhancement of local climate conditions, it provides ecosystem services and reduces human impacts on natural forests (Moreno *et al*., 2018). Most of these are direct benefits for local adaptation while contributing to global efforts to control atmospheric greenhouse gas concentrations (Rosenzweig and Tubiello, 2007). Furthermore, agroforestry provides a particular example of a set of innovative practices that are designed to enhance productivity in a way that often contributes to climate change mitigation through enhanced carbon sequestration, and that can also strengthen the system's ability to adapt to adverse impacts of changing climatic conditions (Verchot *et al*., 2007; Mbow *et al*., 2014).

Climate change is projected to affect agricultural and natural ecosystems around the world, and there is no reason to expect that agroforestry systems will be spared (Luedeling *et al*., 2014). As the impacts of climate change have become apparent around the world, adaptation has attracted increasing attention (Mimura *et al*., 2015). With the world's population increase, the need for more productive and sustainable use of the land becomes more urgent. To meet the demand for food by 2050, world food production will have to increase by over 60% (Mckenzie and Williams, 2015). But the shortfall in domestic cereals production in the developing world was expected to widen from around 100 million tons in 1997 to around 190 million tons in the year 2020 (Rosegrant *et al*., 2001; Verchot *et al*., 2007). In many regions of the world, there will be limited ability for new varieties and increased fertilizer use to further increase the yields (Huang, Pray and Rozelle, 2002; Balemi and Negisho, 2012).

Agroforestry systems include both traditional and modern land-use system dynamics, and ecologically based natural resource management systems that diversify and sustain production in order to increase social, economic, and environmental benefits for land users at all scales (Pandey, 2007). Agroforestry as a tree-based system combines trees and/or shrubs, animals, and agronomic crops. It provides a particular example of a set of innovations designed to enhance REDD+ through carbon substitution, carbon conservation, and carbon sequestration in the agricultural landscape (Charles, Nzunda and Munishi, 2014). The rapid increase in Earth's surface temperature and changing precipitation pattern has resulted in direct implications to multiple sectors and livelihood of communities (Rao and Leal Filho, 2015). The poorest and vulnerable people are being affected the most (Mustafa, 2011). The data trend from 1975 to 2005 shows that the mean annual temperature has increased by 0.06°C, while the mean rainfall has decreased by 3.7 mm (-3.2%) per month per decade (MoE, 2012). Similarly, mean annual temperature is predicted to be increased between 1.3°C to 3.8°C by the 2060s and 1.8°C to 5.8°C by the 2090s while annual precipitation could reduce by the range of 10 to 20 percent across the country Nepal (Joshi and Singh, 2020; MoE, 2010). Studies also indicate that the observed warming trend is not uniform across the country. Agroforestry land-use management is necessary for increasing soil carbon stocks and socio-economic development of farmers; and the research on the carbon sequestration rate of agroforestry is necessary for making future policies and strategies on the issue of climate change. However, there were limited research (Neupane and Thapa, 2001; Regmi, 2003) carried out in the field of agroforestry, mostly focusing on soil fertility and local livelihood.

Methodology

Study Area

The study was carried out in Gangolia village of Tilottama municipality in Rupandehi district, which lies in the Southern part of Lumbini Province of Nepal with the coordinates of 27°37′48″ N latitude and 83°27′36″ E longitude. The district Rupandehi lies in the southern and western parts of Nepal. On the East, it shares a border with Nawalparasi district, on the West with Kapilvastu district, on the North with Palpa district, and on South with India. The elevation of the district lies between 100 m to 1229 m from sea level. The total area of the district is 1,360 km^2 with 16.1% in Churia Range and the rest in the Terai[1] region. Recently, the Government of Nepal is planning to extend the agroforestry system in the Rupandehi district by considering an agroforestry pocket area. Only a few farmers have been practicing different types of agroforestry systems for few decades, although such type of study is lacking in this area.

