

Infrastructure and Climate Change Adaptation in Nepal : An Assessment

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Abstract

Transport and infrastructure determine the path of a nation's economic development by enhancing productive capacity, creating urban agglomerations, enabling access to potent resources and promoting migration of labor for sustenance and livelihoods. In light of the above argument, the objective of this paper is to assess the importance of infrastructure in achieving sustainable development and climate change adaptation in Nepal. Pacing toward generating higher growth, the environmental impact of constructing core infrastructure facilities often goes amiss, which requires constant evaluation. Evident from the experience of Asian economies, the role and impact of developing roadways, communication networks and energy sources on sustaining growth, reduction in poverty, access to markets and increasing farm incomes emerge

significant. The study investigates the impact of infrastructure on climate change adaptation using primary data collected from 773 farmers spread across seven districts in Nepal during January and February 2017. The paper provides a descriptive analysis of household demographics, climate change adaptation and transport infrastructure based on the collected responses. Further, the logistical regression-based econometric model is constructed based on the preceding analysis. The preliminary findings reveal a positive and significant relationship between access to infrastructure and incentive to undertake climate change adaptation. Gender of the farmer and the extent of climate adaptation are significantly interlinked. More importantly, the likelihood and significance of climate change adaptation are 2.7 times higher with lowering of distance from a road network and 6 times higher with availability of loans for farming. Nepal needs to focus more on developing resilient and more climatologically balanced infrastructure along with stable financing, prescriptions for which will be provided in the concluding section of the paper.

Keywords: Climate change adaptation, rural farmers, rice crops, infrastructure, Nepal

1. Introduction

Economic development of a nation is contingent upon the endowment of transport and infrastructure stock available. Pacing toward generating higher growth to support improvement in livelihoods, the environmental impact of constructing core infrastructure facilities has been ignored. Goals to achieve sustainable development and mitigate climate change call for recurring evaluation of the social and environmental costs of projects for developing resilient infrastructure (Uitto, Puri, & van den Berg, 2017; United Nations, 2019). Empirical evidence across Asian economies affirms the significant role and impact of developing roadways, communication networks and energy sources on sustaining growth, reduction in poverty, access to markets and increasing farm incomes (Fuglie, Gautam, Goyal, & Maloney, 2020). Spillover effects generated through infrastructure investment could hence be considered a necessary precondition for regional success.

Topographical profile and formidable landscape make development a challenging task in Nepal (World Bank, 2018). Climate change implications on livelihoods and social security add to the existing miseries (Dixit, 2011; Merrey, Hussain, Tamang, Thapa, & Prakash, 2018). Adjustments to resolve the climate-based conflict call for climate proofing of infrastructure capacity, which is resilient and adaptive in nature (National Planning Commission, 2017). An estimated average investment requirement of Rs. 33.2 billion per year for climate change adaptation is needed during years 2026-30, with more than 50 percent of funds earmarked for resilient infrastructure (National Planning Commission, 2019). In a report on tracing roadmaps for achieving Sustainable Development Goals (SDGs), National Planning Commission (2017) lists the requirement of Rs. 141.1 billion for investment in agricultural development for years 2026-30. Substantial portions of these funds need channeling into the development of support infrastructures like irrigation facilities, electricity and rural roads (National Planning Commission, 2017).

This paper attempts to assess the importance of infrastructure in achieving sustainable development and climate change adaptation in Nepal.

Further structure of the paper encompasses a literature review in Section 2 followed by the methodology used in Section 3. Next, Section 4 provides a descriptive analysis of the responses collected from several dimensions. These are further supplemented by the econometric exercise. The discussion of results obtained using the regression models covered in Subsection 4 is followed by a conclusion and broad policy prescription in Section 5.

2. Literature Review

Infrastructure is considered to facilitate social outcomes (Harris, Riley, Dawson, Friel, & Lawson, 2018) as it reinforces the goals of public health and well-being. Investment in transport systems creates a positive impetus for economic growth and raises the competitiveness of an economy by encouraging greater foreign investment flows (Ivanova & Masarova, 2013). Urban agglomerations or creation of urban economic zones with functionality call for a stronger network of transport connectivity. Hidayat, Rudiarto, and De Vries (2019) use correlation-based analysis to prove the causal relationship shared between mobility and land prices. Roads provide linkage to urban facilities like housing townships, district centres, administrative offices, education and medical facilities, granting greater and timely access for the population (Hidayat et al., 2019).

