STRENGTHENING AGRO-ECOSYSTEMS RESILIENCE FOR CLIMATE CHANGE ADAPTATION TO IMPROVE FOOD AND NUTRITION SECURITY (TCP/NEP/3701)

Baseline survey report

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1. Introduction

About one-third of the earth's surface was used for agricultural production to meet the food demands of the growing world population (FAO, 2007). Though agricultural land is primarily used to produce crops and livestock for food, it also provides other services, such as fibre and biofuel production, opportunities to store carbon, on-farm biodiversity, and aesthetic and recreational opportunities. However, intensive agriculture often results in the loss of ecosystem services at both the farm and landscape scales. The agroecosystem services (AES) are vital to maintain and improve agricultural productivity in order to meet the food nutrition and security of a growing human population through sustainable crop production but many of these services are declining due to anthropogenic-driven ecosystems changes (Kennedy et al 2013).

Before the 20th-century farmers were able to meet the food demands of the population without the use of chemical fertilizer and pesticides, they managed the diverse ecosystem services for agricultural production (Sandhu, 2006). Agriculture constitutes the largest ecosystem services which increased production of agricultural goods which resulted in significant impacts on human health and well-being (Foley *et al*., 2005). Conserving both ecosystems and their services is critical for economic development and poverty alleviation, as the livelihood and wellbeing of many people depend on biodiversity and ecosystem services (Sandhu et al 2014). Biodiversity is essential for the provision of many ecosystem services that are important for human well-being.

The agroecosystem services can be classified into four main categories: provisioning, supporting, cultural, and regulating services (MA, 2005). Agricultural activities are leading to environmental destruction and loss of ecosystem services (ES) leading to a decline in biodiversity and threatening the environment (Tilman *et al.*, 2001, Sandhu et al., 2010). It leads to the loss of the supply of other ecosystem services, such as the maintenance of soil fertility, water quality, pest control, and pollination (Logsdon et al., 2015; Gonzalez et al., 2015).

The ecosystem management approach to agriculture without neglecting its linkages with other components of the system would sustain its development on a long-term basis or otherwise, any of the strategic development efforts may end up in failure. The impact of the farm-level management practices like the use of fertilizer and pesticides, cropping practices, and knowledge about the different ecosystem services has been well documented for the agroecosystem ecosystem services management.

Investigating local people’s perception of ecosystem services can more easily differentiate single provisioning, regulating, cultural and supporting services, which are often supplied in multiple-service bundles, and this can be a useful tool for prioritizing ecosystem services. Local farmers’ perceptions of ecosystem services differ among different regions that appear to reflect differences in local knowledge and background (generated by practice and observations. In order to harmonize the interrelation between humans and nature and to establish sustainable agricultural landscape management, it is important to understand the local people’s perceptions of various ES in different regions. However, only a few studies have addressed local people’s identification or perception of ecosystem services and most studies center on a single or a few ecosystem services.

2.Materials and Methods

2.1 Site description

The baseline survey was carried out in the three project districts Dang, Gulmi and Mustang which are the major commercial mustard, citrus and apple cultivating districts of Nepal. In the Dang district, the mustard was cultivated in an area of 20,978 ha producing 22,401 mt with a productivity of 1.07 t/ha. In Gulmi district, citrus was cultivated in area 747 ha producing 5,501 mt with productivity of 10.98 t/ha. Similarly, in the Mustang district, apple was cultivated in an area of 445.0 ha producing 5727.0 mt with productivity of 12.9 t/ha (MOAD, 2018).

A list of farmers in the project districts was obtained from the Agriculture Knowledge Center (AKC), PMAMP zone office and local government bodies to select the farmer's field school (FFS) participants. The farmer's field school farmers' participants were the respondents to carry out the baseline survey.

2.2 Selection of sample respondents

Altogether 300 farmers were selected using purposive random sampling techniques as the respondents to carry out the baseline survey on the agroecosystem services. From the Dang and Gulmi districts, 240 respondents (120 from each district) mustard growing farmers and citrus growing respectively and in Mustang 60 respondents were selected as the respondents.

2.3 Sampling technique and methods of data collection

The data of this study were collected both from primary and secondary sources. The primary data were collected from a household questionnaire survey, FGD, key informant interviews, and field observations. The questions included in the questionnaire were both closed-ended and open-ended types. The questionnaire was administered from November to February 2019 in the Dang and Gulmi whereas in the Mustang due to climatic factors and later with COVID 19 situation survey was carried out in the November to December 2020. This period was chosen mainly because it is an ideal time when farmers have completed their harvesting activities. Hence, it is easy to interview the sample farm households and collect the required data. Secondary data were also collected from books, journals and internet sources.

Data were collected by face-to-face surveys of each selected farmer. A survey questionnaire was prepared, covering the demographic details of farms, farm management practices and perceptions of ES. Each farmer was asked to rank the importance of the listed ES. The rankings were on a score of 1-5, 1 being least important, 3 being moderately important and five being highly important for their farming.

