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Adoption of climate resilientagro-ecological practices in Karnali river basins

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ABSTRACT

Aim: The aim of the study was to explore the relationship between the socio-economic conditions of farming communities and adoption of these agro-ecological technologies and practices in province.
Materials and Methods: Data collected through households surveys, Focus Group Discussion (FGD) and Key Informant Interviews (KII) from the Karnali river basin districts were analyzed using descriptive and inferential statistics.
Results: Eighteen different climate resilient agro-ecological practices categorized under six different headings, such as cropping/planting method, resilient seed/breed, disease and pest management, water management, carbon/nutrient management, and farmer's risk reduction, were found to be practiced by the farmers. The highest number of climate resilient ecological practices was found being practiced in pulses (11), followed by cereals, vegetables, and oil crops (10). Women were more trained in agro-ecological farming than men. Each variable of the socio-economic condition except caste and income showed a significant relationship with adoption of climate resilient agro-ecological practices.
Conclusion: It was concluded that farmers should be awared about technologies being used are the climate resilient agro-ecological technologies and their importance in the maintenance of the ecosystem balance.

Keywords: agro-ecology, socio-economic condition, climate resilient, awareness.

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Introduction

Bread Agro-ecology is a bridge to promote a dialogue between modern scientific agriculture and agriculture based on indigenous/local knowledge with a concept of developing a resilient agro-ecosystem having minimal dependence on the external inputs and, having synergy and interactions among different biological components of the system (Vijikumar, 2010). It is a way forward for such agriculture that delivers the productivity goal without depleting the environment and disempowering the farming community (Altieri, 2015). Agro-ecology can meet the economic, social, and environmental needs of the farming community, maintaining environmental and social resilience. It is a scientific discipline, a sustainable farming approach, and a social movement in the context of the current changing climate and growing concerns over the healthier food system.

More evidence like case studies are being generated stating its multiple benefits from climate resilience to farm productivity (Silici, 2014). It has 10 functional elements: diversity, synergies, efficiency, resilience, recycling, co-creation and sharing of knowledge, human and social values, culture and food traditions, responsible governance, and circular and solidarity economy (FAO, 2018). Since agro-ecology is based upon the bottom-up and territorial processes that help to deliver context-based solutions to local problems enhancing their adaptive capacity and empowering producer communities as a key agent of change, it is unique to other approaches of agriculture (Bisht et al., 2022).

Karnali province with HDI of 0.53 (UN Nepal, 2021) is one of the least developed provinces in the country. The province is not able to compete with the other provinces in terms of production and productivity due to its geography and having less capital for the investment; consequently, it is a food deficit province. One of the options the province has is to promote locally available agricultural products, add value to them and promote their production at scale. One of the best ways for achieving that objective would be the promotion of agro-ecology. Since province is also being prepared to declare an organic province, agro-ecology is the best to practice as an alternative that is affordable for the province. Large scale adoption of different agro-ecological practices and technologies being popular among farmers can become better alternatives to the agro-chemicals. Therefore, it is necessary to find out those alternatives, understand their efficacy, cost-effectiveness, and ease of application, etc. so that farmers can apply them.

The study was aimed to identify the socio-economic conditions of the farming communities, document existing agro-ecological practices and technologies adopted by the farming communities categorizing them under six different headings : i) Cropping/planting method ii) Resilient seed/breed iii) Disease and pest management iv) Water management v) Carbon/nutrient management, and vi) Farmers risk reduction, their contribution in ecological resilienceand explore the relationship between the socio-economic conditions of the farming communities and adoption of these agro-ecological technologies and practices in the province.