The role played by infrastructure proves imperative for sustaining economic and human development through promotion of inclusive industrialization, providing connectivity to enterprises for accessing markets and providing livelihood opportunities (UNESCAP, 2017). With a deficit of physical infrastructure, Nepal has a road network density of 0.5 km./sq. km., expected to increase to 1.3 km./sq. km. by year 2030 (National Planning Commission, 2017). Meanwhile, Nepal also plans to implement climate change adaptation measures in many ways in all sections like energy, infrastructure and agriculture to mitigate the risk (Ministry of Environment, 2010; NAPA, 2010).

Hilly terrain poses a challenge to the development of transport systems in Nepal. Marred by geographical ruggedness, road connectivity and poverty

alleviation, goals are strictly aligned yet equally stringent. Studying the impacts of topographical and geological conditions on rural road construction, Mulmi (2009) cautions on the destabilization impact of transport development on economic outcomes with the neglect of stricter environmental conditions. Lack of technical knowledge or the ability to evaluate the environmental impact of such projects could inflict greater costs rather than mitigating them. Sustainable economic development thus entails sustainable transport development using bioengineering techniques to address issues like gender inequality and poverty alongside impacts on climate and environment (Mulmi, 2009).

To overcome ‘cultural reductionism’ imposed through spatial complexity, people in mountain regions of Nepal have adapted to conditions by creating systems and strategies for survival (Zurick, 1993). Trade channels, religious activities, market access and migration are strongly embedded within the mountain communities which evolve through interactions with commercial economies. Zurick (1993) further argues that spatial road development carries bias against productive rural sectors like agriculture, fodder and forest activities, leading to conflicts.

Nepal is confronted with the constant tiff between economic and environmental goals. The commodification of natural resources for economic progress has put pressure on ecology. Large-scale development and resultant threats have forced political arbitration to curb the globalization of local resources by protecting the forest areas (Lama & Job, 2014). Road connectivity to extract rich resources intensifies human intervention within the protected regions, leading to biodiversity losses. Socio-economically viable outcomes of poverty reduction, livelihoods and opportunities for the poor, promoted through the provision of roads, become an assault on their very habitat and existence. For Nepal, such material developments have amplified the pace of extraction and increased commercial activities within the protected areas. Rampant development supported by road development, under the garb of facilitating economic opportunities for the poor, has served the vested global interests of tourism, trade, hydropower and farming in Nepal (Lama & Job, 2014).

The efforts and role of government prove paramount in supporting the private sector toward contributing to the economic growth of the country. Public investment in infrastructure for development of roads, railways, irrigation and electricity enhances the productive capacity of private firms and institutions. In light of this discussion, Kumar Shrestha (2009) evaluates the role of public expenditure and deficit financing in sustaining growth through the development of hard and soft forms of infrastructure facilities. Empirically, spending on physical infrastructure out of total public spending possesses a significant impact on the per capita real GDP of Nepal. Political instability has resulted in sluggish growth, which has impeded the steady-state progression of the country. There is a need to curb the declining trends by shifting the fiscal stance in favor of developing physical infrastructure which has strong interlinkage with other sectors of the economy (Kumar Shrestha, 2009). Therefore, this paper investigates the impact of infrastructure on climate change adaptation.

The contribution of this work serves to know the rural farmers' perceptions on the importance of infrastructure to adopt climate change adaptation options available to them. As the government of Nepal has always prioritized building climate-resilient infrastructures, this study can be empirical evidence. This study has produced more information on significant variables across infrastructure and climate change adaptation which have the potential for policy contribution.

3. Data and Research Method

3.1 The Model

This study attempts to capture behavioral aspects of Nepalese rice farmers on their perception of climate change adaptation in the presence of infrastructure available to them. A multiple regression, as in equation 1, is used for variables influencing farmers' adaptation in relation to infrastructural availability in Nepal.

$$y = \beta_0 + \beta_1 \mathbf{X} + \beta_2 \mathbf{Z} + \varepsilon_i \quad (1)$$

Where y is the dependent variable, i.e., climate change adaptation, $\mathbf{X}$ represents the vector of three independent variables, i.e., motorable road, market access and loan availability, toward climate change adaptation and $\mathbf{Z}$ represents a vector of three control variables, i.e., total cultivated rice land, access to agriculture extension and gender. β is *regression coefficient* and ε_i is an *error term*.