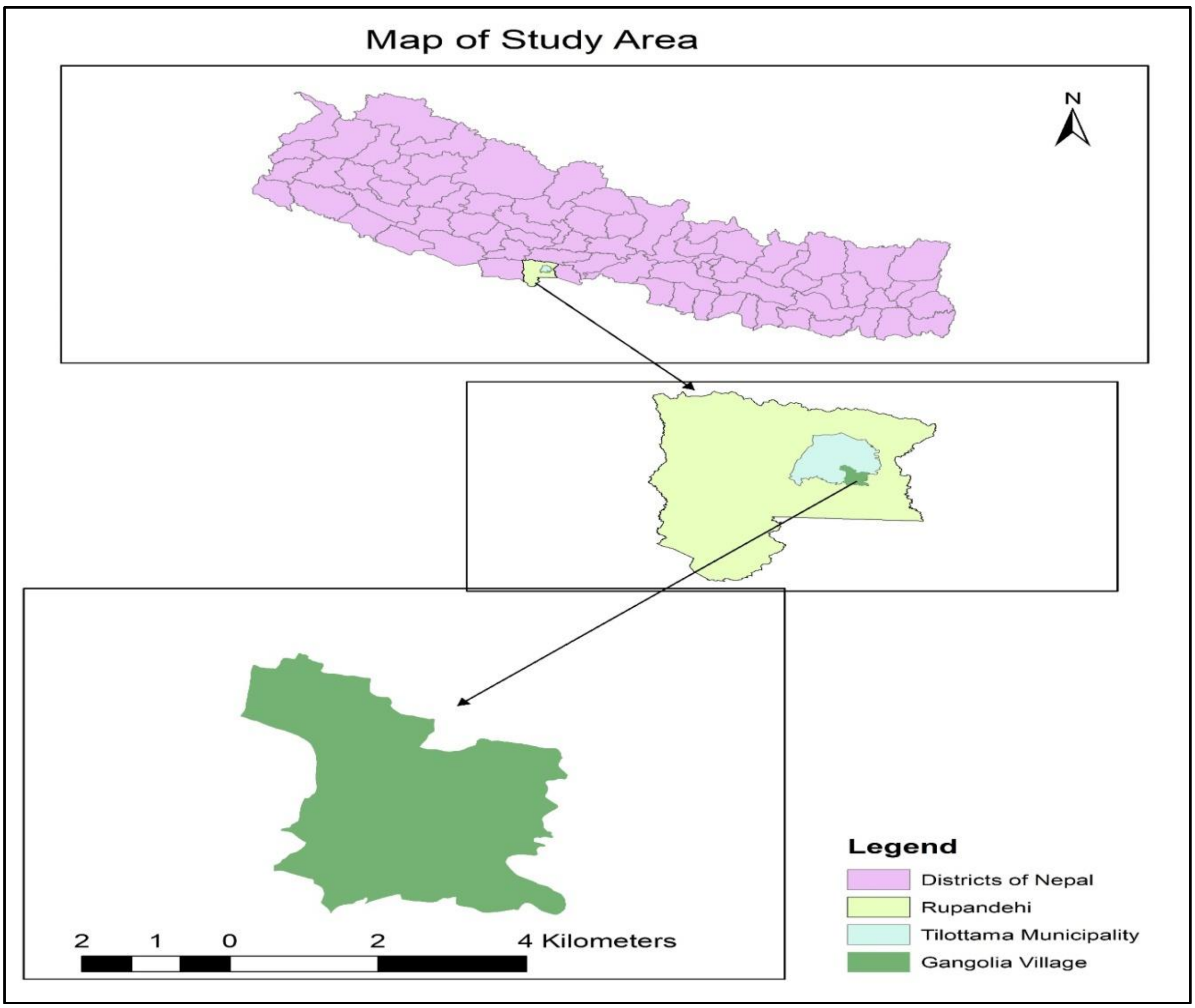

Figure 1: Map of the study area

[1] Terai is a lowland belt of southern Nepal, mainly characterized by tall grasslands, scrub savannah, Sal forests and clay rich swamps (Dahal *et al*., 2021).

Data Collection

The primary data were collected from the study site by employing a combination of social survey methods involving participatory techniques such as on-site field observation, household survey questionnaire, and key informant interview. The sampling used for this study was purposive sampling with a sampling intensity of 10% (Kombo and Tromp, 2006). Out of the total 304 households in Gangolia village of Rupandehi district, 33 households (10% sampling intensity) were sampled.

