Journal of Agriculture and Crops
ISSN(e): 2412-6381, ISSN(p): 2413-886X
Vol. 4, Issue. 4, pp: 36-42, 2018
URL: http://arpgweb.com/?ic=journal&journal=14&info=aims

Academic Research Publishing Group

Original Research | Open Access

Rice Farmers' Climate Change Adaptation in Nepal: Exploring Linkage to Water Availability and Water Sharing Practice

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Abstract

This paper analyzes the availability of water, irrigation and water sharing practices as one of the options of climate change adaptation practices on rice farmers in rural Nepal. By applying multi-stage sampling techniques, 28 wards from 14 VDCs of 7 Districts of Nepal have been selected. 773 rice farmers from both rural Terai and rural Hills have been enquired based on the structured questionnaire in the month of December and January 2017. Logistic regression used to analyze the data revealed that, rice farmers have different opinions regarding adaptation options. Out of 773 rice farmer, 73.7% farmers are adopting available adaptation options which are measured 55% on hilly and 94% in Terai districts. It shows Hilly farmers still have less adaptation practices than Terai. Alternative irrigation as an adoption option is considered as sixth in ranking due to its adaptation cost - it is the most costly option that takes USD[1] 79.1. Result of logistic regression shows that there are several factors like gender (0.726***), total farmland (0.391***), income (7.380*) and credit (1.756***) increase the probability use of alternative water resources while irrigation facilities (-2.693***) and trainings (-1.064*) decrease such probability. Similarly, water sharing practice is found to be common in Hilly belt where in Terai it is comparatively less. Such water sharing featured communal in all respect and it helps to share water among the farmers as per their requirement. Promotion of prevailing water sharing practice can reduce water conflict among the rural farmers and it will be helpful to combat changing climate.

Keywords: Alternative irrigation; Climate change adaptation; Nepal; Rural rice farmers; Water sharing practice.

1. Introduction

Entire world, policy makers and government bodies, including US government [1] are worried today because of a new challenge in the name of climate change which is real and producing threat to the world in every sector including agriculture [2]. Numerous studies [3-10] shows that climate change is altering as well as reducing water availability and damaging agro-farmland and reducing production that is creating serious threat to food security in the coming future. In order to cope with such changes various researches [11-13] have been conducted which opined that mitigation in the long term and adaptation in the short term are necessary.

Adaptation by the farmers in order to manage their farm productivity is not a new issue in the world and even in Nepal [12, 14-16]. From ages, agriculture has been always adopted to climate with possible adaptation system throughout the world [17]. As Mitin [18] rightly remarked that from ages rice farmers are resorted to various adaptation practices that might have deviated from their common practices. Even in the south Asian context, where rice is considered as a prime cereal crop, farmers have been adopting several adaptation options in order to protect and even increase their rice production [16, 19-21]. Researchers argued that such adaptation practice has increased in recent days in comparison with of earlier one to two decades [22, 23]. Rice farmers have been practicing common adaptation options in order to coping with changing climate in Nepal. These are using climate smart rice varieties (such as heat, flood drought tolerance rice grains), denser plantation of local seeds, selecting short duration rice crops, increasing use of chemical fertilizers, pesticides and insecticides, changing size of land under cultivation, off farm activities (like diversifying from farming to non-farming activities), changing in nursery date, build water harvesting schemes and change in irrigation practices (that includes alternative irrigations like boring, using motor for river water lifting), and other similar practices [9, 16, 17, 24].

Irrigation is common in rice cultivation practice in Nepal this is because most of the rice farmland in Nepal is located either at the river basin or at the low land, called Terai. About 63.6% of total rice farmland in Nepal has fully or partial irrigation facilities [25]. Local communities, in many villages, have taken initiatives to prepare irrigation

[1] USD 1 = NRs. 100

channels for paddy cultivations [6]. But several studies [26, 27] revealed that poor water management is one of the serious threats to the agricultural production in Nepal including rice farming that can damage severely in coming days as per the temperature increases. Hence, study about water sharing practice that influences water use and water management is necessary [28]. Successful stipulation of such water sharing practice under water governance mechanism not only helps to cope with rice farming; it further determines the equity and efficiency with water source and service allocation and distribution [29]. Further, successful implementation of water sharing can maintain the balance of water use between socio-economic activities and ecosystem [30]. Considering the evidences, this paper analyze the farmers perception of climate change, current climate change adaptation practices - including alternative irrigations, as an option of climate change adaptation by rice farmers and its adaptation costs along with water sharing practices in rural area of Nepal.