Materials and Methods

Districts situated in the Karnali river basin (Surkhet, Dailekh and Accham) were selected for the study. A structured questionnaire to understand the socio-economic conditions and present status of ecological practices in the region was developed taking reference from the national and international reports and journal articles. Six enumerators were selected for the data collection, two enumerators per district. The data collection process was carried out in Birendranagar Municipality and Barahatal Rural Municipality of Surkhet district, Dullu Municipality and Aathbis Municipality of Dailekh district, and Turmakhad Rural Municipality and Panchadewal Rural Municipality of Accham district. The tools used for the study were household surveys, focus group discussions (FGD), and key informant interviews (KII). Enumerators were oriented for two days on questionnaires and data collection using tablets. Pre-testing of the questionnaire was done to generate confidence in the enumerators and also to check the quality of the questionnaire developed. In total, 310 households were surveyed (80 in Accham, 110 in Dailekh, and 120 in Surkhet) along with 13 FGDs and 11 KIIs. The two-stage stratified random sampling was adopted to select the respondents where municipalities were considered as strata. After that, in the first stage, groups were selected from each municipality, and 10 beneficiaries were selected randomly from each group for data collection. Inclusiveness of the marginalized groups and disadvantaged groups was the prime focus during the entire survey period. It included the poor, women, people with disability, Dalit, and tribal/ethnic minorities. Real-time and actual GPS location of data collection were tracked by collecting the data through tablets to ensure the data quality. The filled questionnaire was checked regularly to ensure accurate information and instant technical backstopping to enumerators when needed. The data collected was cleaned and analyzed using Excel and SPSS. Descriptive statistics including frequency, percentage and mean were used. Inferential statistics such as Logistic Regression were used to establish the relationships between different socio-economic variables (caste, income, family size, Land ownership, land size, gender, age, and education)and the adoption of different agro-ecological farming practices in the farms. The result obtained from the household survey was triangulated with the qualitative information gathered through different complementary sources, including direct observations, KII, FGD, and other related literature.

Under the climate resilient agro-ecological practices study, the practices common in the Karnali river basin were reviewed and categorized under six different headings: i) Cropping/planting method ii) Resilient seed/breed iii) Disease and pest management iv) Water Management v) Carbon/nutrient management, and vi) Farmers risk reduction.

Results and Discussion

Socio-economic status of the respondents

From the study, majority of respondents (44.8 percent) were from age group 25-40 followed by 41-60 (36.5 percent). Among respondents, 31.3 percent were found to have basic level (1-8) education, followed by secondary level (9-12) education (28.1 percent) and 24.5 percent of respondents were illiterate.The major ethnicity of region was found to be Brahmin/Chhetri (66.8

percent), Janajati (20 percent) and Dalit (13.2 percent). Family size of 4-6 persons per household was found to be highest (60.3 percent).

Thirty four percent of the people in Karnali province are illiterate (Republica, 2022), which is slightly more than what we observed in the study (25.5 percent). According to Nepal Outlook (2022), the percentage of Brahmin/Chhetri is 60.6 percent, Magar is 10.3 percent, Dalits (19.8 percent) and others (9.3 percent) and 80 percent of the total population is engaged in agriculture (KPPC, 2020). Almost 76.8 percent of the households were landless or land poor farmers having less than 0.50 ha of land. About 19.4 percent of the farmers fall under the category of 'subsistence farming' with land holdings of 0.5–1.0 ha and only 3.9 percent of the farmers fall under the category of small commercial farmer. The findings are supported by FNCCI, (2020), which states the average land holdings of the Karnali Province as 0.53 ha per holdings. 77.1 percent of the respondents were found cultivating crops in less than 0.5 ha of land comprising 41 percent having less than 0.25 ha and 35.5 percent having the land between 0.25 ha to 0.5 ha. Comparative analyses of these socio-economic parameters between the study sites and Karnali Province indicate that these figures are comparable to a large extent, thereby suggesting that the findings from the study are representative of the Karnali province.

Climate resilientagro-ecological practices

Householdsadopting various climate resilient agro-ecological practices incultivation: It showed that some form of climate resilient agro-ecological practices was found to be used in all farming practices, including livestock (cereal crops, vegetable crops, pulse crops, oils crops, spices crops and livestock rearing) (Table 1). Farmers practiced 11 different climate resilient ecological practices in pulses followed by 10 different climate resilient ecological practices in both cereals and vegetables crops. Only 5 different climate resilient ecological practices were found to be adopted in livestock rearing. Crop diversification, bio-fertilizers/biopesticides, Disease/pestresistant crops, integrated pest management and irrigation management/water harvesting/uplifting are climate resilient agro-ecological practices adopted in all crops (cereal, vegetables, pulses, oils, and spices). The most common climate resilient ecological practice practiced by households is use of farm yard manure/compost, i.e., 27.4 percent in cereals, 30 percent in vegetables, 20 percent in pulses, 13.5 percent in oil crops. The promotion of small-scale irrigation and furrow bed planting is only practiced in vegetable crops (13.2 percent) and (21.0 percent) respectively. Rana et al. (2022) also reported that most of the farmers of Karnali province are adopting different agro-ecological practices like mulching and improved seed and crop rotation. Among 18 different climate resilient agro-ecological practices, 11 of them were indigenous/traditional practices, whereas 7 of them were externally introduced practices. Externally introduced practices may be due to support from the government and projects. These practicesseem to be very important in disease/pest management and water management. Many of technologies that are being used by the farmers are traditional practices that transferred from generation to generation. Some of externally introduced technologies and practices used by farmers are not intentionally adopted by farmers after understanding the climate change impacts, but it is due to support of these technologies and practices from various organizations and government agencies (Karki et al., 2020).

