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Asymmetric of Income, Uneven Adaptive Capacities, and Determinants of Climate Change Adaptation Options among Poor and Non-Poor Rural Rice Farmers of Nepal

Niranjan Devkota
Research Management Cell, Quest International College, Pokhara University, Gwarko, Lalitpur, Nepal
Corresponding Author: niranjandevkota@gmail.com

Ram Kumar Phuyal
Member, National Planning Commission, Government of Nepal, Singha Durbar, Kathmandu, Nepal

Durga Lal Shrestha
Professor, Department of Economics, Tribhuvan University, Kirtipur, Kathmandu, Nepal

Abstract

This study examines the determinants of adaptive capacities of poor and non-poor rural rice farmers in Nepal. A Cost of Basic Needs (CBN) approach is used to classify rural rice farmers as poor and non-poor, and a binary logistic regression model is used to identify the factors associated with adopting climate change adaptation options. The results show that about 20% of the total respondents in the study area were found to be poor with a moderate level of adaptive capacity. The study finds that poor farmers in rural areas are more vulnerable in terms of adaptive capacity and less able to adapt climate change adaptation options in comparison to non-poor farmers. It demands immediate action for greater investment, provision of subsidies, and institutional setup to strengthen rural rice farmers' adaptive capacities.

Keywords: climate change, adaptive capacity, poor and non-poor, rice farmers, Nepal

JEL Classification: D10, I30, Q54, and R20

1. Introduction

The socio-economic literature that considers the climate change nexus argues that world's poorest people often have limited access to livelihood resources that would facilitate adaptation to climate change and have little insurance against loss of income (Smit & Pilifosova, 2003; Heltberg, Siegel & Jorgensen, 2009; Adger, Brown & Surminski, 2018). Access to and control over such resources varies within countries, communities, and even households (Agrawala, Raksakulthai, van Aalst, Larsen, Smith & Reynolds, 2003). Developing countries generally have a lower capacity to adapt to changing climate (Adger et al., 2007; 2018; Castells-Quintana, del Pilar Lopez-Uribe & McDermott, 2018). Developing countries are particularly concerned about climate change, especially in the agricultural sector (Ottinger, Wang & Motel, 2014). In such countries, overpopulation, poverty, and land degradation are prime concerns that translate into low capacity to face any kind of crisis (Watson, 1992; Wynants et al., 2019). It is believed that adaptation centered on agriculture would have a chain effect (Ottinger et al., 2014; Orr, Donovan & Stoian, 2018). Hence, the efficient adaptation to climate change would help to maximize net benefits, but adoption of new technology depends upon the farmers' capacity to do so (Mendelsohn, 2000, 2012; Sedova, Kalkuhl & Mendelsohn, 2019).

For farmers, adaptation options depend in part on the wealth of agricultural households. Poor agricultural households cannot access some options available to the wealthier farmers (Mendelsohn, 2012; Devkota, 2018). A common assumption in the adaptation literature is that richer farmers have more technology and capital options available compared to poor farmers. Consequently, they have more substitutes to allow them to adapt and, therefore, can adapt more readily (Pender, 2007; Kassie, Hengsdijk, Rötter, Kahiluoto, Asseng & Van Ittersum, 2013). Although poor households may have limited budgets, they still have much to gain from making efficient choices for themselves (Mendelsohn, 2012). In such situations, governments may want to help poor households to adapt for equity reasons (Mach & Mastrandrea, 2014).

There is little empirical evidence that wealthier farmers can adapt to climate change more readily than poor farmers (Hertel & Rosch, 2010; Mendelsohn, 2012). To better understand the situation, studies regarding the capacity of poor and non-poor farmers on the adoption of climate change adaptation options for agricultural production are necessary (Burke & Lobell, 2010). Therefore, this case study adds to the literature by examining the determinants of adopting climate change adaptation options for poor and non-poor rice farmers in Nepal. This analysis uses a Cost of Basic Needs (CBN) approach to classify absolute and relative poverty – classifications that are not used in previous studies on climate change adaptation. The correlates with adopting climate change adaptation options across poor and non-poor agricultural households have the potential to contribute to policy formulation in Nepal.

The rest of the article is structured as follows: the methodology is described in section 2. In section 3 the results are analyzed. Section 4 presents a discussion of the results and concludes with broad policy prescriptions.

