Climate Change Adaptation Strategies of the Communities in Bagmati Province, Nepal

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Abstract

The vulnerability to climate change provides critical insights within academic discourse. This study examined climate change adaptation strategies in Bagmati Province, focusing on the characteristics of respondents and their access to socio-economic services, community resources such as land, water, forests, and energy sources, and the impacts of climate change on livelihoods. A quantitative approach and cross-sectional survey design were employed to collect data from 204 households in the villages of Syaphrubeshi, Dobhan, Langtang, and Mundu (Langtang Rural Municipality) and Krishnanagar, Kharikuna, Basantpur, and Inarbaruwa (Madi Municipality). The main ethnic groups in Langtang are the Tamang, Sherpa, and Gurung, while Brahmin and Tharu dominate in Madi. Agriculture, remittances, business, and tourism were identified as key income sources, with many households receiving remittances in the past year. While most households in Rasuwa have piped drinking water, residents in Chitwan primarily use tube wells. LP gas, firewood, and dung ranked as the primary cooking fuels. Challenges such as road connectivity, market access, education, health services, and agricultural support were more pronounced in Langtang than in Madi, with most households walking over 1 km for these services. Water resources are increasing in the Inner Tarai due to tube wells but decreasing in mountain regions, where forest resources are also in decline. The study's community resource index, climate change vulnerability index, and adaptation index varied according to settlement types, with findings grounded in both empirical and theoretical evidence. These results offer valuable insights for policymakers and stakeholders at various levels.

Keywords: *Climate change, community resource, livelihoods, vulnerability, adaptation*

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Introduction

Climate change refers to the average long-term changes over the whole earth. These include warming temperatures and changes in precipitation including effects of Earth's warming and greenhouse effect (NASA, 2021). Global warming brought on by human-caused climate change has increased by roughly 1°C, with a range of 0.8° to 1.2°C over pre-industrial levels (IPCC, 2018). The IPCC (2018) predicted that between 2030 and 2052, global warming is expected to exceed 1.5°C if greenhouse gas emissions continue at their current rate. As a result, there are now unparalleled levels of carbon dioxide, methane, and nitrous oxide in the atmosphere compared to the previous 800,000 years. The average temperature of Earth has increased by 1.5°C during the last century, and over the next 100 years, it is expected to climb by another 0.5 to 8.6°C. IPCC (2007), projects that global average temperature in 2100 will be between 1.8 and 4°c. Higher than the 1980-2000 average. The sea levels are projected to rise by 0.18 to 0.59 meters by 2100 based on observed rates of ice flow from Greenland and Antarctica.

Nepal was ranked as the 4th most vulnerable country due to the impacts of climate change (Maplecroft, 2010 as

cited in Sapkota & Rijal, 2021) but is one of the least contributors to the emissions of greenhouse gases (GHGs), emits only 0.027% of global share (MoPE, 2016). It rates 166 countries on their capacity to mitigate risks to society and the business environment posed by changing patterns in natural hazards, such as droughts, flooding, storms and rising sea level and the resulting effects on ecosystems. Data on trends of Nepal from 1975 to 2020 has been rising by 0.06°C/year and the climate in the Himalayan region of Nepal is changing faster than the global average (Upadhayaya & Baral 2020). Accordingly, mean rainfall has significantly decreased on an average of 3.7 mm (-3.2) per month per decade (Upadhayaya & Baral 2020). Under various climate change scenarios, mean annual temperatures are projected to increase between 1.3-3.8°C by the 2060s and 1.8-5.8°C by 2090s. Annual precipitation is projected to reduce in a range of 10 to 20 across the country (MoPE, 2016).

Forming south-to-north transects, Nepal can be divided into three ecological regions: Mountain, Hill and Tarai. Mountain region covers 15% of the total area of Nepal. This region is famous for alpine culture populated by people with Tibetan affinities, called Bhotiya or Bhutia including the famous Sherpas in Kumbu valley near Mt. Everest and Thakali of Kali Gandaki Gorge. Likewise, the Hill and Terai regions cover 68% and 17% of the total area of Nepal (Uddin et al., 2015). Out of total population, female share is 51.04% (29192480) and male occupies 48.96% (14291311) with average 4.32 family members (Mountain 4.27, Hill 3.95, and Tarai 4.65) and 198 per/km2 population density (NSO, 2021). The Himalayan region's temperature is rising more quickly, which has detrimental effects on the nation's glacier lakes (Regmi et al., 2020). The influence of climate change has been observed in numerous industries, including tourism, hydroelectric power, agriculture, and food security. Floods, droughts, and landslides are just a few of the climate-related hazards that climate change is predicted to bring about. As a result, these effects will directly affect the nation's economy and, by extension, the standard of living for its citizens (Sapkota & Rijal, 2021, Khatri & Pasa, 2023). According to several evaluations of climate change susceptibility, Nepal is extremely vulnerable to the effects of the climatic phenomenon. Approximately 1.9 million people are thought to be highly vulnerable, and an additional 10 million are exposed to ever-increasing risk (MoE, 2011). Nepal's warming is expected to be more than the world average. Under the highest emission scenario (RCP 8.5), Nepal is predicted to warm by 1.2°C–4.2°C by the 2080s relative to the baseline period of 1986–2005 (ADB, 2021).