The various relevant and related secondary data were derived from published research papers, articles, newspapers, brochures, leaflets, annual reports, progress report and other publications of various related authorities. Secondary databases of precipitation and temperature were collected from the Department of Hydrology and Meteorology.

Data Processing and Analysis

Quantitative data were analyzed using descriptive and inferential statistics such as percentage, mean, frequency distribution, and use of graphics and parametric test i.e., F-test (ANOVA). F-test was used to compare the income of farmers from the agroforestry system with its determining factors like caste, well-being ranking, education level, and family size. Similarly, rainfall and temperature data of 30 years (1989-2018) were analyzed using the Least square curve fitting technique i.e., Y=a+bt where, y=temperature or rainfall, t=time (year), a and b are constant estimated.

Results and Discussion

Socio-Demographic Status of Respondents

The age group of the respondents mostly lies between 35 to 60 years. The major castes/ethnic groups in the study area were Brahmin/Chhetri, Janjati, Dalit, and others represented by 30%, 50%, 10%, and 10%, respectively, among the sampled households. Literacy level among the sample respondents was primary level (33.3%), secondary level (30%), and higher secondary and above (36.7%). Most of the households (HHs) had 4 to 12 members. Among the sampled households, about 3.3% HHs were having less than 6 family members, 40% having 6 to 7, 40% sampled households 7 to 9 family members and 16.6% HHs more than 10 family members.

Annual Income of Farmer

The majority of the household income was from agroforestry (50.19%) followed by remittances/pensions (21.01%), services, business, and wages to be 15.79%, 9.27%, and 3.73%, respectively. An increase in size of these parameters brought about an increase in the household's annual income and, thus, contributing to poverty alleviation. Contribution of agroforestry components on total farm income of the farmers showed that mean annual income from agriculture was found to be 42%, followed by livestock, fisheries, poultry, tree and fuelwood with 27%, 16%, 11%, 3%, and 1%, respectively (Figure 2).

Mean Test of Agroforestry Income of the Farmer with respect to different Socio-economic Variables

Distribution of the socio-economic factors influencing agroforestry income showed overall significance to only wellbeing status (rich/medium/poor) of the household. In regard to caste, Brahmin/Chhetri with Janjati was significant; but Brahmin/Chhetri with Dalit and Other are insignificant at a 5% level of significance. Similarly, education level and family size are also insignificant to the total annual income of agroforestry income. So, we can conclude that level of education and family size did not affect the income from agroforestry.