3. Results

3.1 Sociodemographic characteristics

The mean age of the respondents was higher in Gulmi districts (51.5 yrs) followed by the Dang (44.17 yrs) with the least in the Mustang districts (43.31 yrs). Similarly, the average family size was found to be less than 5 persons in Dang and Mustang as compared to Gulmi around 6 persons. The average landholding of the farmers was found higher in Gulmi districts (26.32 kattha) followed by the Dang (20.34 kattha) and the least in the Mustang districts (13.55 kattha) as shown in table 1.

Table 1. The average age, family number and landholding of the respondents from the three districts, Nepal

S.N	Variables	Dang	Gulmi	Mustang	P-value
1.	Age (yrs)	44.176 (14.372)	51.579 (14.091)	43.317 (12.033)	
2.	Family	5.613 (2.376)	6.212 (2.763)	5.200 (2.448)	0.114
3.	Landholding (kattha)	20.349 (17.161)	26.325 (17.423)	13.550 (9.282)	< 0.001

* Figure in the parenthesis shows the standard deviation.

Sex and Education status

In altogether, about 59% of respondents were male followed by female 41%. We found that around 32% of the respondents in Dang district were illiterate, followed by the secondary level (30%), primary (21%) and least having a university degree around 1%. In the case of Gulmi district, most of the farmers were literate (31.6%) and had secondary level degrees (31.6%) followed by primary level education (29.8%) and least illiterate (2.7%). Similarly, in Mustang district most of the farmers received the primary level education (36.7%) followed by secondary (20%), literate (15%), illiterate (8.3%) and least university degree (5%). The results revealed that the economically active population was higher in the Gulmi districts (4.07) followed by Dang districts (3.68) and least on mustang (3.05) as shown in table 2.

Table 2. Education status and sex of the respondents from the three districts, Nepal

S.N	Variables	Dang	Gulmi	Mustang	Total	P-value
1.	**Sex**					
	Male	62 (52.1%)	71 (62.3%)	39 (65.0%)	172 (58.7%)	0.155
	Female	57 (47.9%)	43 (37.7%)	21 (35.0%)	121 (41.3%)	
2.	**Education status**					< 0.000
	Illiterate	39 (32.8%)	3 (2.7%)	5 (8.3%)	46 (16.0%)	
	Literate	7 (5.8%)	36 (31.6%)	9 (15.0%)	51 (17.7%)	
	Primary	25 (21.0%)	34 (29.8%)	22 (36.7%)	81 (27.6%)	
	Secondary	36 (30.3%)	36 (31.6%)	12 (20.0%)	84 (28.7%)	
	Higher Secondary	11 (9.2%)	5 (4.4%)	9 (15.0%)	25 (8.5%)	
	University	1 (0.8%)	0 (0.0%)	3 (5.0%)	4 (1.4%)	

3.	**Economically active member**					< 0.001
	0-15 years	1.370 (1.073)	1.368 (1.358)	1.317 (1.066)	1.358 (1.187)	
	16-60 years	3.689 (1.817)	4.079 (1.786)	3.050 (2.020)	3.710 (1.880)	
	Above 60	0.555 (0.831)	0.772 (0.960)	0.817 (0.792)	0.693 (0.880)	
4.	**Income per year**	331916.387 (312463.23)	237210.526 (325344.05)	308333.333 (586926.54)	290239.078 (389735.75)	

* Figure in the parenthesis shows the standard deviation and percentage

3.2 Income of the respondents from the targeted crops

Among the income from the agriculture crops, the respondents from the Dang average income from the targeted crops (mustard) was 17587.395 (24808.280) whereas the respondents from the Gulmi average income from citrus was 141289.474 (143412.625) and Mustang average income from apple was 194916.667 (273601.981). The result shows the mustard growing farmers receive less income from the mustard crops whereas the farmer's income from the citrus and the apple was quite satisfactory for sustaining.

3.3 Awareness on ecosystem services

The result shows that overall all-around 68% of the respondents were not aware of the concept of ecosystem services. Around 96% of the respondents from the Gulmi district are not aware of the ecosystem services followed by 51% in the Dang and 46.7 % in the Mustang district. Around 90% of the farmers from the study areas perceived there was a change in the ecosystem services. In all three districts, more than 85% of the respondents agreed with the change in agroecosystem services.