Since dependent variables are dichotomous in nature, logistic regression analysis is appropriate (Devkota & Phuyal, 2015). For the purpose of the present study, we econometrically use odds-ratio-based binary logistic regression to measure the impact of the above-mentioned variables on farmers' climate change adaptation behavior. When expressed in the logit form, the equation (1) modifies to:

$$\log[p_i/(1 - p_i)] = \beta_0 + \beta_1 \mathbf{X} + \beta_2 \mathbf{Z} + \varepsilon_i \quad (2)$$

By solving through the above equation, the predicted probability of p_i is described as

$p_i = 1/[1 + e^{-y}]$, where e is the base of natural logarithms and represents $\beta_0 + \beta_1 \mathbf{X} + \beta_2 \mathbf{Z} + \varepsilon_i$. Y is a binary variable with value 1 if the farmer has adopted climate change adaptation, else 0; and $\mathbf{X}$ and $\mathbf{Z}$ refer to independent and control variables undertaken for this study (Table 1). The final equation for the study is, therefore,

$$y = \beta_0 + \beta_1 \text{Distance}_R + \beta_2 \text{Gender} + \beta_3 \text{Availability}_L + \beta_4 \text{Total}_L + \beta_5 \text{Extension}_S + \beta_6 \text{Motorable}_R + \mu_0 \quad (3)$$

Distance of home from a motorable road is expected to be negatively linked to climate change adaptation. Lowering the distance with wider road connectivity should result in a wider and more effective form of climate adap-

tation. Similarly, lowering of distance from a market centre should result in greater adaptability amongst farmers as this would increase awareness about climate and the subsequent impacts of farming on climate. Higher access to loans would ease credit constraints, which could have otherwise impeded adaptation. Also, **Z**, which represents a vector of three control variables, could impact the decision for adopting climate change adaptation. **Total cultivated rice land** represents the size of land (in hectares) under cultivation. A larger size of land is expected to yield positive outcome on climate change adaptation. **Access to agriculture extension** represents a binary variable, which takes a value 1 if extension services are available and is 0 otherwise. Availability of agricultural extension services is instrumental in increasing the efficiency of making adaptation decisions. Extension services could expose farmers to information pertaining to different options for financing new adaptation-related technologies and, hence, is positively related to the adoption of climate change adaptation methods. **Gender** takes on value 1 if the farmer is male and 0 in the case of female farmers. Literature suggests that women would play a key role in climate change adaptation and be positive action and change agents. However, considering the resource poverty faced by them the intent might not translate into tangible actions, whereas resource access of male farmers might better equip them to adopt climate change adaptation. The actual impact of a farmer's gender on climate change adaptation would be reflected in actual estimates only.

Based on the above dependent and independent variables, we estimate two main binary logistic regression models in STATA to analyze the said objective:

Model 1: Impact of distance of home from motorable road on climate change adaptation

Model 2: Impact of distance from market centre on climate change adaptation

3.2 Study Area and Data

Through a case study-based approach to address the objective in the current paper, primary data for the study was collected from diverse agro-ecological zones undertaking rice cultivation across seven districts of Nepal, which include Ilam, Sindhuli, Syangja and Surkhet (Hill districts) and Bara, Dang and Kailai (Terai districts) in January and February 2017. The study area was selected based on the agricultural characteristics of the region and its vulnerability to climate risk.

A respondent sample was selected from a population of rice farmers. The random sampling method was used to select seven districts, one each from Nepal's seven provinces. To capture adaptation practice variability within a district, two clusters were demarcated in each district based on the rice cultivated area/rice pocket area¹ on the basis of information provided by the District Agriculture Office. Thereafter, villages and households, for the implementation of the survey questionnaire, were selected using a mix of simple random sampling and multi-stage sampling (Blaikie, 2010; Gilbert & Stoneman, 2008). National Population and Housing Census (CBS, 2011) results were used to select the rural household population for data collection. The survey questionnaire was implemented in 56 households² from one Village Development Committee (VDC). Therefore, the survey gathered information on 112 households from one district aggregating to a total of 773 households in the entire survey. A pre-tested³ structural questionnaire was designed to collect qualitative and quantitative information. The data collection exercise was held between the end of December 2016 to the end of January 2017.

¹ These areas refer to those regions where almost the entire population is engaged in rice cultivation during the rice growing season, and the most collection of rice for the districts comes from these areas.

² Every VDC in Nepal is divided into nine wards. In the present study, two wards were selected from one VDC, and 28 rice-farming households were selected from each ward.