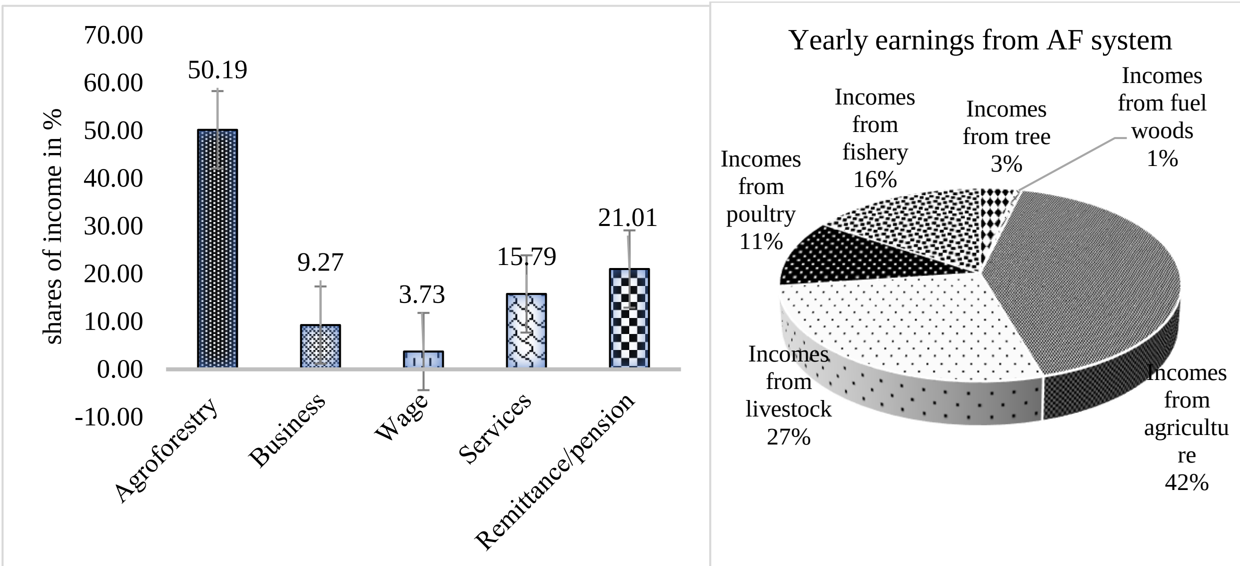

Figure 2: Gross Annual income of Farmer with Yearly Earnings from AF System

Table 1: Mean Test of Agroforestry Income of the Farmer with respect to different Socio-economic Variables

Caste					
Variables	*Co-variates*	*Sig.*	*Overall df*	*Overall F*	*Overall Sig.*
Brahimin/Chhetri	Janajati	0.890	(3, 26)	2.70	0.65
	Dalit	0.027*			
	Other	0.042*			
Wellbeing					
Rich	Middle class	0.0005	(2, 27)	9.43	0.01
	Poor	0.001			
Education level					
Primary level	Secondary level	0.852	(2, 27)	0.17	0.87
	Higher secondary & above	0.609			
Family size					
Family size	-	-	29	3.13	0.29

*The mean difference is significance at the 0.05 level.

Climate Change Adaptation Strategies through Agroforestry System Practices

Almost 30 years' climatic data from 1989 to 2018 of Bhairahawa meteorological station showed that the average annual rainfall was in increasing trend with 0.034 cm per year which is shown in figure 3. The trend of the maximum temperature was also in increasing order of 0.026°C per year as shown in figure 4.