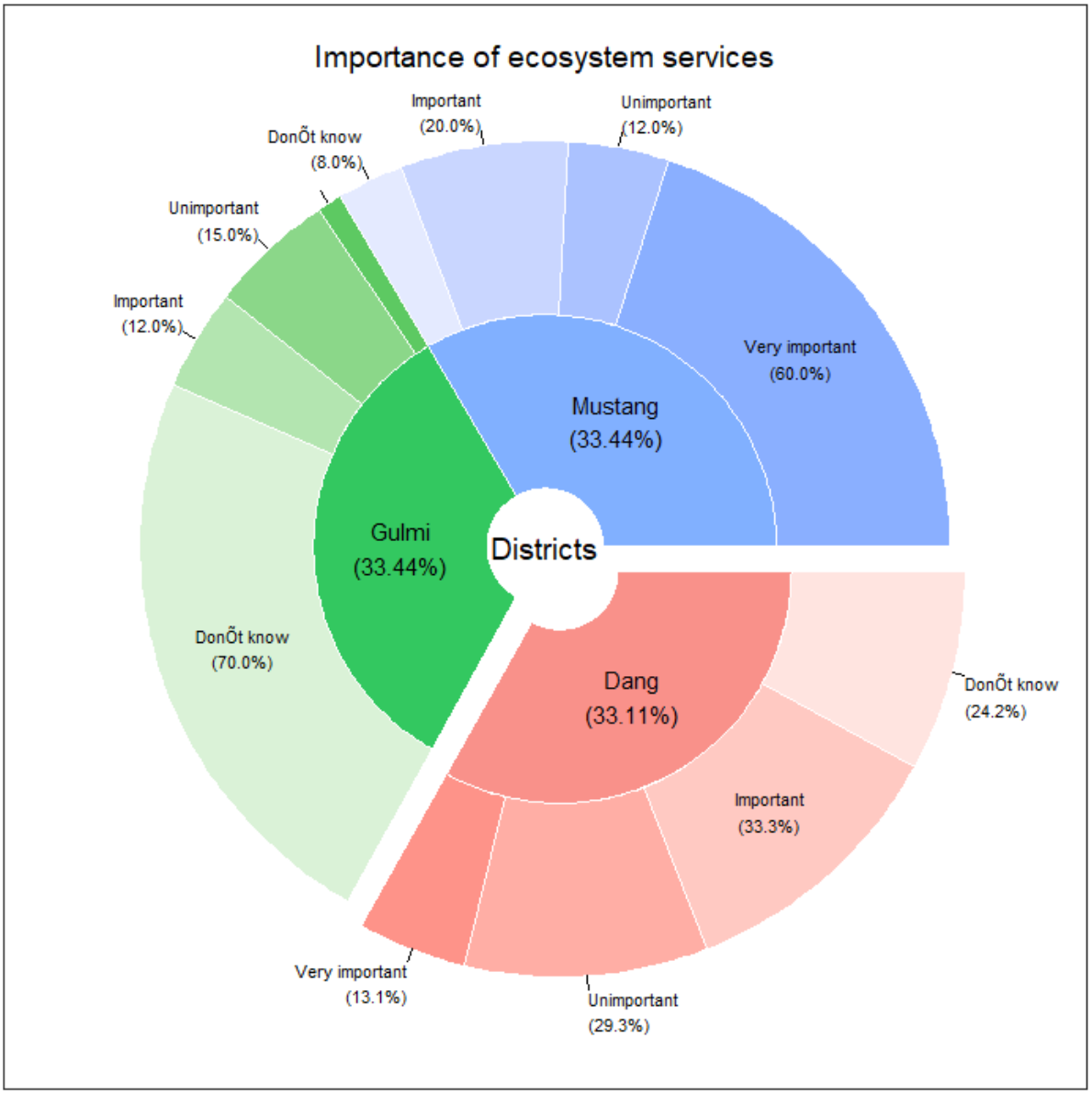
Table 3. Farmers awareness on the concept of ecosystem services and changes in the ecosystem services from the three districts, Nepal

S.N	Variables	Dang	Gulmi	Mustang	Total	P-value
1.	**Awareness on ecosystem services**					
	Yes	58 (48.7%)	4 (3.5%)	32 (53.3%)	94 (32.1%)	< 0.001
	No	61 (51.3%)	110 (96.5%)	28 (46.7%)	199 (67.9%)	
2.	**Change in ecosystem services**					
	Yes	109 (91.6%)	99 (86.8%)	55 (91.7%)	263 (89.8%)	0.589
	No	10 (8.4%)	14 (12.3%)	5 (8.3%)	29 (9.9%)	