The National Adaptation Programme of Action (NAPA), approved in September 2010, was the vehicle through which the Government of Nepal started organizing and implementing plans for climate adaptation (MoE, 2011). According to the NAPA, the government plans to directly fund at least 80% of the available funding for the implementation of selected adaptation initiatives at the local level. The NAPA also aims to ensure that local populations, especially the climate vulnerable poor, are supported in their adaptation efforts through national adaptation planning (Penniston, 2013). Reducing the harm to ecosystems and the people who depend on them requires adaptation, which entails anticipating future impacts and efficiently responding to those that are now being felt. The sustainable use of land, water, energy, and other resources is a prerequisite for adaptation, thus it must be supported in a variety of ways, from local actions to policy development to international involvement (ICIMOD, 2022a).

In this context, this study highlights triple issues: access of community resources, climate change vulnerability on livelihoods and climate change adaptation strategies of the communities residing in Mountain and inner Tarai regions of Bagmati Province. Therefore, the research issues have been observed and understood empirically in two ecological regions of Bagmati Province such as Rasuwa District from Mountain region and Chitwan District from inner Tarai region. More specifically, this study aims to describe characteristics of the sample households and their access to economic services. The study also aims to describe accessibility of community resources, climate change vulnerability on livelihood and climate change adaptation strategies of the communities residing in Bagmati Province.

Hypothesis on Settlement Specific Adaptation Strategies

In this background mentioned above, this study describes settlement specific adaptation strategies by using sustainable livelihood approach and cultural risk theory (CRT) of climate change adaptation. The livelihood

approaches first appeared in the 1990s Zeitgeist and are still useful in the current international commitments of SDG 2030 and NZE 2050 (UN, 2015). Livelihood comprises the capabilities, property (stores, resources, claims and access) and activities vital for a means of living (Chamber & Conway, 1992). Ashley and Carney (1999) developed five fundamental strategies (people centric, participatory, multilevel, dynamic and sustainable) of the development initiatives for reducing poverty. The individuals and societal units are using such livelihood strategies to find purpose in their lives. Therefore, increased income, improved health, ensured less susceptibility, enhanced food security and maintained sustainable use of natural resources are regarded as livelihood outcomes (DFID, 1999).

Accordingly, for CRT, the institutional cultures in market individualistic, hierarchical bureaucracy and egalitarian society have distinct perspectives to risk management (Rayner, 1992). Thus, conflict is explained by CRT as the result of divergent worldviews about the identification and management of risk through social agreement. Contrary to traditional perspectives on risk management, CRT transfers information and communication depend on mutual understanding and trust between communities that form the basis of policy formation and implementation (McNeeley & Lazrus, 2014).Thus, this study hypothesized that: community resources index, climate change vulnerability index and climate change adaptation strategies index of the communities are described significantly by the settlement types.

Materials and Methods

The setting

Purposively, Bagamti Province has been selected as a field of the study. Ecologically, this Province is adjoined by Mountain, Hill and inner Tarai regions. Again Rasuwa district located in Mountain region and Chitwan district located in inner Tarai region have been selected. The Rasuwa and Chitwan districts respectively secure moderate (0.356-0.600) and high (0.601-0.786) on climate change vulnerability index (MoE/NAPA, 2010). More specifically, Gosainkunda rural municipality located in Langtang National Park has been selected from Rasuwa district.

Accordingly, Madi municipality located in Chitwan National Park has been selected from Chitwan district. The communities are also involving in bufferzone management committee, community forestry and involving in agricultural and non-agricultural business. They are also involving in ecotourism and religious tourism activities. Gosaikunda rural municipality is located between 28.1637° N, 85.3369° E with area of 979 km² area. It has total 7, 788 population with 2,017 households and 7.969 person/km² density (GRM, 2022). Langtang region located in this rural municipality is a third most popular tourism destination of the country (Bajracharya et al., 2014). The devastating earthquake 2015 claimed the lives of over 350 local people including hotel staffs and tourists as well as hundreds of livestock animals (Kargel et al., 2016).