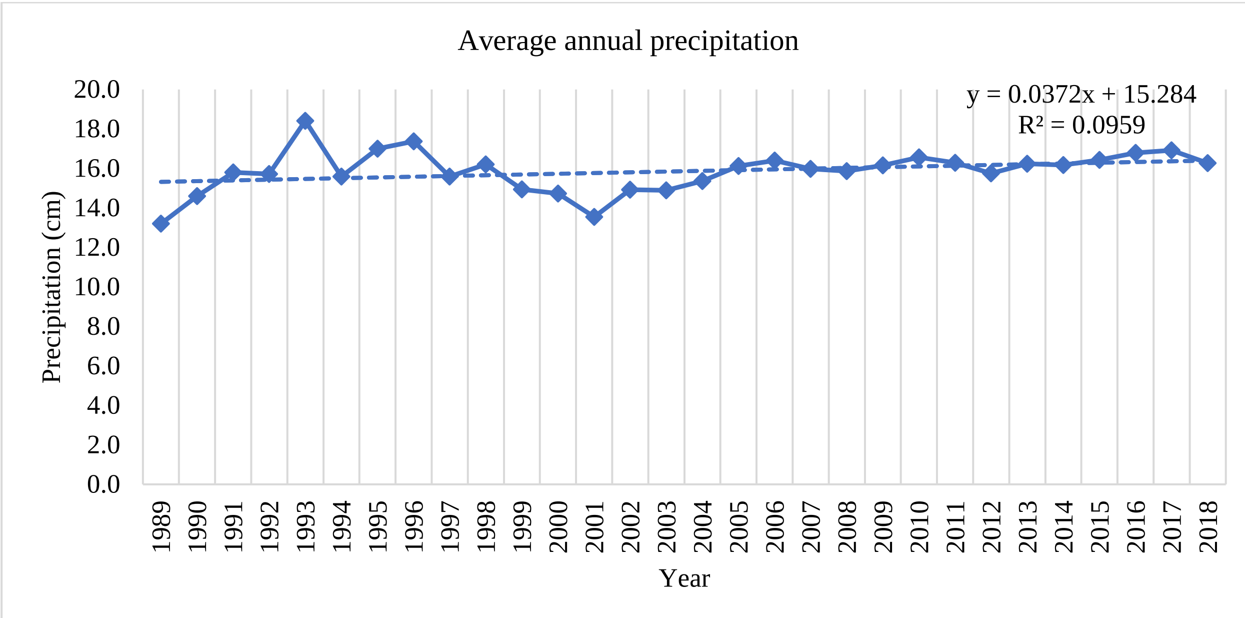

Figure 3: Average annual precipitation

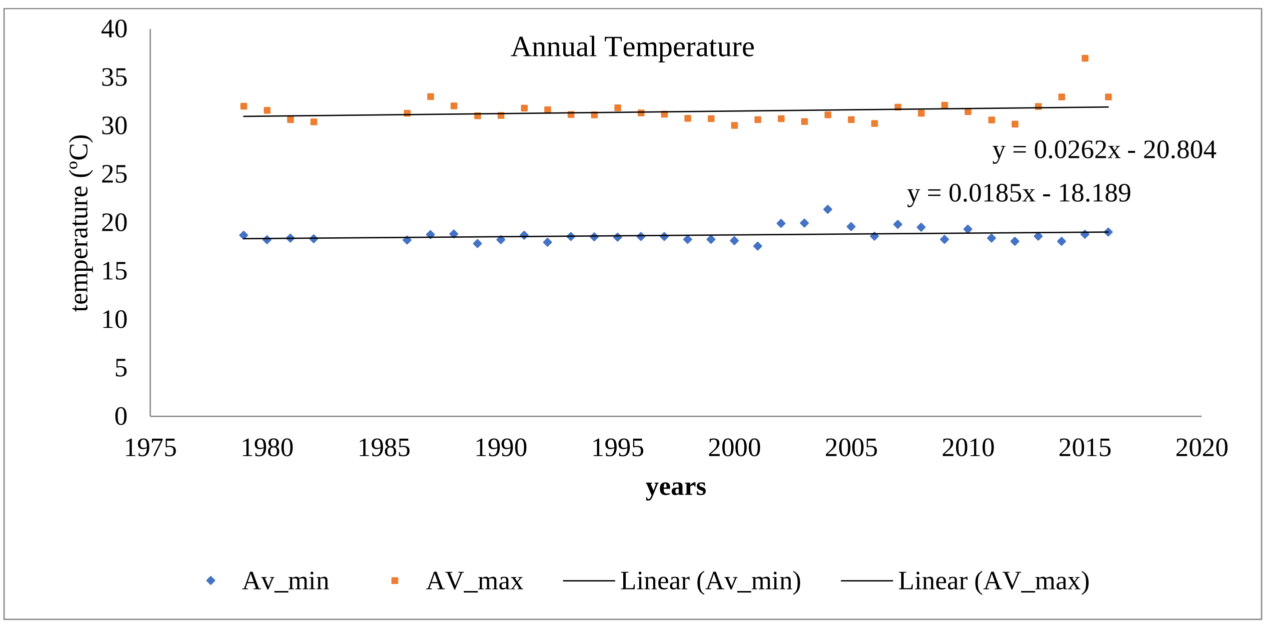

Figure 4: Average annual temperature

Specific Adaptation Strategies' Adopted at Households level

The strategies adopted by the farmers against climate change were found mainly in the form of using chemical fertilizers and pesticides (25%), diversification of income-generating activities (27%), agroforestry (18%), and changing the crop calendar (30%). Similar findings like crop-livestock diversification and multiple cropping strategies were reported by several scholars (Assoumana *et al.*, 2016; Gebreeyesus, 2017; Mekuria and Mekonnen, 2018).

The respondents who practiced agroforestry experienced various benefits such as improved soil fertility rate (32%), improved micro-climate (24%), increased catchment for pump set and boring (29%), and increased wood products (15%), although these methods are not sufficient to control climate change effects.