3.4 Importance of ecosystem services

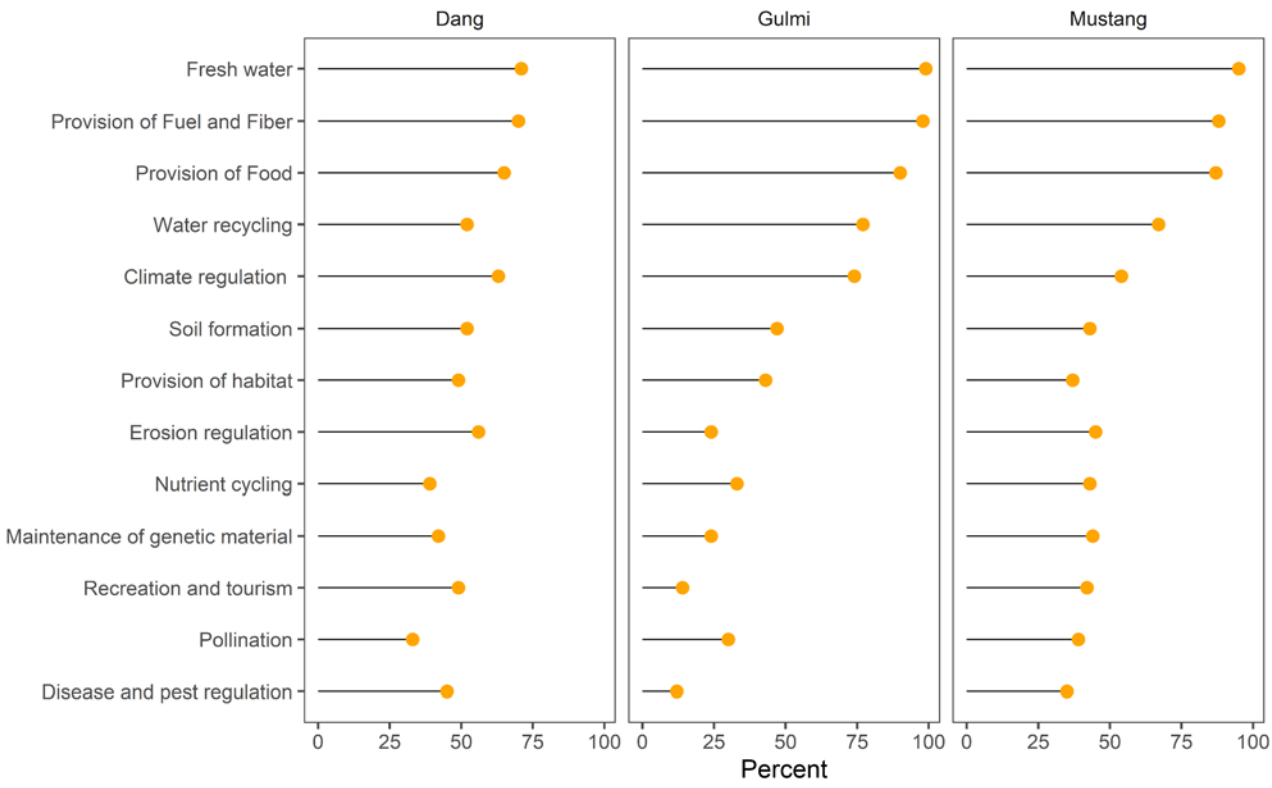
The result shows that around 80% of the farmers don't know about the ecosystem services importance in the agriculture production in the Gulmi districts followed by 24% in the Dang and the least respondent farmers in Mustang districts. About 29% of respondents from Dang and 15% from the Gulmi reported that ecosystem services are not important for agriculture. Most of the around 90% respondents from Mustang and 45% from Dang revealed ecosystem services as important for agricultural production as shown in Figure 1.

Figure 1. Farmer's perception on the importance of the ecosystem services from the three districts, Nepal



3.5 Knowledge on the different ecosystem services

Figure 2. Farmer's knowledge on the different identified ecosystem services in the three districts of Nepal



3.6 Ranking of the importance of the ecosystem services

The result shows that the respondent's farmers perceived the ecosystem services more as the cultural services and provisioning services rather than the regulatory and supporting services as shown in Figure 3. This shows that the respondents were not aware of all the ecosystem services and their importance. The respondents rank the pollination, soil fertility, natural pest regulation less than the 3 scores mean, they perceive these ecosystem services as not so important for sustainable agriculture production.

Figure 3. **Farmer perceptions on the importance of the ecosystem services (average** score on a scale from 1, the lowest importance, to 5, the highest importance) in the three districts of Nepal