³ The pre-testing for the questionnaire was done with 17 households in the three districts of Kathmandu, Lalitpur and Bhaktapur during the first and second week of December 2016.

4. Results and Discussions

4.1 Descriptive Analysis

This section presents the description of respondents' demographics and a discussion of certain key variables along with an econometric model in the succeeding section.

Household Demographics

Of the 773 respondents, 71% were male, and 29% were female (Table 1). 79% of the respondents were household heads, and 94% of household heads reported farming as their main occupation. The average age of household heads in each district ranged from 45 to 55 years (mean of

48), with the youngest in Kailali (44 years) and the oldest in Syangja (52.5 years). Minimum and maximum ages of household heads were 18 years and 86 years, respectively, from the areas surveyed.

Table 1. District-wise Demographics

	Ilam	Bara	Sindhuli	Syangja	Dang	Surkhet	Kailali	Total
Age of household head (in years)	46.5	52	51	52.5	46	44.5	44	48
Household size (in number)	5.5	10.3	7.8	6.1	6.1	5.9	7.8	7.0
Respondent as a HH head (in %)	67	86	87	76	85	71	83	79
Farming as a main occupation of HH head (in %)	98	97	84	95	91	97	98	94

Source: Authors' calculation based on Field Survey, 2017.

Climate Change Adaptation: Regional Distribution

Of the respondents surveyed across seven districts (Table 2), about 73% (562) were found to have adopted methods for climate change adaptation. Dang (19.3%), Bara (18.8%) and Kailali (18.1%) led in terms of

climate change adaptation by rice farmers, with all these districts in the Terai region.

Table 2. Climate change adaptation among rice farmers: Regional distribution⁴

	Total	Ilam	Sindhuli	Bara	Syangja	Dang	Surkhet	Kailali
N (total respondents)	773	112	106	111	109	112	111	112
Climate Change Adaptation	562	34	88	106	79	109	44	102
Non-adaptation	211	78	18	5	30	3	67	10

Source: Authors' calculation based on Field survey, 2017.

Key variables pertaining to Econometric Modelling

Table 3 presents the description across seven districts for key variables pertaining to infrastructure, transport and other facilities useful from the perspective of econometric exercise in the next section. Districts such as Bara, Sindhuli, Kailali and Surkhet had the highest proportion of agriculture extension centres. Whereas, the Bara district had around 36% of the market extension centres. 35% of respondents had lower access to markets, and 156 respondents had easy access to markets.

Skewed distribution is also seen in the distance from the bank (in kilometres), where a distance greater than 10 km had prominence. Most of the farmers have less access to bank since they have to walk long distances. Only 5% of the respondents had access to banks; about 55% walked more than 10 km to reach a bank. This showed the hurdles in accessing credit. Only 9% of the rice farmers availed loans for their farms.

⁴ Refer to Appendix 1 for regional distribution of climate change adaptation based on gender of the household head.

Table 3. Key variables pertaining to transport and infrastructure

	Ilam	Bara	Sindhuli	Syangja	Dang	Surkhet	Kailali	Total
Household size (in number)	5.5	10.3	7.8	6.1	6.1	5.9	7.8	7.0
Respondent as a HH head (in %)	67	86	87	76	85	71	83	79
Agriculture extension centre (in number)	11	55	56	16	8	44	59	249
Market extension centre (in number)	7	61	27	0	8	30	36	169
Distance from the Bank (in kilometres)	> 1 km	0	12	2	0	0	21	37
	1 – 5 km	0	56	4	45	17	34	171
	5 – 10 km	11	7	0	45	32	0	143
	< 10 km	101	36	100	19	63	56	423
Taken any loan for rice farming (in %)	2	21	1	3	6	12	18	9
Distance from Market (in %)	Less than 1 km	2	11	40	1	1	12	10
	1 – 5 km	3	77	26	37	15	30	34
	6 – 10 km	11	4	2	47	40	15	21
	10 km and above	84	8	32	15	44	43	35
Road Access (in number)	Less than 1 km	21	63	82	13	43	22	310
	1 – 5 km	32	47	5	81	51	36	294
	6 – 10 km	18	0	1	11	18	7	58
	10 km and above	41	1	18	4	0	46	111
Mobile	96	95	79	90	89	90	76	615

Source: Authors' calculation based on Field survey, 2017

Respondents also reported to have easy road access. 40% of farmers had road connectivity with their home, while 38% had road access within 5 km. Only, 28% of farmers had lower road access. Mobile was the most accessible source of information under the ICT category.