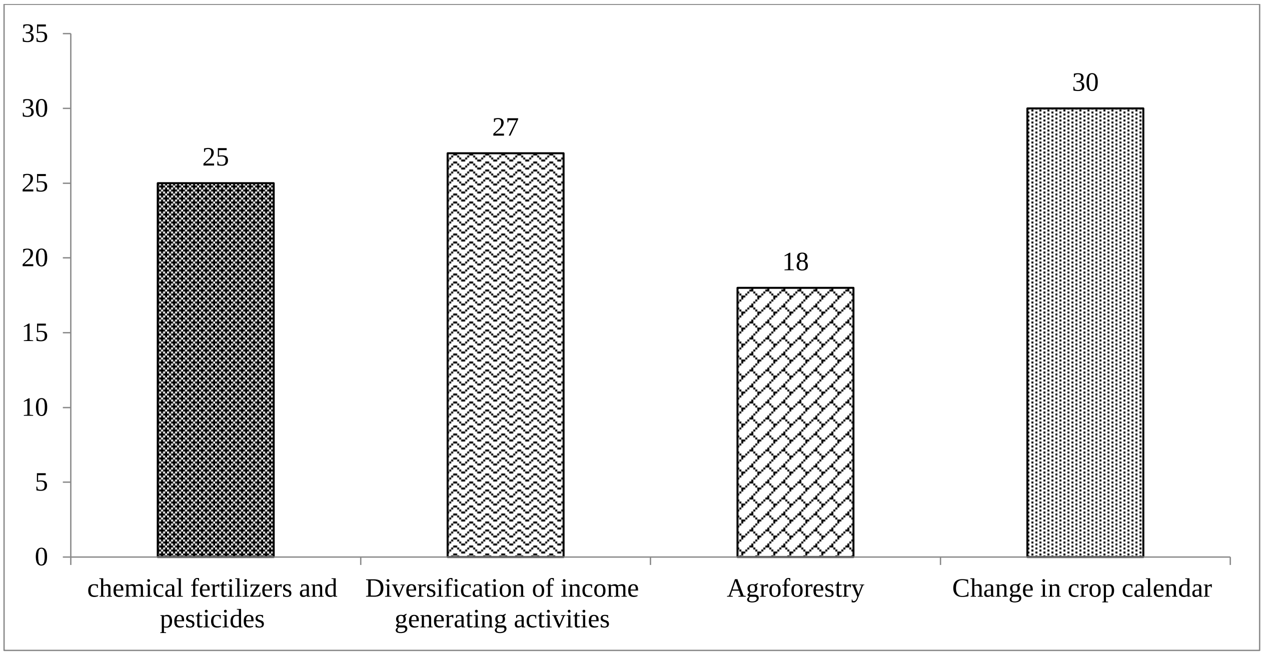

Figure 5: Specific adaptation strategies adopted at household level

Conclusion and Recommendation

Agroforestry has a significant impact on the livelihood of people engaged in agriculture primarily and on those who have low adaptive capacity. In the study area, trees on farmland were found as part of traditional practices. Agroforestry shares about 50% of total HH's income, in which the income from agriculture was highest. Income from the agroforestry system was found highly dependent on the socio-economic status of the households. The temperature has been increased by 0.026°C per year and rainfall by 0.04 cm per year. Change in the cropping calendar was found as a major climate change adaptation strategy by the farmers.

Agroforestry is one of the best options to make the community more resilient from adverse impacts of climate change through increased income and environmental services. Thus, the promotion of agroforestry practices in private land should be emphasized by the government. The practice of agroforestry should be done on a large scale to mitigate the adverse effects of climate change. Commercialization of agroforestry products should be done to enhance the farmer's income. To encourage the farmers to practice agroforestry practices, they should be provided with capacity building, training, and information to make them aware of the benefits of agroforestry.

Acknowledgement

We are grateful to Tribhuvan University's Institute of Forestry, Office of Dean, Pokhara/ NORHED-SUNREM project for assisting under Faculty Strategic Research Grant scheme. The authors would like to acknowledge Ms. Sushma Bhattarai, Ms. Neeru Thapa, Mr. Prabin Pandit, Mr. Ajay Bhandari, and Mr. Prasiddha Khadka for assisting in providing valuable sources of information for this study. The authors are thankful to the local people of Gangolia village, Rupandehi district for their generous support during the fieldwork.