Likewise, Madi municipality is located between 27.4129° N, 84.3752° E over 218.2 km² area. It has total 38, 295 population with 9660 households and 175.5 person/km² density (MM, 2022). The municipality located 38 Km southern part from the Bharatpur metropolitan city. It is adjoined by Chitwan National park in the East, west and north and adjoined by Someshwor hill range in the south. The Madi valley has huge amount of fertile land.

Research design and data sources

The study is grounded in a cross-sectional research design (Khatri, 2020). This investigation utilized an objective ontological framework (Moore & Bruder, 2007) alongside a deductive epistemological methodology (Khatri & Pasa, 2022) to address research objectives. The idea was to generate generalized knowledge on climate change adaptation strategies. Furthermore, this study used cross sectional survey (Gupta & Gupta, 2015) without manipulating of the studied variables (Creswell & Creswell, 2018). The household survey covered three measurement indicators such as community resources, climate change vulnerability on livelihood and climate change adaptation strategies. The measurement indicators have only 15 items variable (5 for each). Therefore, 204 sample household were selected for the study purpose as White (2022) and Wolf et al. (2013) suggested to select at least 200 to 400 respondents in the small instrument (≤15 items).

Again for the geographical representatives of the field, core and peripheral wards were selected. More specifically, ward number 5 (core) and 4 (periphery) were selected from Gosainkunda rural municipality whereas ward number 3 (core) and 9 (periphery) are selected from Madi municipality. Finally, in equal sampling basis, 102 sample households were selected from each of the local level. The reliable tools having 0.79 Cronbach alpha (Cohen at al., 2018) developed based on five points (5 to 1 points) Likert scale questions. The responses which are strongly disagreed with receive one point, while those that are strongly agreed receive five points. The respondents were given the option to choose the appropriate response based on their categorization.

Measures

The study has three outcome measures. For describing outcome measures, data are collected from sample households as reported by the household informant. All the outcomes are related to settlement specific households which are associated with availability of community resources (outcome I), climate change vulnerability on livelihood (outcome II) and climate change adaptation strategies of the communities (outcome III) as well.

Analytical strategy

The descriptive statistics, frequency tabulations (Gupta & Gupta, 2015) and summative analysis (Sava, 2016) of the studied variables have been presented (Tables 1-3). Likewise, the multivariate analysis model (Field, 2009; Chakrabartty, 2014) also has been used to describe three measurement outcomes (Tables 4-5). The normality of the measurement indexes and multiple regression models have been described separately. The study also brought theoretical insights from sustainable livelihood approach and cultural risk theory of climate change adaptation. Therefore, the research issues are described, analyzed and interoperated empirically and theoretically.

Results

Household characteristics

This section presents information on household characteristics residing in Langtang rural municipality and Madi municipality. It deals on distribution of ward types, sex, caste, and education levels, primary and secondary occupations within these municipalities (Table 1).

Table 1

Household Information

Category	Responses	Langtang Rural Municipality		Madi Municipality		Total	
		N	%	N	%	N	%
Ward types	Core ward	46	22.60	51	25.00	97	47.60
	Periphery ward	56	27.50	51	25.00	107	52.50
Sex group	Male	85	41.70	81	39.70	166	81.40
	Female	17	8.30	21	10.30	38	18.60
Caste group	Brahmin	0	0.00	45	22.10	45	22.10
	Chhetri	0	0.00	5	2.50	5	2.50
	Janjati	102	50.00	40	19.60	142	69.60
	Dalit	0	0.00	10	4.90	10	4.90
	Muslim	0	0.00	2	1.00	2	1.00
Education	Basic	3	1.50	35	17.20	38	18.70
	Higher	4	2.00	12	5.90	16	7.80
	Iliterate	48	23.50	17	8.30	65	31.90
	Literate	47	23.00	38	18.60	85	41.70
Primary occupation	Agriculture	49	24.00	69	33.80	118	57.80

	Business	53	26.00	28	13.70	81	39.70
	Service	0	0.00	5	2.50	5	2.50
Secondary occupation	Remittance	65	31.90	38	18.60	103	50.50
	Business	33	16.20	40	19.70	73	35.90
	Wage/labor	4	2.00	24	11.80	28	13.80
Total		102	50.00	102	50.00	204	100.00

The data of Table 1 reveals notable differences in household characteristics and occupational status between the two study areas. Langtang rural municipality has a higher concentration of Janjati individuals, lower educational attainment, and a greater focus on remittance and business as secondary occupations. Madi Municipality shows a more varied caste composition with Brahmin dominated, higher education levels, and a greater engagement in agriculture and wage/labor occupations.