The remaining part of the paper is organized in four sections. In the next section, the methodology is discussed followed by result and discussion of the key issues and provide concluding remarks in final section.

2. The Methodology

2.1. The data

The study area of this research covers 7 districts of Nepal that consists Ilam (Hill); Sindhuli (Hill); Surkhet (Hill) and Syangja (Hill) and Bara (Terai); Dang (Terai) and Kailali (Terai). Further, the total population of the study was all rice producing households residing in the selected villages. A combination of multi-stage and simple random sampling was used to select the villages and households where questionnaire survey was carried out. A structural questionnaire with both closed and open-ended questions were prepared and used to obtain required information from 773 rice farming households from the study area, see [16, 31]. Initial data was entered into Excel and STATA software was used to analyze the data (see *Annex 1).*

2.2. Analytical Framework

The decision of rice farmers on whether or not to adapt any adaptation options is considered under the general framework of the utility and profit maximization [32, 33]. It is assumed that a rational farmer uses adaptation methods only when the net benefit from using such a method is significantly greater than not using it [34]. Although the utility (benefit) is not directly observed, the actions of economics agents are observed through the choices they make [32]. In this study, alternative irrigation adaptation is measured by a dummy variable in the model which was assigned a value of 1 for farmers who adopt alternative irrigation as an adaptation options and a value of 0 for youth who does not. It indicates that the probability of farmers with a given set of attributes fall in one choice (perceive) rather than the alternative (or not) but not both.

A logistic regression model was selected to identify the significant variable that determines whether farmers chose alternative irrigation as a suitable adaptation options or not. Since logit model is the best to describe observational data, which is the main data of this study, it used a logit model to identify the factors affecting choice of alternative irrigation, dependent variable as an adaptation option with other independent variables mentioned in equation 1. The advantage of logit model is that it guarantees the estimated probability increase and never crosses the range of 0 - 1. Let us suppose that *Y* is the adoption of alternative irrigation as an option of climate change adaptation among the several options available to the farmers which is a random variable and X is the socioeconomic factors and other determinants. The inferential statistical analysis used for this study is a logistic model applied by Devkota and Phuyal [31]. The logit regression equation that is used to ascertain variables influencing farmers' use of alternative irrigation as a climate change adaptation options which is expressed as follows:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \beta_{11} x_{11} + \mu_0 \quad \text{..... (1)}$$

The hypothesis for the dependent variables is that there is no significant relationship/association between adoption alternative irrigation as a climate change adaptation options and the given explanatory variables. The expected sign of the explanatory variables are explain in *Annex 1*.

3. Result and Discussion

3.1. Climate Change and Irrigation Practice among Rice Farmers

This study finds that farmers perceived increase in all time temperature and decrease in rainfall over 30 years period. This study observed that about 80.7% respondents from rural farmland were aware about increase in temperature and 94% were noticed change in rainfall especially in decreasing trend. Among the respondents, 73.7% were affirmed that they had knowledge of climate change. 97.8% farmers were receiving irrigation[2] for their rice cultivation in a way or other. However, only 84.8% of the respondent reported that they received 100% irrigation for their rice cultivation season. Western part of the country i.e. Dang, Surkhet and Kailali were found to be more dryland where farmers lack sufficient irrigation even for their rice cultivation season.

[2] One important note is that it is not the case of the whole country. Since the research is conducted in rice pocket area where water is sufficiently available from several sources the irrigation available to the farmers is higher. Otherwise the national irrigation availability to the farmers are 28% [35] .