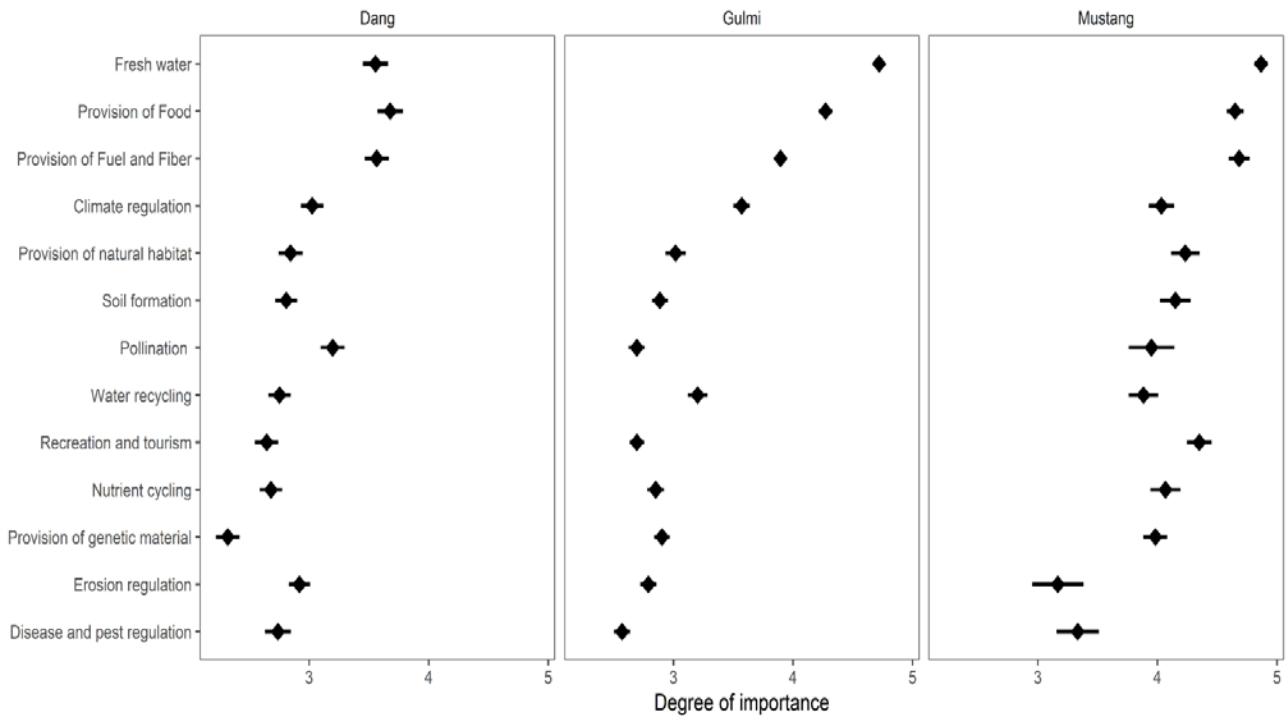
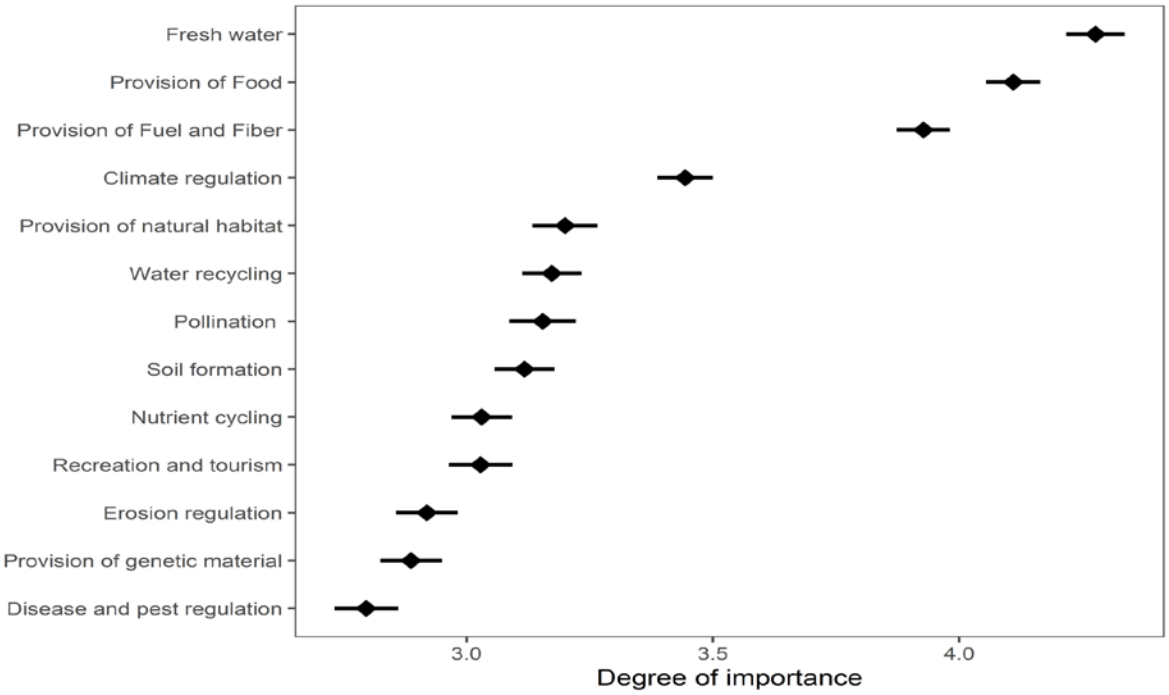


Figure 4. Overall **farmer perceptions on the importance of the ecosystem services (average** score on a scale from 1, the lowest importance, to 5, the highest importance) in the three districts of Nepal



3.7 Agricultural practices adopted by the farmers

The results show the adoption of the agroecosystem-friendly practices by the respondents in the project districts as shown in Table 4. About 88% of the farmers and half of the farmers don't practice the crop rotation and mixed cropping respectively in Dang districts whereas in the Gulmi and Mustang 100% of the farmer's respondents adopted the crop rotation practices and mixed cropping. In the case of the kitchen garden practices, around 77% of the farmers in the dang districts adopted this practice followed by 55% in the mustang and the least number of respondents (36%) adopted it in the Gulmi districts.