References

Assoumana, B.T., Ndiaye, M., Puje, G., Diourte, M. and Graiser, T. (2016). Comparative assessment of local farmers' perceptions of meteorological events and adaptations strategies: Two Case Studies in Niger Republic. *Journal of Sustainable Development*, 9(3): 118-135. DOI: https://doi.org/10.5539/jsd.v9n3p118

Balemi, T. and Negisho, K. (2012). Management of soil phosphorus and plant adaptation mechanisms to phosphorus stress for sustainable crop production: a review. *Journal of Soil Science and Plant Nutrition*, 12(3): 547-562. DOI: https://dx.doi.org/10.4067/S0718-95162012005000015

Charles, R.L., Nzunda, E.F. and Munishi, P.K.T. (2014). Agroforestry as a resilient strategy in mitigating climate change in Mwanga District, Kilimanjaro, Tanzania. *Global Journal of Bilogy, Agriculture and Health Sciences*, 3: 11-17.

Dahal, B., Joshi, R., Poudel, B. and Panta, M. (2021). Community Forestry Governance in Federal System of Nepal. *Journal of Policy & Governance*, 01(01): 30-45. DOI: https://doi.org/10.33002/jpg010103

Gebreeyesus, K.A. (2017). Impact of climate change on the agroecological innovation of coffee agroforestry systems in Central Kenya (Doctoral dissertation, Montpellier SupAgro).

Haile, K.K., Tirivayi, N. and Tesfaye, W. (2019). Farmers' willingness to accept payments for ecosystem services on agricultural land: The case of climate-smart agroforestry in Ethiopia. *Ecosystem Services*, 39: 100964. DOI: https://doi.org/10.1016/j.ecoser.2019.100964

Huang, J., Pray, C. and Rozelle, S. (2002). Enhancing the crops to feed the poor. *Nature*, 418(6898): 678-684. DOI: https://doi.org/10.1038/nature01015

Joshi, R. and Singh, H. (2020). Carbon sequestration potential of disturbed and non-disturbed forest ecosystem: A tool for mitigating climate change. *African Journal of Environmental Science and Technology*, 14(11): 385-393. DOI: https://doi.org/10.5897/AJEST2020.2920

Kombo, D.K. and Tromp, D.L. (2006). Proposal and thesis writing: An introduction. *Nairobi: Paulines Publications Africa*, 5(1): 814-30.

Luedeling, E., Kindt, R., Huth, N.I. and Koenig, K. (2014). Agroforestry systems in a changing climate-challenges in projecting future performance. *Current Opinion in Environmental Sustainability*, 6: 1-7. DOI: https://doi.org/10.1016/j.cosust.2013.07.013

Mbow, C., Smith, P., Skole, D., Duguma, L. and Bustamante, M. (2014). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability*, 6: 8-14. DOI: https://doi.org/10.1016/j.cosust.2013.09.002

Mbow, C., Van Noordwijk, M., Luedeling, E., Neufeldt, H., Minang, P.A. and Kowero, G. (2014). Agroforestry solutions to address food security and climate change challenges in Africa. *Current Opinion in Environmental Sustainability*, 6: 61-67. DOI: https://doi.org/10.1016/j.cosust.2013.10.014

McCord, P.F., Cox, M., Schmitt-Harsh, M. and Evans, T. (2015). Crop diversification as a smallholder livelihood strategy within semi-arid agricultural systems near Mount Kenya. *Land Use Policy*, 42: 738-750. DOI: https://doi.org/10.1016/j.landusepol.2014.10.012

McKenzie, F.C. and Williams, J. (2015). Sustainable food production: constraints, challenges and choices by 2050. *Food Security*, 7(2): 221-233. DOI: https://doi.org/10.1007/s12571-015-0441-1

Mekuria, W. and Mekonnen, K. (2018). Determinants of crop–livestock diversification in the mixed farming systems: evidence from central highlands of Ethiopia. *Agriculture & Food Security*, 7(1): 1-15.

Mimura, N., Pulwarty, R.S., Elshinnawy, I., Redsteer, M.H., Huang, H.Q., Nkem, J.N. and Kato, S. (2015). Adaptation planning and implementation. In *Climate Change 2014 Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects* (pp. 869-898). Cambridge: Cambridge University Press. DOI: https://doi.org/10.1017/CBO9781107415379.020

MoE (2010) National adaptation programme of action (NAPA) to climate change. Government of Nepal, Ministry of Environment, Kathmandu, Nepal, Kathmandu

MoE (2012). Mountain Environment and Climate Change in Nepal: National Report prepared for the International Conference of Mountain Countries on Climate Change, 5–6 April 2012, Kathmandu: Ministry of Environment, Government of Nepal, 56 pp.