Cropping/planting method: Crop diversification manages problems related to crop productivity, depletion in soil quality, food security, and climate change mitigation affecting soil carbon and regulating the soil carbon balance. However, Martinez-Mena et al. (2021) stated that crop diversification with perennial crop species increases annual soil carbon content but with annual species cannot. According to Zhang et al. (2020), crop diversification enhances range of biological products that enhance performance of crops, nitrogen-fixing bacteria, arbuscular mycorrhizal fungi, Trichoderma and other microorganisms that have great potential to increase sustainability in agriculture. The cropping system (crop rotation) improves soil condition and increases productivity. It also contributes to sustainable soil development by reducing insect and disease incidence, suppressing weeds and improving physiochemical properties of soil (Shah et al., 2021; Yang et al., 2020). Farming with contour furrows and raised beds promotes soil and water conservation, reforestation of slopes, development of irrigation, and agroforestry in cropland (Gebreegziabher et al., 2009).

Table 1: Household utilizing climate resilient agro-ecological practices in different types of crop cultivation

Practices		Cereal crops	Vegetable crops	Pulse crops	Oil crops	Spice crops	Livestock rearing
Cropping/planting method							
Indigenous/traditional practices	**Externally introduced practices**						
Crop Diversification		21.3	25.2	17.1	7.1	20.0	0.0
Cropping system (crop rotation)		23.2	0.0	17.1	8.7	0.0	0.0
Contour planting		9.7	0.0	7.4	0.0	0.0	0.0
Furrow bed planting		0.0	21.0	0.0	0.0	0.0	0.0
Resilient seed/breed							
Indigenous/traditional practices	**Externally introduced practices**						
	Flood/drought resistance varieties of crops	2.3	0.0	1.3	0.6	2.6	0.0
Promotion of local varieties		0.0	24.2	0.3	0.0	0.0	0.0
Local breed of animals		0.0	0.0	0.0	0.0	0.0	14.2
Disease and pest management							
Indigenous/traditional practices	**Externally introduced practices**						
	Bio fertilizer/bio pesticide	3.9	12.6	2.3	1.9	3.5	0.0
	Disease/pest resistant crop	4.5	0.0	4.2	2.6	3.9	0.0
Integrated pest management		4.8	7.1	3.2	2.6	3.9	0.0
Water management							
Indigenous/traditional practices	**Externally introduced practices**						
Irrigation management/water harvesting/uplifting		16.1	11.3	11.3	5.8	12.6	2.6
	Use of small Irrigation technologies	0.0	13.2	0.0	0.0	0.0	0.0
	Plastic house/poly house	0.0	11.0	0.0	0.3	0.0	0.0
Carbon/Nutrient management							
Indigenous/traditional practices	**Externally introduced practices**						
Farmyard manure/Compost		27.4	30.0	20.0	13.5	28.7	0.0
Mulching		13.9	23.2	12.9	5.5	32.3	0.0
Improved animal shed/hive/sty		0.0	0.0	0.0	0.0	0.0	10.3
	Improved feed management	0.0	0.0	0.0	0.0	0.0	10.3
Farmer's risk reduction							
Indigenous/traditional practices	**Externally introduced practices**						
	Livestock insurance	0.0	0.0	0.0	0.0	0.0	2.3
Not practiced/not farming		69.7	63.2	77.7	85.5	64.8	85.8

Note: Percentage adds up to more than 100 due to multiple responses.

Resilient seed/breed: Resilient seeds/breeds promote agro-ecological resilience from the different aspects by fostering genetic diversity, crop species diversity, and diversity at the landscape level. They reduce seed supply channels, thereby reducing the use of external resource inputs (Klien & Sievers-Glotzbach, 2022). The resilient seed also helps in the conservation of soil and water andthe efficient water management. In the agricultural system, local seed reduces the negative impact of climate change and assures stability in crop production, strengthening the capacity of the agro-ecosystem to combat abiotic and biotic stresses (Climate ADAPT, 2021; Singh et al., 2015).