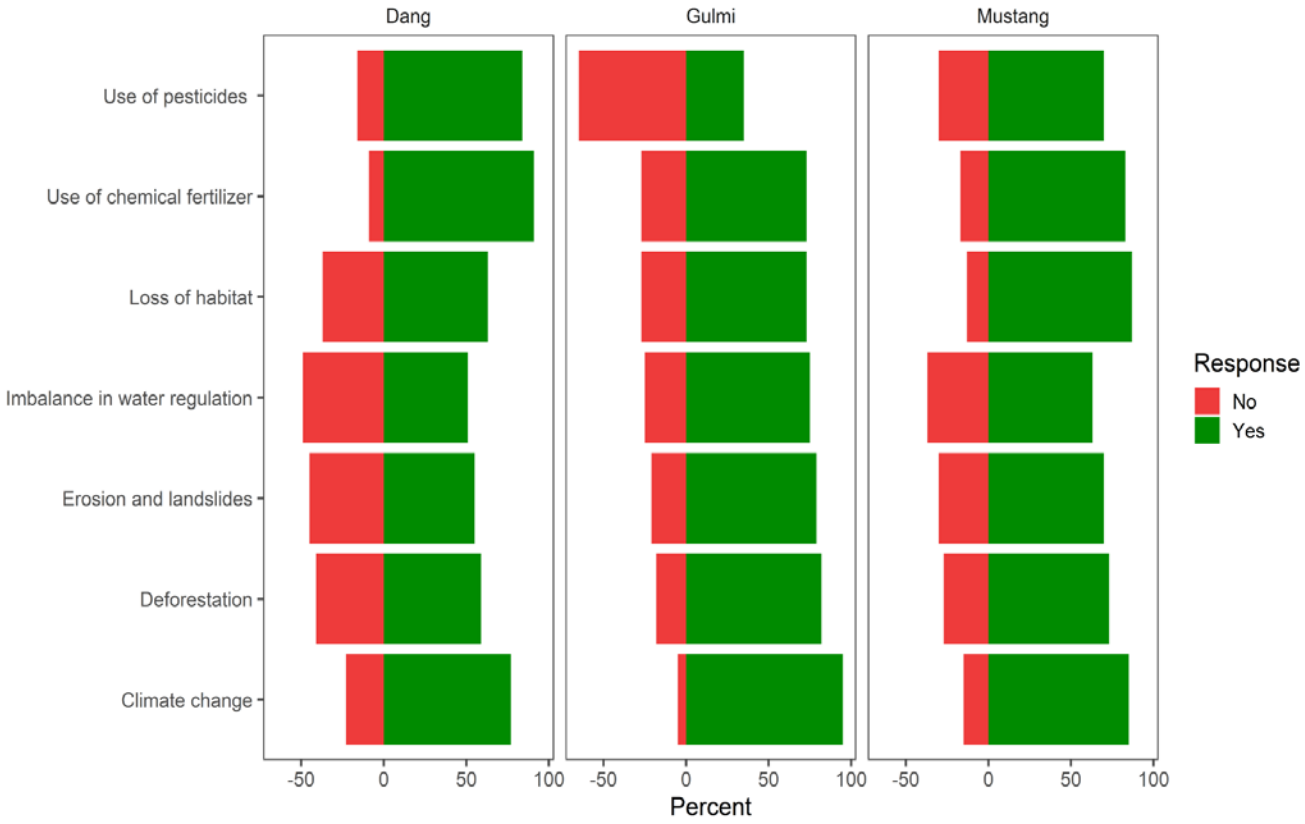
Table 4. Agriculture practices followed by the respondents in the three districts of Nepal