2. Methodology

2.1 Study Area and Data

Nepal is a landlocked country in South Asia located in the foothills of the Himalayas with an area of 147,181 square kilometers (Bhatnagar & Shahab Ahmed, 2021). The country's population is about 27 million, the annual population growth rate is 1.35%, and the population density is 180.1 people per square kilometer (CBS, 2011; Devkota, 2018). Nepal is an agricultural country (Takeshima & Justice, 2020). More than 66% of the population have livelihoods based on agriculture – primarily subsistence based crop farming integrated with livestock – and agriculture accounts for 34% of total GDP (FAO, 2019). Farming in Nepal is characterized by limited access to irrigation, improved seeds, fertilizer, credit, and other agro-services (Devkota et al., 2018). Access limitations are especially pronounced for farmers living in rural and hilly areas (Gupta et al., 2021). Although there are numerous government initiatives to promote agriculture in the country, farmers still have limited access to new technology and market opportunities (FAO, 2019). Farmers who engaged in agriculture are generally poor and practice subsistence farming (Karki, Burton & Mackey, 2020) on modest landholdings (Devkota, Phuyal and Shrestha, 2017). Due to such conditions, farmers in rural areas of Nepal often suffer from food shortages (Tamang, Paudel and Shrestha, 2014; Devkota, 2018).

Nepal is one of the most vulnerable countries to climate change (Dulal, Broding and Thakur et al., 2010; Shrestha, Wake, Mayewski & Dibb, 1999; Aryal, Thapa & Lamichhane, 2019; Karki & Gurung, 2012; Mainali & Pricope, 2017). The country has experienced varying temperatures and altered rainfall patterns for a long time (Bhatta, van Oort, Stork & Baral, 2015). Observed temperature increases are higher compared to the global average, while rainfall has dropped significantly (Devkota & Paija, 2020). Erratic rainfall patterns have increased, causing decreased agro-production and undermining farmers in their production processes (Adhikari, Devkota and

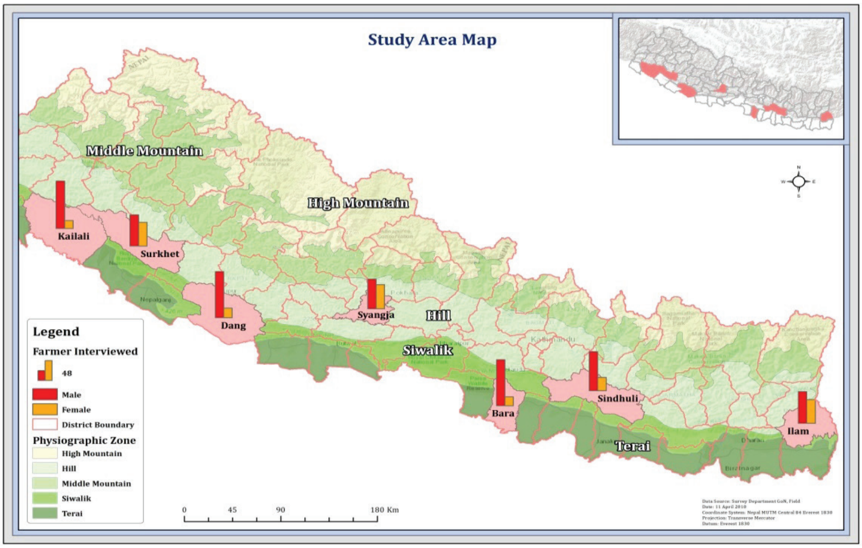
Phuyal, 2017). In addition, Nepal is likely to be affected by various climate related hazards such as Glacier Lake Outburst Flood (GLOF), flash flood, melting snow, irregular rainfall, drought, and submerged land (Shrestha et al., 1999; Malla, 2008). Since 66% of the Nepalese population depends on agriculture for their livelihoods and largely follows traditional cultivation practices that rely on rainwater, changes in climatic conditions and altering rainfall patterns will have adverse impacts on a large proportion of the Nepalese people (Devkota et al., 2018). This means that there is a growing risk of food insecurity in the country that will eventually affect the economic wellbeing of the people.

Farmers, including rice farmers, have already suffered from such climate hazards. Although the history of rice production in Nepal is very old, climate change has negatively impacted recent rice yields. In various studies, Pant (2011), Adhikari (2012), Karn (2014), Thapa-Parajuli and Devkota (2016) and Devkota et al. (2018) find that Nepalese rice farmers are vulnerable to climate change. This growing vulnerability has accelerated climate change adaptation practices throughout the country. Studies by Devkota et al. (2017; 2018) find that rice farmers in Nepal practice endogenous knowledge as well as adopt modern tools. However, such adaptation remains higher in urban areas compared to rural areas, and in the Terai (plains areas) in compare to hilly areas. This pattern indicates that climate adaptation has occurred in areas where it is accessible. Mendelsohn (2012) remarked that farmers' adaptation options depend on the wealth of the farmers. This paper is an attempt to provide empirical evidence of this pattern in rural Nepal.