Household facilities and socio-economic services

This section highlights information on socio-economic access of sample households residing in Langtang rural municipality and Madi municipality. It deals on organizational memberships, saving family income, farm mechanization, receiving support from agriculture support center and distance to road-market-school-health center-agriculture support center within these municipalities (Table 2).

Table 2

Socio-economic Access related Information

Category	Response	Langtang rural municipality		Madi municipality		Total	
		N	%	N	%	N	%
Member in CBOs	Yes	102	50.00	99	48.50	201	98.50
	No	0	0.00	3	1.50	3	1.50
Regularly saving	Yes	102	50.00	100	49.00	202	99.00
	No	0	0.00	2	1.20	2	1.20
Farm mechanization	Yes	102	50.00	94	46.10	196	96.10
	No	0	0.00	8	3.90	8	3.90
Received agriculture support	Yes	102	50.00	91	44.60	193	94.60
	No	0	0.00	11	5.40	11	5.40
Distance to road	<1 km	46	22.50	102	50.00	148	72.50
	10-20 km	5	2.50	0	0.00	5	2.50
	>20 km	51	25.00	0	0.00	51	25.00
Distance to health center	<1 km	65	31.90	74	36.30	139	68.10
	1-2 km	27	13.20	28	13.30	55	27.00
	>2 km	10	4.90	0	0.00	10	4.90
Distance to school	<1 km	63	30.90	75	36.80	138	67.60
	1-2 km	29	14.20	27	13.20	56	27.50
	>2 km	10	4.90	0	0.00	10	4.90
Distance to market	<1 km	46	22.50	51	25.00	97	47.50
	10-20 km	16	7.80	51	25.00	67	32.80
	>20 km	40	19.60	0	0.00	40	19.60
Distance to agriculture support center	<1 km	14	6.90	0	0.00	14	6.90
	1-2 km	77	37.70	51	25.00	128	62.70
	>2 km	11	5.40	51	25.00	62	30.40
Total		102	50.00	102	50.00	204	100.00

Table 2 depicts information on notable differences in socio-economic access related information of the sample

households residing in the study areas. Langtang rural municipality and Madi municipality show high levels of involvement in Community Based Organization, regularly saving, and farm mechanization, with both areas having good agricultural support. However, Madi municipality has better access to roads, health centers, schools, and markets comparing to Langtang. Likewise, Langtang rural municipality tends to have better proximity to agriculture support centers and a greater distance from markets. These comparative insights highlight differences in infrastructure and service accessibility between these two local level representatives of Mountain and inner Tarai regions of Bagmati Province.

Measuring community resource, livelihood vulnerability and adaptation strategies

This section presents information about summative analysis of the item variables. The items are developed based on three measurement indicators: access of community resources, impact of climate change vulnerability on livelihoods and climate change adaptation strategies (Table 3).

Table 3

Summative Analysis of Measurement Items

Community resource			Climate change vulnerability on livelihood			Climate change adaptation		
Items	Mean	SD	Items	Mean	SD	Items	Mean	SD
agriculture land	1.71	0.87	Perceived changes	4.23	0.68	Organic farming	3.51	1.39
Arable land	1.74	0.89	Affect agriculture production	3.66	1.45	Modern technology	3.46	1.37
Forest	1.50	0.79	Increased water scarcity	3.16	1.46	Participating community risk management	3.35	1.36
Renewable energy	1.53	0.69	Increased flood landslide	3.50	1.36	Selecting multiple crops	3.42	1.31
Non-renewable energy	1.82	0.88	Increased erratic rainfall	3.48	1.34	Basic skills understand risk and shift livelihood	3.42	1.33

The statements, changes in water availability, changes in arable land and changes in use of renewable energy got the highest mean values ranging from 1.85 to 1.51 with standard deviation 0.65 to 0.76 respectively. This means the responses are falls nearer to decreased points with consistent data. However, the statements, use of non-renewable energy and changes in forest cover got lowest mean values ranging from 1.48 to 1.49 with standard deviation 0.76 to 0.77 respectively. This means the responses are falls around increased point with consistent data. Likewise, the statement, noticeable changes in climate change pattern got the highest mean values 4.23 with 0.68 standard deviation. This means the responses are falls nearer to strongly agree points with consistent data. Similarly, the statement, climate change has affected agriculture production also got second highest mean 3.66 with 1.44 standard deviation. This means the responses are falls nearer to agree points with consistent data. However, the statements, community experiencing water scarcity, increased occurrence of erratic rainfall and increased occurrence of land slide and flood got lowest mean values ranging from 3.17 to 3.49 with standard deviation 1.46 to 1.35 respectively. This means the responses are falls above neutral point with consistent data. The data indicate that communities' people are experiencing thunders of climate change related effects such as drought, flood, erratic rainfall and decreasing trend of agriculture production. And their livelihood vulnerability also has been increased annually which must be addressed collectively by government and non-government stakeholders including community people residing in Mountain and inner Tarai regions.