4.2 Econometric Analysis

Primary regression-based outcomes on Farm Income are presented in Tables 4 and 5. The impacts on farm incomes are measured specifically using climate change adaptation with and without access to motorable roads in Tables 4 and 5, respectively, along with other important control variables. Our aim with this exercise remains focused on the impact assessment of infrastructure, especially road infrastructure, on farm incomes and, further, upon climate change adaptation. Empirical results presented in Tables 4 and 5 are precursors to the actual case study on climate change adaptation conducted through binary logistical regression, the results for which are presented in Table 6.

In the build-up exercise, climate change adaptation results in a significantly positive impact on farm incomes. Larger numbers of family members working in the field add to the income for the entire household. Intuitive evidence for this is provided by the positive and significant coefficient of Household Size. Rice cultivation requires an abundance of water. With larger tracts of land being under irrigation, farm incomes for rice cultivators show a positive trend with the availability of irrigation facilities. Climate change adaptation facilitated through proximity to motorable roads results in a strongly significant positive impact on farm incomes.

Notably, a shorter distance from the market centre also provides favourable impetus to earn more. Most importantly, households with shorter distances from a motorable road witness strong and significant increases in farm incomes. Incomes for households with a distance less than 5 km have higher income levels in the range of 1060 to 1170 units. The prevalence of a shorter distance to motorable roads becomes vital to accessing banking services. Larger distances to banks lead to a significant loss in farm incomes; the intensity of loss is reduced through proximity to motorable roads.

The gendered effect on farm incomes is captured through interaction with household headship. Farm incomes are higher across the genders for the families headed by the direct respondents. Strikingly, farm incomes for families are more than double if the household is headed by a female compared to a

male (Tables 4 and 5). Accessing financial services requires traveling to the bank. Larger distances, in comparison to access to a motorable road within 5 km or less, significantly reduces the farm incomes because farmers do not want to walk far for banking services.

Table 4. Regression Results for Farm Income

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income
Climate Change Adaptation	3259.674*** (883.000)	2612.041*** (800.175)	2322.071*** (778.276)	2528.823*** (830.290)	1729.355*** (770.634)	1670.118*** (846.403)	1414.302* (734.433)	1290.295 (802.659)	1436.387*** (726.539)	1235.936 (764.130)
Distance - Market Centre		4079.555*** (1176.748)	3568.955*** (1213.799)	3616.933*** (1205.045)	2559.262** (1119.356)	2566.042** (1113.151)	2448.675** (1104.601)	2457.230** (1101.121)	3142.893** (1546.458)	3249.477** (1529.875)
Distance - Motorable Road		1454.505** (660.139)		1138.034* (650.486)	1078.350* (646.420)	1060.001 (654.340)	1194.739* (649.911)	1169.395* (652.089)		
Total Irrigated Land (Rice)				34.418** (16.231)	44.416** (15.794)	43.582** (16.714)	50.700** (16.458)	49.153** (17.264)	53.439** (17.020)	51.182** (17.424)
HH Size					1226.742*** (254.553)	1225.456*** (255.848)	1127.864*** (254.123)	1123.086*** (256.287)	1132.964*** (254.698)	1125.816*** (256.156)
Loan Availability - (Rice)						438.740 (1264.856)		896.846 (1258.925)		1443.256 (1103.796)
Gender x Respondent HH Head	1 0						-1145.018 (856.489)	-1296.884 (870.867)	-1106.714 (859.906)	-1346.023 (864.244)
	0 1						5667.800* (3236.307)	5588.295* (3267.891)	5543.297* (3205.485)	5397.717* (3232.282)
	1 1						2090.331** (874.767)	2103.624** (869.343)	2037.676** (874.479)	2056.773** (871.212)
Distance - Motorable Road x Distance Bank	1 0								-3277.069*** (858.501)	-3416.339*** (764.474)
	0 1								1380.156* (759.990)	1380.604* (755.637)
	1 1								-576.687 (1627.835)	-785.608 (1595.402)
Constant		5061.840*** (572.044)	4442.967*** (619.338)	1258.873 (1797.872)	-6479.250** (2652.636)	-6397.340** (2757.970)	-7759.896*** (2967.018)	-7580.615** (3080.908)	-7946.039*** (3059.373)	-7683.588** (3120.340)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' calculation.