This research was conducted in seven districts in Nepal (see Figure 1) ranging from the Hill to Terai Belt. Three study districts are located in the Terai Belt and four are located in the Hilly Belt (Devkota et al., 2018; Devkota & Phuyal., 2018). The districts were selected based on its agricultural activities and proneness to climate change. The rice production environments of Nepal can be classified into Terai (60 – 900 meters above sea level), hills (1,100 –

1,500 meters above sea level) and mountains (1,500 meters above sea level) (Adhikari et al., 2017). The Terai Belt is considered to be the grain basket of Nepal and has fertile agricultural land (Springate-Baginski & Blaikie, 2013) due to its proper and regulated irrigation facilities compared to the hilly regions of the nation (Phuyal & Devkota, 2018).

Figure 1: Study Area and Sample



Source: Authors' compilation.

This study applies a multistage sampling technique. At the first stage, seven rice producing-districts (one from each state) were randomly selected. In the second stage, 14 VDC (two from each district) were selected based on being rice pocket areas through telephone enquiries to each district agriculture office.[1] Similarly, in the third stage, further telephone inquiries were made to each VDC secretary and social mobilizer in order to select 28 rice pocket wards as the primary sampling units (PSU) (two wards from each VDC).

[1] A VDC is an administrative body containing nine wards similar to a municipality in Nepal. Each ward constitutes one to several villages (Khanal, Wilson, Lee & Hoang, 2018).

Finally, in the fourth stage, 28 farmers were selected from each ward on a convenience basis.[2] The final interviews were conducted from December 2016 to January 2017 for the crop year 2016 since the main season for rice cultivation in Nepal falls from June/July to October/November in each year. A total of 773 farm households irrespective of gender, farm size, or tenancy status were interviewed with the help of a structured questionnaire.

2.2 Measuring Poverty among Farmers

The Cost of Basic Needs approach is a commonly used method to construct an absolute poverty line. The method first estimates the cost of acquiring enough food for adequate nutrition – usually 2,100 calories per person per day – and then adds the costs of other essentials such as clothing and shelter (Haughton & Khandker, 2009). A major strength of this approach is that it ensures that the poverty line covers basic needs that are stipulated in a consumption bundle that is deemed to be adequate in terms of both food and non-food components, and estimates the cost of the bundle for each subgroup (i.e., urban/rural, region, and so forth) (Bellù & Liberati, 2005; Haughton & Khandker, 2009). Such estimation is beneficial in accounting for rural transactions where money is not the measuring rod of all available foods. National-level surveys on income, expenditures, and employment carried out in Nepal – which are the basis for all Nepalese poverty analysis so far – have been conducted according to the CBN method for estimating poverty lines (Acharya, 2004; Bhatta & Phuyal, 2015).

Since an increase in household members does not need to be accompanied by the same proportional increase in income to maintain the

[2] This study found difficulties reaching the selected farmers in the first day since most of the farmers were not available in their homes when the enumerators were present in the area. As a result, selection was based on availability of the farmers in their homes at the time of data collection. However, caution was taken for the distance of households for each questionnaire. After each household questionnaire was completed, few surrounding houses were left for the sake of covering the entire study area.

same level of welfare, equivalence scales are used (Buhmann, Rainwater, Schmaus & Smeeding, 1988). Economists use equivalence scales to construct representative income taking into account economies of scale within the household. There are multiple options for choosing equivalence scales such as the Oxford Scale, Modified Oxford Scale, and the square root scale developed by the Organization for Economic Co-Operation and Development (OECD) (OECD, 2013). The choice of a particular equivalence scale depends on the technical assumptions about economies of scale in consumption as well as on value judgment (Besharov & Couch, 2012). For a country like Nepal, where household population composition is much higher than in developed countries, the square root scale is less appropriate. Hence, this study uses the Oxford and OECD equivalence scales to classify poor and non-poor households.