It is also found that for the rice cultivation - canal, rain-fed and tube-well water is the major source of irrigation with the proportion of 53.8%, 27.4% and 14.2% respectively. Tubewell irrigation facilities were observed only in Terai land whereas rain-fed irrigation system found more common in hilly area. Most of the respondents mentioned that their land is satisfactorily fertile for rice cultivation. Government subsidy for rice cultivation is noticed more in western part of the country as compared to eastern and central region. One cause may be that government has implemented 100 Local Adaptation Plan of Action (LAPA) in 2016 for 14 districts of western part of the country that covers three provinces to support climate change resilient (Nepal Climate Change Support Programme, 2016).

This study found that rice farmers have been using 12 adaptation options in order to protect their rice field. Terai has a long history of such adaptation practice while in hilly belt it is new phenomenon. It shows that out of 773 respondents, 562 (72.7%) farmers' state that they have been adopting while 27.3% farmers have not started any adaptation mechanism yet. Among the adaptation options, the first three common and popular adaptation options practiced adopted by rice farmers are increasing use of chemical fertilizer, use of climate smart verities and change in nursery date. Alternative irrigation comes in the sixth position in terms of popularity among farmers. The selection of alternative irrigation may influence of its cost since it is the most costly adaptation options among the available options to the rice farmers to cope with changing climate scenario. The first three most costly adaptation options were measured as; change in alternative irrigation practice with average adaptation cost (USD 79.1) followed by denser plantation of local seeds (USD 21.3) and using climate smart varieties (USD 18.6) [36].

3.2. Alternative Irrigation Practice and Challenges

Among the respondents questioned, 656 (i.e. 84.9%) believe that alternative irrigation means to provide sufficient water to the rice field and could be best options among the available options to cope with changing climate. Whereas, 5% think opposite, and they don't think alternatives as best options, while 10.1% respondents don't know about alternative irrigation practice can be also an adaptation options. Among them, only 171 (i.e. 22.1%) farmers stated that they were changing irrigation practice (or use of alternative irrigation) as adaptation strategy against climate change. Such adaptation practice within alternative irrigation was found tube-well, and boring. Such options can be seen more on districts of Terai, adopted by 161 farmers (i.e. 94%) while hilly districts use only 6%. Researcher also asked respondents to identify the first five adaptations that have been adopted. Among such best 5 adaptation options, out of 171 respondents only 75 (i.e. 43.86%) mentioned that irrigation comes within that 5 adaptation options.

The situation shows that alternative irrigation seems low popularity and less priority among rice farmers. One reason for that might be the highest cost of adaptation; as we see above the average cost of adaptation of alternative irrigation options is comparatively higher than other adaptation options available to the farmers. Farmers opined that the major challenges to adopt alternative adaptation options are the associated cost that it takes. 262 out of 773 respondents (i.e. 33.9%) reported that the major problem to them is high cost of such alternative irrigation options. Similarly, only 158 out of 262 farmers (i.e. 60.3%) reported that irrigation comes within top five major problems to them to adopt. For the 61 (i.e. 7.9%), farmers adaptation is the first major problem whereas for 35 (i.e. 4.5%) farmers, it is the second major problem followed by 27 (i.e. 3.5%) farmers as a third, gradually 22 (i.e. 2.8%) farmers as forth and 13 (i.e. 1.7%) farmers as fifth.

Table-1. Ranking of Alternative Irrigation options (n=171)

Selection of Alternative Irrigation Options as						
Popular ranking	0	1	2	3	4	5
Total respondent	96	30	20	9	7	9

Source: Researcher's calculation based on field survey, 2017

3.3. Water Sharing Practice among the Farmers

The study found the discrete and different water sharing practices among rice farmers in Terai and Hilly belts of Nepal. In Terai, farmers are often use tractor, hires labor on per day basis and import irrigation water either by their well or canal available to them. Only poor and marginal farmers work for communal labor and go voluntarily for wages labor for other fields in their leisure time. But in the hilly area, farm practice is made by the labor and bullocks. If they required bullocks, more in number they manage in communal (sharing) basis regardless of their status and income level. Irrigation practice is also made for the similar basis. By such practice, water availability is sufficient to them for rice cultivation. Along with it, during re-watering for rice the first plantation gets water as per its requirement and the last one will get at the last. It makes a cycle that is sufficient enough to provide water for all the rice land in hilly area. Our study found communal decision is still prevailing in rural part of Nepal even for agricultural practice.