Table 5. Regression Results for Farm Income (Climate and Motorable Road interaction)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income	Farm Income
Climate Change Adaptation x Distance – Motorable Road	4283.837*** (989.411)	3210.546*** (854.559)	3155.331*** (859.605)	2514.294*** (803.579)	2471.187*** (889.027)	2314.640*** (772.335)	2216.256*** (850.366)	2632.248*** (1064.050)	2407.883*** (1127.431)
Distance - Market Info. Centre		3415.863*** (1134.457)	3436.045*** (1126.048)	2439.420*** (1040.225)	2446.473*** (1031.224)	2387.155*** (1030.311)	2402.198*** (1022.750)	3188.183*** (1554.299)	3274.882*** (1536.019)
Total Irrigated Land (Rice)			27.132* (15.422)	40.099*** (14.669)	39.625*** (15.322)	47.862*** (15.400)	46.929*** (15.969)	51.780*** (16.931)	50.168*** (16.931)
HH Size				1222.811*** (253.600)	1221.740*** (255.059)	1123.946*** (253.067)	1119.714*** (255.421)	1127.921*** (253.587)	1121.457*** (255.185)
Loan Availability					320.487 (1274.288)		740.072 (1271.966)		1254.015 (1123.572)
Gender x Respondent HH Head	1	0							
						-1000.544 (842.965)	-1132.517 (864.834)	-895.750 (862.230)	-1126.921 (877.150)
	0	1				5693.664* (3229.228)	5621.792* (3264.025)	5577.064* (3202.269)	5438.849* (3232.549)
	1	1				2143.864*** (881.610)	2148.222*** (879.368)	2112.173*** (886.353)	2114.271*** (885.535)
Distance - Motorable Road x Distance Bank	1	0						-3063.943*** (877.489)	-3213.355*** (785.601)
	0	1						-337.002 (879.163)	-203.736 (879.808)
	1	1						-2259.199 (2061.078)	-2349.355 (2041.933)
Constant	6288.619*** (344.596)	5397.980*** (423.194)	2861.806* (1549.401)	-5409.950*** (2468.894)	-5379.191*** (2518.521)	-6941.309*** (2806.724)	-6854.314*** (2871.879)	-7089.229*** (2890.809)	-6969.554*** (2924.739)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' calculation.

Average Farm Incomes with Climate Change Adaptation with respect to Temperature changes.

Table 6a

	Maximum Temperature		Minimum Temperature	
Climate Change Adaptation	Otherwise	Increase	Otherwise	Increase
Without	5979.6	6457.0	6070.3	6502.4
With	9356.5	9690.7	7847.6	10156.9

Source: Authors' calculation.

Table 6b

	Summer Season Temperature		Winter Season Temperature	
Climate Change Adaptation	Otherwise	Increase	Otherwise	Increase
Without	7824.9	6203.9	6550.0	6262.3
With	9642.9	9656.9	9852.3	9483.8

Source: Authors' calculation.

Results presented through the preliminary econometric exercise pave the way to study the case for climate change adaptation.

Table 7: Binary Logistic Regression on Climate Change Adaptation (CCA)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	CCA	CCA	CCA	CCA	CCA	CCA	CCA	CCA	CCA
Distance - Market Centre	0.223 (0.190)	0.150 (0.192)	0.159 (0.194)	0.161 (0.194)	0.022 (0.208)	0.112 (0.218)			0.130 (0.219)
Distance - Motorable Road	1.095*** (0.190)	1.084*** (0.191)	1.017*** (0.194)	0.948*** (0.197)	0.871*** (0.201)	0.906*** (0.206)	0.965*** (0.203)		
HH Size		0.098*** (0.035)	0.100*** (0.035)	0.073** (0.036)	0.074** (0.036)	0.076** (0.037)	0.072* (0.037)	0.074** (0.036)	0.076** (0.036)
Loan Availability (Rice)			1.713*** (0.398)	1.688*** (0.400)	1.598*** (0.401)	1.658*** (0.407)	1.811*** (0.424)	1.652*** (0.407)	1.656*** (0.405)
Total Irrigated Land (Rice)				0.434** (0.191)	0.431** (0.191)	0.417** (0.190)	0.327* (0.180)	0.422** (0.188)	0.422** (0.191)
Agri. Extn. Services					0.474** (0.227)	0.469** (0.227)	0.412* (0.219)	0.499** (0.230)	0.473** (0.227)
Distance Bank						-0.250 (0.234)	-0.175 (0.228)	-0.183 (0.231)	
Gender x Respondent HH Head							0.220 (0.304)		
		0 1					0.735 (0.447)		
		1 1					-0.159 (0.532)		
Distance - Market Centre x Motorable Road		1 0						1.044*** (0.227)	
		0 1						0.830 (0.516)	
		1 1						-0.899 (0.565)	
Distance - Motorable Road x Distance Bank		1 0							0.945*** (0.211)
		0 1							0.381 (0.726)
		1 1							-0.701 (0.756)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' calculation.