2.3 Modelling Adaptive Capacity among Poor and Non-poor Households

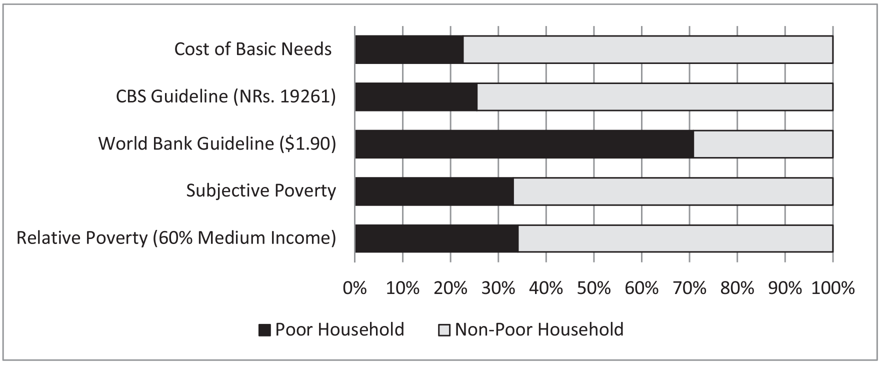
To model the determinants of adopting climate change adaptation techniques, we use a standard logit regression model. The dependent variable is whether or not a household adopts one of several climate change adaptation techniques. The independent variables are correlates with adaptive capacity that are widely discussed in the literature (see for example, Peñalba & Elazegui (2013), Awolala & Ajibefun (2015), and Eyasmin, Ghosh & Hossain (2017)). Such studies argue that farmers' adaptive capacity to climate change is influenced by socio-economic factors, including age, education, gender, household size, farm size, farming experience, and wealth. Further, Hassan & Nhemachena (2008), Bryan, Deressa, Gbetibouo and Ringler (2009), Deressa, Hassan, Ringler, Alemu and Yesuf (2009), and Gbetibouo (2009) observe that institutional factors, such as access to extension services, climate information, credit, tenure status, and social capital (farmer-to-farmer extension services and the number of relatives living close by) are determinants of adaptive capacity. These determinants may assist or restrict adaptation choices and the proper utilization of resources. Farmers across geographical areas and varying access to information may not have equal adaptive capacity since the adoption of new adaptation options is associated with knowledge about the options and their cost. Finally, we stratify the sample by poor and non-poor (identified by the CBN approach discussed above) to see whether the correlates with climate change adaptation are similar across household types.

3. Results

3.1 Poverty Mapping of Rural Rice Farmer Households

As discussed earlier, this study measures and classifies poverty using various poverty measurement techniques. Poverty calculations using five different measures are shown in Figure 2 to understand rural rice farmers' existing poverty levels. We observe in the study area that only about 20% of the total respondents were found poor according to the CBN approach. Compared to the national poverty average and rural poverty average, this figure is surprisingly high. The CBN and CBS (2011) guideline-based measures indicate 1/5 of the rice farmers are poor while subjective poverty and relative poverty measures show 1/3 of the rural rice farming households are poor. This analysis suggests that that the majority of rice farmers in the study areas are able to manage their needs since their consumption capacity is higher. However, using the international comparison, only 1/3 of the farmers are able to manage their household requirements, indicating that even if rice farmers seem to be relatively well-off at the domestic level, they are still poor compared to an international standard.

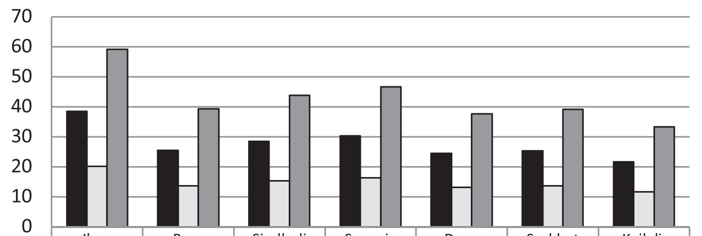
Figure 2: Poverty Prevalence Using Various Indicators



Source: Researchers' calculation from field data.

Similarly, our results show that the rate of poverty is high in hilly regions compared to the Terai, and the western part of the country compared to eastern and central parts (Figure 3). Additionally, the absolute poverty line throughout the study area is calculated on the basis of minimum income required to purchase the subsistence calorie requirement per person per day for survival and social existence. De (2015) mentions that such poverty can be calculated with the help of the Cost of Basic Needs approach. In Nepal, expenditure on minimum per capita food consumption differs with the district. Chhetry (2009) and Bhatta & Phuyal (2015) argue that total calorie requirements for survival per person per day is 2,256 calories, of which 65% can be obtained from the net consumption of 605 grams of cereal and 60 grams of pulses; the remaining 35% from non-food items such as clothes and other necessities. As Figure 3 depicts, the eastern and central parts of the country require higher expenditures for basic calorie attainment compared to western part of the country.

Figure 3: District-wise Expenditure Calculation for Food and Non-food Items



	Ilam	Bara	Sindhuli	Syangja	Dang	Surkhet	Kailali
■ Food-Expenditure	38.47	25.59	28.5	30.32	24.5	25.43	21.7
□ Non-Food Expenditure	20.17	13.77	15.35	16.33	13.19	13.69	11.68
■ Total-Expenditure	59.18	39.36	43.85	46.65	37.69	39.12	33.38

Source: Researchers' calculation from field data

Following De (2015), both the Oxford Scale and the OECD scale were measured to equivalence for the sample households (i.e. 773).[3] From this equivalence scale, this study identifies absolute poor and non-poor across the study districts as presented in Figure 4. It is observed that 175 households are absolute poor based on the Oxford scale, while with the OCED scale the numbers are 121 households. Figure 4 shows the poor households under various circumstances.