Disease and pest management: Chemical fertilizers and pesticides are the major factors deteriorating the quality of soil health, water systems, and the whole agroecology. Since agro-ecology is an approach with no harm to soil, water, forest and mankind, it is important to promote biofertilizers and bio-pesticides that do not harm the ecosystem and maintain balance among inhabitants within the agro-ecosystem (G.C., 2015). Biofertilizers contain different beneficial microorganisms that help in nitrogen fixation, phosphorus solubilization, potassium solubilization, and a mixture of other beneficial fungi and molds that can play a critical role in advanced crop nutrient management. They play a vital role in safeguarding the environment by being cost-effective options and eco-friendly to the producers (Rehman etal., 2022). Integrated Pest Management (IPM) is about considering all the techniques and measures that reduce the disease and pest while minimizing risk to human health and environment. It makes the effective use of local knowledge, experience, technology, and local resources that promote pollination as well as sustainable agro-ecosystem in a socially acceptable way (Croplife International, 2014; Franco, 2020; FAO, 2022).

Water management: Effective and judicious management of water is a valuable constituent of the environment, nature conservation, and agricultural production. In areas with water scarcity, the major thrust is to minimize the use of water and reduce its loss through evaporation or percolation beyond the depth of the root zone (Chartzoulakis and Bertaki, 2015). Water harvesting and multiple uses of water in water stagnant or water-logged areas through the construction of a canal and re-collecting it again by making a fish pond and planting vegetables and fruits along the bunds is a popular practice among the farmers (Upadhyaya, 2015). Polyhouse/plastic tunnels are found to significantly increase the yield of the crop and protect the crops from climate change effects such as heavy rainfall and cold weather (KC etal., 2021).

Carbon/nutrient management: Improved livestock shed always gives quality FYM and an adequate amount of urine for the farm.The use of farmyard manure significantly increases organic matter content in the soil along with soil pH, improves the water holding capacity of the soil, reduces water runoff, benefits the environment by recycling organic resources, adds nutrients and microbes in soil and provides the supplemental amount of slow-release nutrients (Giesel and Seaver, 2009; Gautam etal., 2018). Organic mulching protects from soil erosion, conserves the moisture, and assists plants in maintaining an even temperature in the soil, and controls weed growth. Mulching helps in addition of soil organic matter, humus, and nutrients to the soil providing substrate for beneficial microorganisms (Ngosong et al., 2019).

Farmer's risk reduction: Climate change has extreme impacts on landslides, floods, and drought, and brings difficulties in agriculture, causing huge economic losses. Livestock insurance is a tool to mitigate the climate hazards in the livestock sector in Nepal (Koirala and Bhandari, 2018).

Households with a number of climate resilient agro-ecological practices adopted

The highest percentage of people not using any climate resilient agro-ecological practices was observed in livestock rearing and oil crops (85.8 percent and 85.5 percent), respectively followed by pulses (77.7 percent). In terms of a number of different climate resilient agro-ecological practices adopted, cereals and vegetables are the highest with (9-10) different practices adopted, whereas the highest number of climate resilient practices adopted in pulses, oils, and spices is 7-8. A least number (5-6) of climate resilient agro-ecological practices are used in livestock rearing. Among the variables, the percent of people using 1-2 and 3-4 climate resilient agro-ecological practices is the highest in Spices (14.6 percent) and (16.1 percent), respectively. The percentage of people using 5-6 climate resilient practices among the variables is highest in vegetables, i.e., 15.8 percent. On average, 74.5 percent of households are not using any climate resilient agro-ecological practices. Overall, the percentage of people using 3-4 climate resilient agro-ecological practices is the highest (9.2 percent), followed by 1-2 climate resilient agro-ecological practices, i.e., 7.0 percent. Households using the highest (10-11) climate resilient agro-ecological practices is 0.5 percent (Table 2). Studies have been done on the different types of climate resilient ecological practices that are practiced. Some of the climate resilient ecological practices practiced in this province are use of bio-pesticide, farmyard manure, local and recommended seed varieties with four irrigation and compost manure (Adhikari, 2018). However, there aren't any studies that say a number of technologies that have been used under different crops.

Table 2: Households with a number of climate resilient agro-ecological practices adopted during farming and animal husbandry.