S.N	Agricultural practices	Dang	Gulmi	Mustang	Total	P-value
1.	**Crop rotation**					
	Yes	14 (11.7%)	114 (100.0%)	60 (100.0%)	187 (64.1%)	< 0.001
	No	105 (88.2%)	0 (0.0%)	0 (0.0%)	105 (35.8%)	
2.	**Mixed cropping**					
	Yes	57 (47.9%)	114 (100.0%)	60 (100.0%)	231 (78.8%)	< 0.001
	No	62 (52.1%)	0 (0.0%)	0 (0.0%)	62 (21.2%)	
3.	**Kitchen garden**					
	Yes	92 (77.3%)	42 (36.8%)	33 (55.0%)	167 (57.0%)	< 0.001
	No	27 (22.7%)	72 (63.2%)	27 (45.0%)	126 (43.0%)	
4.	**Contour farming**					
	Yes	0 (0.0%)	25 (21.9%)	19 (31.7%)	44 (15.0%)	< 0.001
	No	119 (100.0%)	88 (77.2%)	41 (68.3%)	248 (84.6%)	
5.	**Terrace farming**					
	Yes	0 (0.0%)	100 (87.7%)	17 (28.3%)	117 (39.9%)	< 0.001
	No	119 (100.0%)	13 (11.4%)	43 (71.7%)	175 (59.7%)	
6.	**Zero tillage**					
	Yes	4 (3.4%)	7 (6.1%)	17 (28.3%)	28 (9.6%)	< 0.001
	No	115 (96.6%)	107 (93.9%)	43 (71.7%)	265 (90.4%)	
7.	**Agroforestry**					
	Yes	2 (1.7%)	108 (94.7%)	17 (28.3%)	127 (43.3%)	< 0.001
	No	117 (98.3%)	5 (4.4%)	43 (71.7%)	165 (56.3%)	
8.	**Mulching**					
	Yes	92 (77.3%)	2 (1.8%)	18 (30.0%)	112 (38.2%)	< 0.001
	No	27 (22.7%)	112 (98.2%)	42 (70.0%)	181 (61.8%)	

3.8 Drivers of change in ecosystem services

The use of chemical fertilizer, use of pesticides, loss of habitat and climate change are the major drivers which cause the change in the ecosystem services. The respondents from the Dang districts revealed that the use of chemical fertilizer followed by the use of pesticides, climate change are the major drivers of the change in the ecosystem services. Similarly, farmers respondents from the Gulmi district perceived climate change as the major factor followed by deforestation, erosion and landslides, loss of natural habitat with the least impact of pesticides that causes the change in the ecosystem services. In the case of the Mustang district, loss of natural habitat was a major driver followed by the use of chemical fertiliser, climate change, use of pesticides as shown in Figure 5.

Figure 5. Farmer's perception on the drivers of the change in the ecosystem services in the three districts of Nepal



3.9 Ranking of the key drivers of change in ecosystem services

Table 5. Farmer perceptions on the key drivers of change in ecosystem services (average score on a scale from 1, the lowest importance, to 5, the highest importance) in the three districts of Nepal

Key drivers of change in ecosystem services	**Dang**	**Gulmi**	**Mustang**
Climate change	1.481 (0.853)	2.044 (0.309)	1.233 (0.500)
Use of pesticides	1.301 (0.789)	3.807 (0.578)	1.233 (0.563)

Deforestation	2.096 (0.730)	2.833 (0.459)	1.450 (0.790)
Imbalance in water regulation	2.246 (0.730)	2.772 (0.442)	1.783 (0.825)
Erosion and landslides	2.424 (1.447)	2.752 (0.454)	2.317 (1.000)
Use of chemical fertilizer	1.315 (0.757)	3.702 (0.547)	1.500 (0.834)
Loss of habitat	2.420 (0.907)	2.741 (0.533)	1.400 (0.588)

3.10 Source of information about the ecosystem services

The result showed that the overall information about the ecosystem services will be obtained from the friends (23.2%) followed by the self-experience 20.5%, agriculture extension staff (20.1%), Radio/TV/Internet (14%) and with the least from the farmer's field school (5.1%). The accessibility of the agriculture extension workers in Dang (36.1%) is very high as compared to the Gulmi (11.4%) and Mustang (5.0%) districts as shown in Table 6.

Table 6. Source of the information about the ecosystem services to the respondents in the three districts of Nepal

S.N	Source of information	Dang	Gulmi	Mustang	Total	P-value
1.	Agriculture extension staff	43 (36.1%)	13 (11.4%)	3 (5.0%)	59 (20.1%)	< 0.001
2.	Farmer field school	15 (12.6%)	0 (0.0%)	0 (0.0%)	15 (5.1%)	
3.	Radio/TV/Internet	13 (10.9%)	17 (14.9%)	11 (18.3%)	41 (14.0%)	
4.	Self-experience	14 (11.8%)	20 (17.5%)	26 (43.3%)	60 (20.5%)	
5.	Friends	27 (22.7%)	40 (35.1%)	7 (11.7%)	68 (23.2%)	
6.	Others	6 (5.0%)	24 (21.1%)	13 (21.7%)	43 (14.7%)	

3.11 Insect pest and disease incidence

The result showed that around 59% of the farmers from total perceived as the increase in the incidence of the insect pest and disease in the major crops grown in the project districts, showing that 87.4% of the respondent from the Dang and 46.7% of the respondents from the Mustang perceived increased whereas 59.6% of respondents in the Gulmi districts perceived no change in the incidence of insect pest and disease shown in Table 7..