[3] There are multiple options for choosing equivalent scale such as Oxford Scale, Modified Oxford Scale and Square root scale developed by OECD (OECD, 2013). Such scale is common among economist to construct household equivalence. This study follows OECD and Oxford Scale mentioned by Poverty and its measures (De, 2015), where the number of consumption units in a household (c. u.) is calculated as the combination of the weightings allocated to each member. The weightings are allocated in the following way:

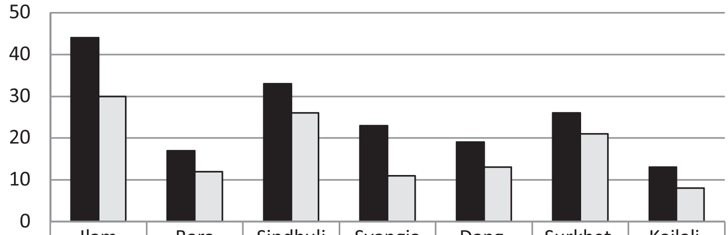
First adult	1
Second adult and subsequent adults	0.7
Under 14 years old	0.5

In other words, the number of c.u. is calculated in the following way:

No. of c.u.= 1 + (a-1) x 0.7 + b x 0.5

(*a* is the number of adults and *b* is the number of minors)

Figure 4. Number of poor households as per different scales



	Ilam	Bara	Sindhuli	Syangja	Dang	Surkhet	Kailali
■ Oxford Scale	44	17	33	23	19	26	13
□ OECD Scale	30	12	26	11	13	21	8

Source: Researchers' calculation from field data

3.2 Descriptive Statistics

Table 1 reports variable descriptions and descriptive statistics using in the analysis. For the whole sample the average age of respondents is 47.74 years, respondents have 29 years of farm experience, 93% are married, 80% of household heads are male, 44% have irrigation facilities, and 44% have moderately fertile land. There is little difference across poor and non-poor households across these characteristics. Despite the similarities, the mean income of poor households is 3,459 Nepalese rupees (NPR) compared to NPR 25,052 for non-poor households. The average area of farmland held by the farmers is 0.68 hectares, but poor households average only 0.37 hectares compared to 0.76 hectares for non-poor households. Similarly, poor households have less access to off-farm activities, market information, road access, extension services, market center access, and access to subsidies in comparison to non-poor households. Despite living in the same communities, having high levels of climate change knowledge (75%), and receiving an almost equal level of weather information (0.71%), non-poor farmers adopt climate change adaptation options at higher rates (75%) compared to poor rice farmers (66%).

Table 1: Descriptive Statistics

Variable	Variable Description	All	Non-poor	Poor
cc_adoption	Dummy = 1 if adopted any adaptation options	0.73 (0.45)	0.75 (0.43)	0.66 (0.48)
age	Continuous (in years)	47.74 (13.14)	47.58 (13.30)	48.30 (12.59)
marital_status	Dummy = 1 if married	0.93 (0.26)	0.94 (0.24)	0.90 (0.30)
gender	Dummy = 1 if gender is male	0.71 (0.45)	0.72 (0.45)	0.66 (0.48)
hh_head	Dummy = 1 if HH head is male	0.80 (0.40)	0.80 (0.40)	0.79 (0.41)
main_occupation	Dummy = 1 if the main occupation is farming	0.95 (0.22)	0.93 (0.25)	0.99 (0.08)
household_size	Continuous (in number)	6.45 (2.92)	6.57 (3.08)	6.05 (2.25)
level_of_education	Dummy = 1 if education > secondary level	0.08 (0.27)	0.08 (0.28)	0.06 (0.23)
native	Dummy = 1 if farmers is native	0.84 (0.37)	0.85 (0.35)	0.79 (0.41)
total_farmland	Continuous (in hectares)	0.68 (0.78)	0.76 (0.86)	0.37 (0.28)
total_income_1000	Continuous (Per month/ in 1000 NRs)	20.17 (22.23)	25.05 (23.09)	3.49 (1.67)
irrigation_facilities	Dummy = 1 if farmer received irrigation facilities	0.45 (0.50)	0.46 (0.50)	0.42 (0.50)
fertile	Dummy = 1 if land is fertile	0.44 (0.50)	0.44 (0.50)	0.42 (0.50)
credit	Dummy = 1 if have access to credit	0.14 (0.34)	0.14 (0.35)	0.11 (0.32)
offfarm_activities	Dummy = 1 if have off-farm activities	0.77 (0.90)	0.89 (0.90)	0.34 (0.75)
received_weather_info	Dummy = 1 if received weather related info	0.71 (0.45)	0.71(0.45)	0.72 (0.45)
farm_experiance	Continuous (in years)	29.01 (13.28)	28.90 (13.13)	29.37 (13.85)
market_information	Dummy = 1 if have access to market info	0.44 (0.50)	0.47 (0.50)	0.36 (0.48)
distance_road	Dummy = 1 if have access to road	0.73 (0.45)	0.75 (0.44)	0.66 (0.48)
menbership_organization	Dummy = 1 if have member of any organization	0.21 (0.41)	0.21 (0.41)	0.21 (0.41)