Similarly, the statement, practicing organic farming and traditional technology as well as practicing modern technology got the highest mean values ranging from 3.59 to 3.51 with 1.640 to 1.34 standard deviation respectively.

This means the responses are falls nearer to important points with consistent data. Similarly, the statements, selecting multiple crops and practicing integrated farming participating for community risk management and offering basic skills for understand risk/shift livelihood also got second highest mean values ranging from 3.34 to 3.46 with standard deviation 1.30 to 1.34 respectively. This means the responses are falls above the neutral point and nearer to important points with consistent data

Normality Test

The normality of measurement indices (community resource index, vulnerability on livelihood index and climate change adaption index) with respect to settlement types of the sample households have been observed (Table 4).

Table 4

Normality of the Measurement Indices

Settlements	N (%)	Community resource index			Vulnerability index			Adaptation index		
		Kolmogorov-Smirnova								
		Statistic	df	Sig.	Statistic	df	Sig.	Statistic	df	Sig.
Syaphrubeshi	33 (16.20)	0.13	33	0.11	0.15*	33	0.04	0.17*	33	0.01
Dobhan	13 (06.40)	0.35**	13	0.00	0.28**	13	0.00	0.22	13	0.08
Langtang	33 (16.20)	0.26**	33	0.00	0.12	33	0.19	0.13	33	0.17
Mundu	23 (11.30)	0.23**	23	0.00	0.13	23	0.20	0.15	23	0.16
Basantpur	25 (12.30)	0.18*	25	0.03	0.12	25	0.20	0.13	25	0.20
Inarbaruwa	26 (12.70)	0.20**	26	0.00	0.14	26	0.19	0.21**	26	0.00
Kharikuna	25 (12.30)	0.29**	25	0.00	0.19*	25	.01	0.20*	25	0.01
Krishnan	26 (12.70)	0.29**	26	0.00	0.20**	26	0.00	0.17*	26	0.04

**. This is a lower bound of the true significance. a. Lilliefors Significance Correction*

**p< .05, **p< .01*

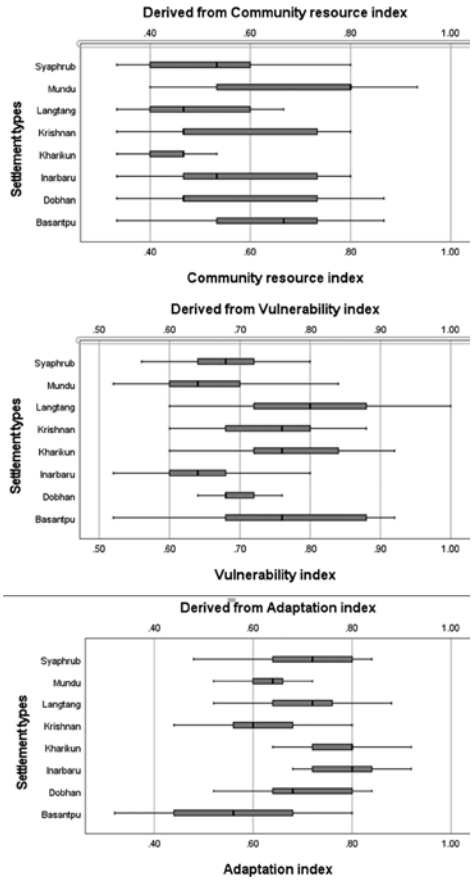

Table 4 depicts normality of community resource index found insignificants (p >0.05) for Syaphrubeshi. This means null hypothesis is accepted ad the index is normally distributed in this settlement. However, the index found significant (p <0.05, 0.01) for the remaining settlements. This means the null hypothesis is rejected and the index is not normally distributed in the settlements. According to the Box plot, the lower limit found comparatively low in Syaphrubeshi, Langtang and Kharikuna. The inter quartile ranges found positive for Basantpur (0.23), Dobhan (0.33), Inarbaruwa (0.27). Kharikuna (0.10), Krishnanagr (0.27), Langtang (0.20), Mundu (0.27) and Syaphrubeshi (0.20) as well. Similarly, the upper limit also found comparatively high in board member. However, the box plot contains no outliers and the data are not even symmetric which is, in fact, skewed to the right for the settlements except Basantpur.