Table 7. Farmer's perception on the incidence of the insect pest and disease on the targeted crops in the three districts of Nepal

S.N	Insect pest and disease incidence	Dang	Gulmi	Mustang	Total	P-value
1.	Decline	11 (9.2%)	0 (0.0%)	20 (33.3%)	31 (10.6%)	< 0.001

2.	No change	3 (2.5%)	68 (59.6%)	3 (5.0%)	74 (25.3%)	
3.	Increase	104 (87.4%)	41 (36.0%)	28 (46.7%)	173 (59.0%)	
4.	Don't know	1 (0.8%)	5 (4.4%)	9 (15.0%)	15 (5.1%)	

3.12 Reason to increase the incidence of insect pest and disease

The result showed that climate change is the major reason followed by the use of pesticides and the least is due to the loss of the ecosystem services as in Table 8.

Table 8. Reason for the increase in the incidence of the insect pest and disease in the three districts of Nepal

S.N	Reason for the incidence of insect pest and disease	Dang	Gulmi	Mustang	Total	P-value
1.	Climate change	56 (47.1%)	28 (24.6%)	24 (40.0%)	108 (36.9%)	< 0.001
2.	Loss of ecosystem services	12 (10.0%)	23 (20.2%)	13 (21.7%)	47 (16.3%)	
3.	Use of pesticides	41 (34.5%)	23 (20.2%)	18 (30.0%)	82 (28.0%)	
4.	Don't know	9 (7.6%)	40 (35.1%)	5 (8.3%)	54 (18.4%)	

3.13 Trends of chemical pesticide use

The result showed that around 50% of the farmers from total perceived as the increase in the use of chemical pesticide in the major crops grown in the project districts, showing that 80.7% of the respondent from the Dang and 50.5% of the respondents from the Mustang perceived increased whereas 79.8% of respondents in the Gulmi districts don't know about the trend of chemical pesticide use shown in Table 9.

Table 9 Farmer's perception on the trends of the chemical pesticide use in the three districts of Nepal

S.N	Trends of the chemical pesticide use	Dang	Gulmi	Mustang	Total	P-value
1.	Decline	6 (5.0%)	0 (0.0%)	7 (11.7%)	13 (4.4%)	< 0.001
2.	Increase	96 (80.7%)	16 (14.0%)	36 (60.0%)	148 (50.5%)	
3.	No change	5 (4.2%)	4 (3.5%)	15 (25.0%)	24 (8.2%)	
4.	Don't know	12 (10.1%)	91 (79.8%)	2 (3.3%)	103 (35.9%)	

3.14 Biocontrol agents

The result shows that overall 94% of the respondents don't use the biocontrol agents in the project districts. Among, around 97.5% of the respondents from the Dang district don't use the biocontrol agents for the control of the insect pest and disease followed by 95.6% in the Gulmi and 85 % in

the Mustang district as shown in Table 10. This showed that almost no farmers use biocontrol agents to control insect pests and diseases.

Table 10. Use of the biocontrol agents to control the insect pest and disease in the three districts of Nepal

S.N	Use of biocontrol agents	Dang	Gulmi	Mustang	Total	P-value
1.	No	116 (97.5%)	109 (95.6%)	51 (85.0%)	276 (94.2%)	< 0.001
2.	Yes	3 (2.5%)	5 (4.4%)	9 (15.0%)	17 (5.8%)	

3.15 Knowledge on Pollination

The result shows that around 61% of the respondents don't have knowledge of pollination and pollinators in the study districts. Among them, around 77.2% of the respondents from the Gulmi district followed by 53.3% in the Mustang and 49.6 % in the Dang district don't have knowledge on the pollination and pollinators as shown in Table 11.

Table 11. Farmer's knowledge on the pollination and pollinators on the three project districts of Nepal

S.N	Knowledge on pollination	Dang	Gulmi	Mustang	Total	P-value
1.	Yes	60 (50.4%)	26 (22.8%)	28 (46.7%)	114 (38.9%)	< 0.001
2.	No	59 (49.6%)	88 (77.2%)	32 (53.3%)	179 (61.1%)	

3.16 Status of pollinator population

Table 12 shows the trends of the pollinator population on the farmers' perception. The result shows that on aggregate more than 50% of the farmers perceived the decrease in pollinators' population. About 65% of the farmers in the Dang districts followed by 55% in Gulmi and at least 32% in Mustang reported the decline in the pollinator population. Similarly, total of 24% of farmers from the three districts perceived there is an increase in the pollination population followed by around 14% no change and 12% who don't know the status of the pollinator population.

Table 12. Trends of pollination population on the Farmer's perception on the three project districts of Nepal

S.N	Trends of pollination population	Dang	Gulmi	Mustang	Total	P value
1.	Decline	77 (64.7%)	63 (55.3%)	19 (31.7%)	159 (50.56%)	< 0.001

2.	Don’t know	1 (0.8%)	16 (14.0%)	12 (20.0%)	29 (11.6%)	
3.	Increase	36 (30.3%)	21 (18.4%)	14 (23.3%)	71 (24.0%)	
4.	No change	5 (4.2%)	14 (12.3%)	15 (25.0%)	34 (13.83%)	

Conclusion

Recommendation