training	Dummy = 1 if received training	0.05 (0.22)	0.06 (0.24)	0.03 (0.17)
extension_service	Dummy = 1 if have access to extension service	0.32 (0.47)	0.35 (0.48)	0.24 (0.43)
market_center	Dummy = 1 if have access to market center	0.22 (0.41)	0.23 (0.42)	0.18 (0.38)
availability_subsidy	Dummy = 1 if have access to subsidy	0.08 (0.26)	0.09 (0.29)	0.02 (0.15)
knowledge_cc	Dummy = 1 if have climate change knowledge	0.75 (0.43)	0.76 (0.43)	0.72 (0.45)
hilly_region	Dummy = 1 if farmers lives in hilly regions	0.57 (0.50)	0.52 (0.50)	0.72 (0.45)
plain_region	Dummy = 1 if farmers lives in plains regions	0.43 (0.50)	0.48 (0.50)	0.28 (0.45)
	Observations	773	598	175

Notes: Standard deviations in parentheses. "Training" refers to participation in any type of conferences and/or training organized by the government and private sectors in past 10 years. Extension services in Nepal are provided by the Agricultural Service Centre (ASC) which is under government control. Department of Livestock Services (DLS) and Department of Agriculture (DOA) are responsible for the public service extension centers in Nepal. Throughout the county, there are 378 Agriculture Service Centers under DOA and 999 Livestock Service Centers under DLS (Thapa, 2010).
Source: Authors' calculations.

3.3 Adaptation Practices among Rice Farmers

Climate change is likely to have serious consequences for Nepalese agriculture (Malla, 2008). In most of the region, production is affected by changes in the reliability of stream flow, more intense and potentially more erratic monsoon rainfall, and the impact of flooding (Devkota, 2018). Adhikari et al. (2017) also mention that an increase in temperature and precipitation results in decreased paddy yields. To cope with these adverse impacts of climate change, farmers use several adaptive measures (NAPA, 2010). The three most common adaptation options practiced by rice farmers is increased use of chemical fertilizers, use of climate smart verities of rice, and changes in nursery dates (Devkota et al., 2018). Short-duration rice crop varieties, changes in planting dates, and alternative irrigation are the next three most common adaptation options for both poor and non-poor farmers (Devkota, 2018). It is observed that 75% of non-poor rice farmers adopt climate change adaptation options compared to 66% of poor rice farmers. The adaptation gap is driven by greater use of fertilizers, climate smart rice varieties, short duration rice crops, and vitamins by non-poor farmers. Coping strategies such as denser planting of local seeds and changing land size for production are found more among poor households, indicating that these households are coping as per their capacity. Other adaptation practices are adopted at similar rates by farmers regardless of their incomes, as shown in Table 2. It indicates that rice farmers are coping against climate change given their capacity.

Table 2: Climate Change Adaptation Practices Adopted by Farmers

Adaptation Options	All	Non-poor	Poor
Total adaptation adoption	562	447	115
	(72.7%)	(74.7%)	(65.7%)
Use climate smart verities	381	306	75
	(49.3%)	(51.2%)	(42.9%)
Denser planting of local seeds	102	76	26
	(13.2%)	(12.7%)	(14.9%)
Selecting short duration rice crop varieties with heat, flood, and drought tolerance	232	191	41
	(30.0%)	(31.9%)	(23.4%)
Rice crop switching	53	46	7
	(6.9%)	(7.7%)	(4.0%)
Increase use of chemical fertilizers, pesticides, and insecticides	471	381	90
	(60.9%)	(63.7%)	(51.4%)
Starting/increasing use of vitamins	123	102	21
	(15.9%)	(17.1%)	(12.0%)
Change in land size	33	25	8
	(4.3%)	(4.2%)	(4.6%)
Off (farm activities	26	22	4
	(3.4%)	(3.7%)	(2.3%)

Change in nursery date	248	193	55
	(32.1%)	(32.3%)	(31.4%)
Changing planting dates	220	173	47
	(28.5%)	(28.9%)	(26.9%)
Change in irrigation practice	171	137	34
	(22.1%)	(22.9%)	(19.4%)
Average adaptation	218	173	45
	(28.3%)	(29.3%)	(24.9%)
No adaptation	211	151	60
	(27.3%)	(25.3%)	(34.3%)
Observations	773	598	175

Source: Researchers' calculation from field data.