The normality of climate change vulnerability on livelihood index found insignificants (p >0.05) for Langtang, Mundu, Basantpur and Inarbaruwa. That means vulnerability index is normally distributed in these settlements. However, the index found significant (p <0.05, 0.01) for Syaphrubeshi, Dobhan, Kharikuna and Krishnanagar. This means the index is not normally distributed in these settlements. According to the Box plot, the lower limit found comparatively low in Dobhan and Krishnanagar. The inter quartile ranges found positive for Basantpur

(0.20), Dobhan (0.06), Inarbaruwa (0.08). Kharikuna (0.12), Krishnanagr (0.13), Langtang (0.16), Mundu (0.12) and Syaphrubeshi (0.08) as well. Similarly, the upper limit also found comparatively high in Mundu and Inarbaruwa. However, the box plot contains no outliers and the data are not even symmetric which is, in fact, skewed to the right for Syaphrubeshi, Mundu, Dobhan and Mundu but skewed to the left for remaining settlements.

The normality of climate change adaptation index found insignificants ($p > 0.05$) for Dobhan, Langtang, Mundu and Basantpur. That means acceptance of null hypothesis and the adaptation index is normally distributed in these settlements. However, the index found significant ($p < 0.05$, 0.01) for Syaphrubeshi, Inarbaruwa, Kharikuna and Krishnanagar. This means rejection of null hypothesis and the index is not normally distributed in these settlements. According to the Box plot, the lower limit found comparatively low in Inarbaruwa, Kharikuna and Mundu. The inter quartile ranges found positive for Basantpur (0.24), Dobhan (0.16), Inarbaruwa (0.13). Kharikuna (0.08), Krishnanagr (0.14), Langtang (0.12), Mundu (0.08) and Syaphrubeshi (0.20) as well. Similarly, the upper limit also found comparatively high in Langtang, Kharikuna and Basantpur. However, the box plot contains no outliers and the data are not even symmetric which is, in fact, skewed to the right for Krishnanagar, Kharikuna, inarbaruwa and Dobhan but skewed to the left for remaining settlements.

Measurement of association

The study used multiple regression model (MRM) for describing the associations between dependent variable (indexes) and independent variables (characteristics of the sample households). MRM for the dependent variable community resource index (Model I), climate change vulnerability index (Model II) and climate change adaptation index (Model III) with respect to 12 independent variables (Table 5) have been described. The results of MRM indicated that dependent variables measurement indexes which are 9%, 24% and 14% respectively described by the predicted variables (Table 5). All the predictor variables were not found positive and significant in the models.

Table 5

Model Summary

MRM	Community resource index	Climate change vulnerability index	Climate change adaption index
	Model I	Model II	Model III
Measures	B	B	B
(Constant)	0.31	0.79**	0.66**
Local level	-0.00	0.01	-0.04
Received remittance during 12months	0.04	0.00	0.00
Having farming experience	0.03	-0.06	0.06
Regularly saving in cooperatives/others	0.23	-0.21	-0.06
Members in community based organization	-0.11	0.05	-0.08
Received support from agriculture support center	0.14	-0.08	-0.04
Current farm mechanization	-0.12	0.14*	0.09
Distance to motor able road	-0.01	0.10**	0.04*
Distance to health center	0.07	-0.02	0.05
Distance to secondary school	-0.01	-0.05	0.02
Distance to market	0.01	0.11**	0.00
Distance to agriculture support center	0.03	0.11**	0.01

**p< .05, **p< .01*

More specifically, in the first model, the predictors received remittance in the past 12 months (t= 1.80), having farming experience (t= 0.30), regularly saving family income in cooperatives and other informal institutions (t= 1.04), received support from agriculture support center (t= 1.19), distance to health center (t= 1.23), distance to market, (t= 0.33) and distance to agriculture support center (t= 1.11) have positively described to the community resource index. Very interestingly, no any variables described significantly to the model.

Likewise, the predictors current farm (t= 1.93, p<0.05), distance to road (t= 5.11, p<0.01), distance to market (t= 4.87, p<0.01) and distance to agriculture support center (t= 4.32, p<0.01) found significant in the second model. Besides, the predictors local level (t= 0.65), received remittance in the past 12 months (t= 0.63) and member in CBOs (t= 0.50) also describe positively to the model. Similarly, the predictor distance to motor bale road (t= 5.11, p<0.05) also found significant predictor in third model. Besides, the predictors received remittance in the past 12 months (t= 0.43), having farming experience, (t= 0.75), current farm mechanization (t= 0.97), distance to health center (t=1.16, p<0.05), distance to school (t= 0.63, p<0.05), distance to market (t= 0.17) and distance agriculture support center (t= 0.71) also have positively described to the climate change adaptation index.