No. of practices	Cereals	Vegeta-bles	Pulses	Oils	Spices	Livestock rearing
None	69.7	63.2	77.7	85.5	64.8	85.8
1-2	7.1	6.4	4.9	5.4	14.6	3.5
3-4	10.3	8	6.7	5.5	16.1	8.4
5-6	8.4	15.8	8.1	2.2	4.2	2.3
7-8	3.9	4.2	2.5	1.3	0.3	0
9-10	0.6	2.2	0	0	0	0
11-12	0	0	0	0	0	0
>13	0	0	0	0	0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Inter-relationship of various socio-economic variables with the adoption of climate resilient agro-ecological practice: Test results showed that the adoption of climate resilient agro-ecological practices is significantly different from the socio-economic variables of the households except for the caste and income level of the people. Adoption of the climate resilient agro-ecological practices like the use of bio-pesticide, IPM technology, Improved FYM, and Use of plastic houses are significantly different among the surveyed districts at 99% level of confidence ($p<0.01$), whereas practices like crop diversification, Water harvesting/Irrigation management, Indigenous crop cultivation are significant at 95% level of confidence ($p<0.05$). The use of drip irrigation was significant in the surveyed district at a 90% level of confidence ($P<0.1$), but the mulching practice is common across the districts. This may be due to the promotion of bio pesticides, plastic house and livestock shed improvement by the different stakeholders working in the agriculture sector and their presence in the study area (Ghimire et al., 2022).

Looking at other social characteristics, the crop diversification practices were significantly different with Family size ($p<0.1$), Land ownership ($p<0.05$) and Land size ($p<0.01$). Households having higher family members and owning their own land have been found to have higher crop diversification. Land holding size is found to have a highly significant relation with crop diversification, and this may be due to the household with higher land size having a higher number of crops in the field and vice versa. Similarly, cultivation of Indigenous crops was also significantly different with the family size ($p<0.1$), Land ownership ($p<0.01$), and Land size ($p<0.01$) which may be due to small size families growing less in small areas. This may be due to the households having large areas not being able to buy hybrid seeds for this bigger land size.

The use of plastic houses was significantly different at a 1 % level of significance at a 99% level of confidence interval with family size. It may be due to the quantity of vegetables required in the house and the number of people required to work in the tunnel during its establishment and producing crops. The use of bio pesticide was significant with Gender ($p<0.05$), this may be due to the higher engagement of women in spraying of the bio-pesticides and men in other works. The IPM technology was significantly different with the level of education ($p<0.05$), which is true because IPM is knowledge-intensive andrequires a certain level of education for the use of IPM technologies such as identifications of labels of the bio-pesticides, knowledge of identifying agro-chemicals and bio-pesticides, methods of using traps etc. The water harvesting/irrigation management was also significant with the age level of the respondent ($P<0.1$), which may be due to the engagement of certain ages of people in water harvesting/Irrigation management works, such as the involvement of only youths in water harvesting, canal construction work etc. The other two socio-economic variables did not show any correlation with the climate resilient ecological practices. In the case of caste, it might be due to the higher number of respondents being from the same caste (Brahmin/Chhetri (66.8 percent), and the reason behind the income not showing any relationship with the adoption of climate resilient technologies could be due to the collection of income only from the agriculture, which did not vary much amongst the households. According to Rana et al. (2022), the adoption of agroecological studies was governed by different socio-economic variables. Adoption of agroecology technologies and practices showed significant results with Age, gender and income. Youth can learn faster and take risks in the adoption of the technologies and practices. Rao et al., (2021) also stated the influences of soci-economic variable in adoption of climate resilient technologies and practices.

Conclusions

It was concluded that farmers should be awared on technologies being used for climate resilient agro-ecological approach and their importance in the maintenance of the ecosystem balance. If not, once they have access to agro-chemicals and modern inputs, they can leave these practices and degrade their agro-ecosystem. Weaning farmers from the use of agro-chemicals would be an uphill task once they are hooked. In the Karnali Province, there is a use of modern inputs, and the wide scale application of agro-chemicals is limited which creates the opportunity to orient and train farming communities on agro-ecology based farming that fully focuses on practical aspects with the optimum utilization of indigenous knowledge and local resources.

Socio-economic variables are found to impact the adoption of climate resilient ecological practices. In order to effectively promote agro-ecological technologies and practices and to provide alternatives to conventional farming systems, these variables are to be considered. Since the understanding levels of the farmers differ from each other, the promotion of these practices should be arranged in such a way that these practices are demonstrated, engaging the farming communities, and the evidenceis shown in front of their eyes. Better targeting of technologies according to different socio-economic conditions of households stands a better chance of adoption of these technologies.

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