Results based upon Interaction effects are presented in the following tables:

Variable	Observations	Mean	Std. Dev.	Min	Max
Logit IE	773	-.0339234	.0093133	-.0416549	-.000351
Logit se	773	.0927959	.0321514	.0008553	.127988
Logit z	773	-.3835087	.0592484	-.4707966	-.2583843

Variable	Observations	Mean	Std. Dev.	Min	Max
Logit IE	773	-.1787192	.0514874	-.2205459	-.0011125
Logit se	773	.1020477	.0298687	.0016432	.137514
Logit z	773	-1.742427	.1261885	-1.910008	-.5992804

Variable	Observations	Mean	Std. Dev.	Min	Max
Logit IE	773	-.1325453	.0415674	-.1709713	-.0008295
Logit se	773	.1485612	.044866	.0014815	.1883618
Logit z	773	-.8839358	.0340099	-.9077911	-.5178196

Figure 1a: Interaction effects for
Gender x Respondent HH Head

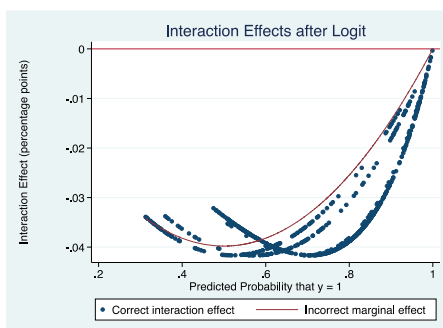
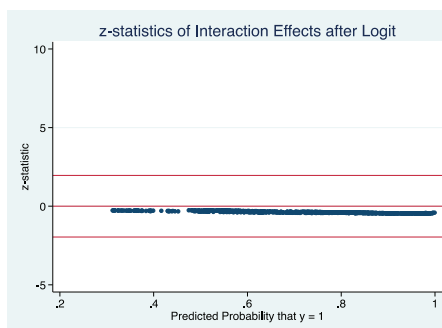
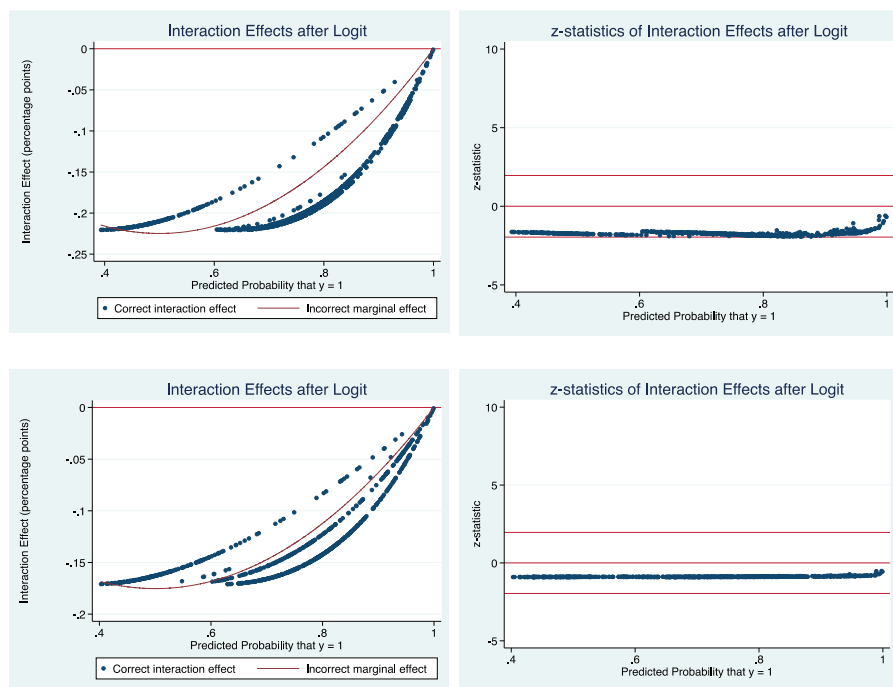


Figure 1b: z values for
Gender x Respondent HH Head





We estimated two binary logistical regressions, for which the results obtained are presented in [Table 4](#).