Discussion

Most of the respondents are belonging to Tamang, Brahmin and Tharu ethnicity. Tamang and Sherpa, are dominated ethnic groups in Langtang whereas Brahmin and Tharu are dominated in Madi valley. The majorities of the household head are male that has differentially shape households' coping strategies and ability to adaptation (Goodrich et al., 2017). Agriculture, business, remittance and tourism sectors are major sources for family income. Agriculture plays a significant role in the economic growth of developing countries (Diallo et al., 2020; Pasa, 2021). Besides, tourism is another prominent sector for family income and led sector of rural and national economy. Nepal's tourism industry generated NRs. 240.7 billion in 2018 that stood at 7.9% GDP (Prasain, 2019). There are about 200,000 people who are directly employed in hotel, restaurants, trekking, mountaineering, airlines, and other tourism subsectors in Nepal (ADB, 2020). Involving in such diversified earning sectors helped to increase family income in the study area. Theoretically, increase family income and reduced vulnerability are major outcomes of sustainable livelihood framework (DFID, 1999).

The access of water resource and irrigated lands are increased in Madi valley whereas decreased in Langtang. Therefore, smallholder agriculture in mountain region becoming critical in the creation of employment, improving food security. Pant (2011) also mentioned agriculture sector is becoming highly vulnerable to climate change due to more marginal farmers with small landholding and limited irrigation. Therefore, local development stakeholders must provide technical/financial support to run agrotourism development activities. K.C. (2016) highlighted triple principles of ecotourism such as biodiversity conservation, poverty reduction and promoting local business is possible through entrepreneurship development.

Unemployment is a burning issue in the study area. Most (569 HHs) of the family members are thus involving in foreign employment (MM, 2022; GRM, 2022). Besides, there are 510 (269 male & 241 females) absentees population in Gosaikunda rural municipality which equals to 7.14 percent of the total population (GRM, 2022). Similarly, there are total 4393 (3961male & 432 females) absentees population in Madi municipality which equals to 11.66 percent of the total population (MM, 2022). The excessive costs of male out-migration pursue girls in better workloads, responsibilities, and burdens, and that the spillover of this extra burden often outcomes in low enrollment and disenrollment for ladies from formal schooling (Goodrich et al., 2017). This might be reason that most of the female respondents are illiterate. There are only 23,974 people fully literate in Madi municipality whereas 3,753 people fully literate in Gosaikunda rural municipality (MM, 2022; GRM, 2022).

For the community resources, the statements changes in water availability, changes in arable land and changes in use of renewable energy got the highest mean values. This might be reason, more sustainable use of the natural resources for ensuring food security is also regarded as major outcomes of sustainable livelihood framework (DFID, 1999). However, in the study area, the measurement items crop production and remittance got highest mean values falls between high and essential priority points. Pasa (2021) also mention that agriculture provides nearly one-third of national GDP and two-third of national employment. Hence, local development stakeholders must appreciate role model farmers and small farmers through different incentives. The diversified livelihood strategies helped them to achieve their livelihood outcomes such as more income, increased wellbeing and food security as well as reduced vulnerability (Ashley & Carney, 1999).

For assessing climate change vulnerability on livelihoods, the statement noticeable changes in climate change pattern and increased landslide got the highest mean values. Amadio et al. (2023) also observed that landslides

are much more likely to occur in the northern mountainous whereas southern parts are at better exposure to river flooding, warmness, and drought dangers. Tupelo (2012) also claimed that main challenge for agriculture in the twenty-first century is the need to conserve ongoing soil degradation and water depletion in the face of limited resources. In this respect, Mai et al., (2024) recommended to expand soil remediation strategies contain a couple of physical, chemical, organic and remedial technologies.

Therefore, development stakeholders must appraise their prospects and weakness and motive them to identify livelihood priorities themselves. Fadeyi et al. (2022) also found that education, finance and access of extension are prominent factors to appraise weakness of smallholder agriculture in Africa. Even though, the adaption strategies of the local people have been upgrading livelihood outcomes by involving in agriculture, business and tourism. However, tourism activities found higher in the settlements of Langtang rural municipality whereas commercial farming and other business activities found higher in the settlements of Madi municipality. This might be reason that better understanding of the local dimensions of adaptation strategies is essential to develop appropriate measures that will mitigate adverse consequences (Ahmed, 2016). In the reference of Cultural Risk theory, stakeholders have different worldview to manage vulnerability which can lead to conflict between groups with different cultures (McNeeley & Lazrus, 2014).