3.4 Econometric Analysis

The logit results estimating the probability of adopting climate change adaptation options conditional on various household and community characteristics are presented in Table 3.[4]

Table 3: Logit Regression: Adoption of Climate Change Adaptation Options

Variables	Model 1 (All)		Model 2 (Non-Poor)		Model 3 (Poor)	
	Odds ratio	dy/dx	Odds ratio	dy/dx	Odds ratio	dy/dx
age	0.996	-0.001	0.991	-0.001	0.998	0.000
marital_status	1.035	0.005	1.243	0.031	0.561	-0.141
gender	1.201	0.027	1.134	0.017	1.724	0.135
hh_head	1.076	0.011	1.047	0.006	0.607	-0.124
main_occupation	0.733	-0.040	0.792	-0.029		
household_size	1.082*	0.011*	1.069	0.009	1.12	0.028
level_of_education	0.763	-0.041	0.944	-0.008	0.486	-0.175
native	1.065	0.009	0.949	-0.007	1.395	0.083
total_farmland	0.774	-0.036	0.866	-0.019	0.0315***	-0.865***
total_income	1.000	0.000	1.000	0.000	1.000	0.000
irrigation_facilities	0.607**	-0.072**	0.584**	-0.073**	0.772	-0.065
fertile	0.754	-0.041	0.624**	-0.064**	1.294	0.064

[4] Diagnostics for the analysis can be found in the appendix.

credit	3.972***	0.140**	3.876**	0.130**	7.289	0.397
offfarm_activities	0.841	-0.025	0.79	-0.031	1.288	0.063
received_weather_info	1.18	0.024	1.081	0.010	1.485	0.098
farm_experiance	1.007	0.001	1.014	0.002	0.984	-0.004
market_information	1.036	0.005	0.863	-0.020	2.989*	0.264*
distance_road	2.694***	0.162***	1.970**	0.101**	10.75***	0.527***
menbership_organization	0.776	-0.038	0.721	-0.046	0.538	-0.153
training	2.202	0.088	2.599	0.095	0.714	-0.084
extension_service	2.010**	0.091**	2.645***	0.118***	0.957	-0.011
market_center	0.596*	-0.080*	0.471**	-0.115**	1.354	0.075
availability_subsidy	3.629**	0.126**	2.795*	0.102*		
knowledge_cc	1.163	0.022	1.097	0.013	0.852	-0.040
plain_region	12.48***	0.334***	9.952***	0.307***		
Constant	0.51		0.884		0.166	
Observations	773		598		175	

Note: *** p<0.01, ** p<0.05, * p<0.1. *dy*/*dx* for factor levels is the discrete change from the base level.

Source: Researchers' calculation from field data.

The common correlates with adopting climate change adaptation options across all three models is access to a road. The positive sign on the marginal effect indicates that the probability of adopting an adaptation option increases with road access. The first model including all 773 respondents indicates that household size, credit facilities for farmers, access to the road network, extension service availability, access to subsidies, and living in the plains region are positively associated with adopting climate change adaptation options. On the other hand, availability of irrigation facilities and access to a market center is associated with a lower incidence of adopting climate change adaptation options.

Model 2 considers only non-poor rice farmers and their adaptation to cope with climate change. Non-poor rice farmers have a lower probability to adopt available adaptation options if they are provided with irrigation facilities, more fertile land, and access to a market center. Additionally, access to extension services, access to credit, road access, and availability of subsidies are positively associated with the probability to adapt available adaptation options. Model 3, which includes only poor rice farmers, indicates that adaptation to climate change are associated with total farmland, market information, and distance to a road. Total farmland is found to be negatively associated with the adoption of adaptation options, meaning that farmers have a lower probability of climate change adaptation if they have access to larger plots of land. However, farmers' adaptation status is positively associated with market information and road access.