Results pertaining to Model 1: Referring to [Table 4](#), access to motorable roads was of primary interest. The estimated results show that with a lower distance to motorable roads, climate change adaptation becomes 2.56 times more likely. Further, the gender-based coefficient reveals that females as heads of household are 2.06 times more likely to adopt climate best practices. Availability of loans for rice farming makes it almost 6 times more likely for farmers to adopt climate change mitigation methods. With an increase in area under rice cultivation, the likelihood of climate change adaptation increases by 1.54 times, and access to agriculture extension increases this likelihood by 1.48 times. All these coefficients are statistically significant.

Results pertaining to Model 2: With reference to distance from the market centre, the second model (Table 4) estimates the impact on climate change adaptation along with other control variables. Here, the shortening of distance from the market centre increases the chances of climate change adaptation by 1.5 times, whereas loan availability enhances the chances by 6.39 times (higher than Model 1). Total area under rice cultivation (with an impact likelihood of 1.73 times) and access to agriculture extension (with an impact likelihood of 1.70 times) yield larger effects on climate change adaptation compared to Model 1. However, gender results in a slightly lower impact of 1.96 times. All impacts here are statistically significant.

Discussion

Climate change has been a key global issue in today's context, and adaptation can be the best measure to cope with it (Devkota, & Phuyal, 2015; Maharjan, Sigdel, Sthapit, & Regmi, 2011). With the emergence of the issue of climate change, adaptation is vital among farmers of Nepal as well to cope with its severe impact (Devkota, Phuyal, & Shrestha, 2018; Gurung & Bhandari, 2009). This study reveals that the majority of farmers (73%) have adopted various methods for climate change adaptation, which also shows farmers' awareness levels of climate change. Factors, e.g., access to motorable roads, agriculture extension centres, credit facilities, distance from the market, land area and gender of the farmer, significantly affect climate change adaptation methods.

The result of the study is somewhat consistent with the results of Fuglie et al. (2020), which state proper road access and market accessibility have a greater impact on farmers' incomes and their climate change adaptation. However, due to the geographical disparity among Nepalese farmers, hilly regions are deprived of certain facilities more than the Terai region (Devkota et al., 2018). Pokhrel and Pandey (2011) mentioned that lack of research and awareness among farmers regarding climate change and its adaptation has

created difficulties in coping with the problem. In contrast to Pokhrel and Pandey (2011), this study depicted that 73% of farmers are aware of climate change adaptation and are somehow adopting it through various ways; it has been observed that infrastructural development is equally important for farmers to adapt to climate change.

Therefore, the Nepalese government should emphasize providing loans to farmers and increasing agriculture extension centres, which would eventually help farmers in climate change adaptation as well as in creating a positive impact on the nation's economy. This study can serve in policy-making where policymakers may have insight into the infrastructural policies led by the government. They can link these findings with agricultural and climate change policies so that a proper vision can be formulated that directs farmers to climate change adaptation. Hence, local governments can devise various strategies that would benefit farmers in those areas. Further study in a similar field can be conducted examining farmers in larger or different areas to give a larger picture of the country's status on climate change adaptation.

5. Conclusion and Policy Implications

The econometric exercise highlights the importance of distance to the market centre and distance of home from motorable road. With both variables standing statistically significant, the effect of transport on climate change adoption cannot be ignored. It becomes important for the government to realize the dire need for providing a better-quality road infrastructure to mitigate the direct and indirect costs arising from these physical asymmetries and channel funds in substantiating the emergent need for a more climatologically sustainable form of infrastructure. Fostering climate change adaptation requires the development of resilient and robust infrastructure. Also, the access to loans makes it viable for farmers to undertake farming and allied activities, which along with the provision of infrastructure, would make credit outcomes more potent and effective. Funding agencies must realize that a well-developed transport network would also result in a financially inclusive society with access to credit.

However, this raises various issues on the policy front, the most significant of them pertaining to the formulation of effective mechanisms for financing infrastructure projects. Development of infrastructure projects is investment intensive and at the same time fraught with time delays, later translating into cost escalations. As such, banking authorities that loan out funds for providing investment to these projects need to be extra vigilant as the possibility of these turning into non-performing assets remains high.

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