For climate change adaptation, the statement practicing traditional and modern technology got the highest mean values. In the study area farmers are also using traditional organic pesticides and insecticides for controlling plant and animal diseases. Such indigenous knowledge and practices have been applying from generation to generation. Saikanath et al. (2023) also found that Indian farmers are applying special version measures like altering planting dates consisting of traditional practices, aid conservation technologies, and socio-financial interventions. Farmers are also involving in organic farming which is becoming demand of the visitors in tourism destinations. Milford et al. (2022) argue that low level of client consider in farmers or public authorities will increase clients' propensity to purchase organic meals. Hence, for organic entrepreneurship, national government must play specific role in establishing the policy and regulatory environment to encourage adaptation by individuals, households and private sector businesses (IFRC, 2009).

However, communities participating for risk management got second highest mean values. In the reference of Cultural Risk theory, the risk communication and management are predicated on shared meaning and trust among individuals who make up the communities (Rayner, 1992). Khatri and Pasa (2023) also suggested enhancing locals' capacity to cope to changing climate in coming days. Sustainable livelihood approach also argues that external support must recognize the dynamic nature of livelihood strategies and respond flexibly to changes in people's situation (DFID, 1999).

Normality of the community resources index found insignificant in Langtang but significant in Madi. However, the vulnerability index on livelihood and adaptation index found significant and insignificant in Langtang and Madi. The respondents having multiple sources of earning, access of farming land and access of economic activities including tourism. The Local Adaptation Plan of Action programs are helping to upgrade institutional capacities of the local government for risk management and reducing vulnerability.

In the reference of sustainable livelihood approach, the development stakeholders are working for economic, institutional, social and environmental sustainability (DFID, 1999). MoALD (2019) reported that farmers are updated the indigenous practices to agricultural diversification by crops varieties and adopting alternative crops, hybrid livestock, dairy co-operative and microcredit services. They are becoming aware about the climate change and its consequences. Farmers are producing winter and summer cash crops, seasonal and off seasonal vegetables, and also involving in animal husbandry. However, for mitigation to climate change impacts, application of agriculture and non-agriculture livelihood strategies are regarded as the adaptation strategies applying by the communities in Bagmati Providence.

The community resource index, climate change vulnerability on livelihood index and climate change adaptation index are well explained by the predicted variables characteristics of the respondents and socio-economic services. The communities are applying diversified adaptation strategies for sustaining their livelihoods. In the case of livelihood, local people are applying diversified livelihood strategies in the study area. Khatri and Pasa (2023) also reveal that maximum of the local community perceived considerable boom in climate alternate indicators in

recent years and going through numerous level of livelihood influences. However, illiterate farmer having small size of faming land not yet getting technical and financial support from agriculture support center have some reservation with the development stakeholders. The variables current farm mechanization, distance to motorable road, distance to market and distance to agriculture support center found significant predicators in the models.

Conclusion and Implications

The study comes to the conclusion that communities of Bagmati Province are applying diversified livelihoods. The livelihoods are affecting by climate change impact such as melting snow, increased erratic rainfall and thunderstorm, increased river flooding and landslide, depletion of water resources, increased drought, and decreased crop production. Besides, communities are also facing biodiversity loss, animal and plant diseases and disaster vulnerability related challenges. Combating to climate change impact, communities are also applying diversified adaptation strategies. They are practicing integrated farming, selecting multiple crop spices, using both organic and commercial farming including animal husbandry. Communities are also involving in local business, tourism, foreign employment, government and private jobs, daily wages and seasonal migration. The communities are becoming skillful and resilient and becoming capable enough to analyze climate change risk. The local development stakeholders are also motivating communities to identify livelihood priorities themselves, supporting to develop new knowledge/skills about evolving livelihoods.

Finally, impact of climate change vulnerability on agriculture and non-agriculture sector found positive and negative. Therefore, developing robust resources utilization and conservation mechanisms (structure, issue, time and space) under Local Adaptation Plan of Action is must. This mechanism need to perform site-specific climate-smart agriculture practices as well as promote need to promote ecotourism in Langtang region and religious tourism in Madi valley. Furthermore, local government can also develop Community Adaptation Plan of Action for upgrading institutional capacities related to climate change risk management.

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Conflict of Interest

The authors declare that there is no conflicts of interest.

Data Availability Statement

The data will be available from the corresponding author upon request.

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