In summary, Model 1 shows that an increase in the availability of irrigation facilities and access to a market center plays a statistically significant role in lowering the probability of adopting adaptation options regardless of their income status. In addition, timely availability of credit facilities, access to roads, and being located in the plains region, the probability of the adoption of adaptation options increases regardless of circumstance. Several studies, including Peñalba & Elazegui (2013), Awolala & Ajibefun (2015), and Eyasmin et al. (2017) have measured farmers' adaptive capacities. Such studies also argue that farmers' adaptive capacity to climate change is influenced by socio-economic factors (age, education, gender, household size, farm size, farming experience and wealth), institutional factors (access to extension services, climate information, credit, and tenure status), and social capital (farmer-to-farmer extension services and the number of relatives living close) (Hassan & Nhemachena, 2008; Bryan et al. 2009; Deressa et al., 2009; Gbetibouo, 2009). The results of this present study are largely consistent with previous work in other country contexts.

4. Conclusions and Discussion

In this study, we observe the age, marital status, and male as a household head, are common features of both poor and non-poor farmers in rural communities. However, despite similarities in personal characteristics, poor households living in the same communities possess less income and farmland. Additionally, they have less access to off-farm activities (consistent with Ellis (2000) and Anang (2019)), market information, extension services, and subsidies. Despite of living in the same communities, having high levels of climate change knowledge, and similar access to weather information, poor farmers adopt climate change adaptation options less often than non-poor rice farmers who have access to more resources. The findings in this study are consistent with previous work that indicates that poverty exacerbates vulnerability among rural farmers and acts as a barrier to developing their adaptive capacity to cope with climate-induced anomalies.

The World Bank (2018) estimates that there are about 783 million extremely poor who live below the poverty line of $1.90/day, and 33% of the extremely poor live in South Asia. Using this international standard, we observe that 66% of the rural rice farmers are classified as poor in Nepal even though one-third of rice farming households are poor based on three different national approaches discussed in section 3.1. Even if rice farmers seem relatively well-off according to domestic measures, they are still considered poor compared to international standards. Using an adaptive capacity index similar to Asante et al. (2012), we observed that the overall adaptive capacity measure for Nepalese rural rice farmers is moderate at 0.48.[5] Two recent projects by Mabe, Bruce & Yaw (2012) in Ghana and Akongo et al. (2016) in Northern Uganda observe moderate adaptive capacity with scores of 0.64 and 0.55, respectively, among the rice farmers. Defiesta and Rapera (2014) found 60% of members in an agricultural community in the Philippines faced low adaptive capacity. Similarly, Abdul-Razak and Kruse (2017) found low adaptive capacity among 58% small land holder farmers in Ghana. The results from previous research and this current study highlights

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[5] The adaptive capacity index introduced in Asante et al. (2012) classifies index values 0-0.33 as low capacity, 0.34-0.66 as moderate capacity, and 0.67-1 as high capacity.

low to moderate adaptive capacity for farmers in areas are under pressure from climatic anomalies. This current study suggests that access to more resources is associated with higher adaptive capacity, which is important for addressing and promoting successful adaptation. Given that access to roads and credit facilities are major determinants of the adoption of climate change adaptation options among both poor and non-poor farmers, these are policy options that the government can pursue to increase adaptive capacity for Nepalese rice farmers that can help them cope with climate change in the future.

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Appendix

Before performing actual logistic regression model several tests have been performed. Both pre-test and post-test estimations were made to ensure our model fits sufficiently well. Normally, cross-sectional data analyses involve two problems i.e. heteroscedasticity in the error term and multicollinearity among explanatory variables (Greene 2003). The results from Collin test indicate the entire dataset was free from multicolleniary. Since, hererosedasticity test, under Breusch-Pagan / Cook-Weisberg test, indicates the presence of heteroskedasticity in dataset, we estimate robust standard error regression to prevent our dataset. Also, some post estimation tests including specification error, Hosmer and Lemeshow's goodness-of-fit test, McFadden's R^2, Count R^2 were performed (test results are in table 4). Value obtained from Count R^2 for all model is above 76%, Pearson (Prob>-Chi2) indicates goodness of fit and McFadden's R^2 ranges from 0.26 to 0.30 which indicates all the model selected for the study are fit and can accurately estimate the adaptive capacity of different level farmers for the adoption of the climate change adaptation options.

Appendix Table 1: Pre- and Post-test Estimations

	All	Non-Poor	Poor
Observations	773	598	175
LR Chi^2	250.340 (0.0000)	176.880 (0.0000)	49.615 (0.001)
McFadden's R^2	0.276	0.262	0.296
Maximum likelihood R2	0.277	0.256	0.336
Count R2	0.794	0.794	0.769
Pearson (Prob>Chi2)	768.29 (0.2867)	565.76 (0.5657)	116.26 (1.1007)
_hat	1.045 (0.0000)	.9348 (0.0000)	1.016 (0.0000)
_hatsq	-.0207 (0.692)	0.2913 (0.690)	-0.104 (0.330)
VIF	1.54	1.59	1.66

Source: Authors' calculations from the field data.