Moreno, G., Aviron, S., Berg, S., Crous-Duran, J., Franca, A., de Jalón, S. G. and Burgess, P.J. (2018). Agroforestry systems of high nature and cultural value in Europe: provision of commercial goods and other ecosystem services. *Agroforestry Systems*, 92(4): 877-891. DOI: https://doi.org/10.1007/s10457-017-0126-1

Mustafa, Z. (2011). Climate Change and Its Impact with Special Focus in Pakistan. *Pakistan Engineering Congress, Symposium*, 33: 290.

Neupane, R.P. and Thapa, G.B. (2001). Impact of agroforestry intervention on soil fertility and farm income under the subsistence farming system of the middle hills, Nepal. *Agriculture, Ecosystems & Environment*, 84(2): 157-167. DOI: https://doi.org/10.1016/S0167-8809(00)00203-6

Pandey, D. (2007). Multifunctional agroforestry systems in India. *Current Science,* 92(4): 455-463. Available online at http://www.jstor.org/stable/24097558 [accessed on 24 June 2021]

Nair, P.K.R. (2007). Agroforestry for sustainability of lower-input land-use systems. *Journal of Crop Improvement*, 19(1-2): 25-47. DOI: https://doi.org/10.1300/J411v19n01_02

Rao, P. and Leal Filho, W. (2015). Local community perception of climate change and scientific validation: a review of initiatives and perspectives in the Indian region. *Climate Change in the Asia-Pacific Region*, 89-101. DOI: https://doi.org/10.1007/978-3-319-14938-7_6

Regmi, B.N. (2003). Contribution of agroforestry for rural livelihoods: A case of Dhading District, Nepal. In: *International Conference on Rural Livelihoods, Forests and Biodiversity, Bonn, Germany* (pp. 19-23).

Rosegrant, M.W., Paisner, M.S., Meijer, S. and Witcover, J. (2001). *Global food projections to 2020: Emerging trends and alternative futures*. International Food Policy Research Institute, Washington, USA, 206 pp.

Rosenzweig, C. and Tubiello, F.N. (2007). Adaptation and mitigation strategies in agriculture: an analysis of potential synergies. *Mitigation and Adaptation Strategies for Global Change*, 12(5): 855-873. DOI: https://doi.org/10.1007/s11027-007-9103-8

Stigter, K.C.J. (2015). Agroforestry and micro-climate change. *Tree-crop Interactions: Agroforestry in a Changing Climate, CABI, University of Nottingham, Malaysia*, 509: 119-145.

Verchot, L.V., Van Noordwijk, M., Kandji, S., Tomich, T., Ong, C., Albrecht, A. and Palm, C. (2007). Climate change: linking adaptation and mitigation through agroforestry. *Mitigation and Adaptation Strategies for Global Change*, 12(5): 901-918. DOI: https://doi.org/10.1007/s11027-007-9105-6.

Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2	Author 3
Conceived and designed the research or analysis	Yes	Yes	Yes
Collected the data	Yes	No	No
Contributed to data analysis & interpretation	Yes	No	Yes
Wrote the article/paper	Yes	Yes	Yes
Critical revision of the article/paper	No	Yes	No
Editing of the article/paper	Yes	Yes	Yes
Supervision	No	Yes	No
Project Administration	Yes	Yes	Yes
Funding Acquisition	Yes	Yes	Yes
Overall Contribution Proportion (%)	40	30	30

Funding
The funding was available for the research conducted for and writing of this paper from the Institute of Forestry, Office of Dean, Pokhara under NORHED-SUNREM project (Faculty Strategic Research Grant scheme).

Research involving human bodies (Helsinki Declaration)
Has this research used human subjects for experimentation? No

Research involving animals (ARRIVE Checklist)
Has this research involved animal subjects for experimentation? No

Research involving Plants
During the research, the authors followed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora. Yes

Research on Indigenous Peoples and/or Traditional Knowledge
Has this research involved Indigenous Peoples as participants or respondents? No

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
Have authors complied with PRISMA standards? No

Competing Interests/Conflict of Interest
Authors have no competing financial, professional, or personal interests from other parties or in publishing this manuscript.

Rights and Permissions