Rice farmers have managed their canal in communal labor sharing. In Hilly area community appointed water man, named to the person who takes care of water sharing. The responsibility of the water man is to look after and proper distribution of water and maintain the water cycle as per need basis which helps to reduce water conflict among the farmers. The decision of water man to provide water also seems to play vital role for the better cultivation of rice in such region. To maintain such water sharing process farmers who depend on that water canal for their field

are charged nominal amount each year. Farmers said that they use such water charge for the improvement of efficiency of water man, maintenance and the overall development of local canals.

In Terai, some people who could not afford their personal boring and also borrow water from other with certain charge. Such charge primarily depends upon the electricity bill or petroleum production that they use to generate pumping water. In this context, farmers having dry land need to pay more amount of money in order to manage water to their field whereas the people having water logged or low land need very less amount of water that helps them to reduce production cost. However, this study has not calculated all such petty cost at this cost.

3.4. An Econometric Approach

To check the determinants of use of alternative irrigation as an adaptation options among the rural rice farmers, the binary logit model was adopted. As Greene [37] mentioned there should be heteroscedasticity in the error term and multicollinearity among explanatory variables along with the cross sectional data, we tested it as per needed. After performing Collin test to check the multicollinearity as Abid, *et al.* [38] it is found that the mean VIF score is 1.59 which indicates that there is no multicollinearity problem exist with the data set. Similarly, we estimated robust logistic regression in order to prevent model from heteroscedasticity. The post estimation found that the overall percentage correctness for all model is 80% and above which confirm the better fit of all the models used in our study. Similarly χ^2 value is significant and value of Pseudo-R^2 ranges is 21 which indicates that the model selected for the study are fit and can accurately estimate the use of alternative irrigation as an adaptation options.

Econometric analysis shows that the probability of adoption of alternative irrigation is statistically significant with gender, total farmland, total income, existing irrigation facilities, credit and training. However, our model is unable to explain the most important variables like age, level of education, farm experience. The details of regression result have been presented in *Annex 1*. From the table, it is very clear that gender (0.726***), total farmland (0.391***), total income (7.380*) and credit (1.756***) show the positive relationship with the application of alternate irrigation options. It means male as a gender, higher the farmland, higher the income and sufficiency of credit increases the probability of use of such adaptation practice also increases. It also indicates that available irrigation facilities (-2.693***) and water management training (-1.064*) shows inverse relationship with the adaptation of alternative irrigation options. The result sounds quite accurate as farmers are having enough irrigation from their own source, they don't need to worry about the additional irrigation scheme or practice which attached some cost associated with it. Similarly, providing water management and other farming related trainings help farmers to manage the water available to them in a better way that enhances their farming efficiency and reduces several unusual practices they have been applied to their land.

Surprisingly, the model indicates that level of education is negatively associated with use of alternative irrigation resources. It may be the outcome of low number of educated farmers compared to non-educated farmers in the study area. However, probability can be that farmers with higher education may acquire knowledge about the proper water management practice and other practices which is helpful to produce better rice yields. Additional benefit of being educated is to understand and recognize several plans, policies, ideas and though provided via various channels of Information and Communication Technologies (ICTs), experts and Agriculture Training Assistance (JTA).

3.5. Policy Concerned

This study concerns about the rice farmers' perception, worry and opinion regarding long term resilience policy and/or strategic intervention from the government, I/NGOs and other stakeholders in order to cope them from changing climate. For capturing it, two open questions were posed to them; (i) what do you purposed to be done by policy makers and other relevant stakeholders to help you adapt the changes in climate in the long term? (ii) Do you have any complain, suggestion and recommendation which can help you to cope with the changing climate? The results are varied; such as Irrigation and Flood Control, Seeds and Fertilizer, Technology, Training and Information, Soil test and other government facilities, Labor and Tractor uses and its costs , Provision of Loan and Insurance, Disease, Pest and its Management, Storage House Facilities, Recognition of Actual Farmer and Proper Remuneration and Government Service, Policies and Program.

Very few farmers argued that they don't have canal, some mentioned that their land is not suitable for surface irrigation which requires boring and other alternative irrigation. Farmers also worried about cost it incurs to install such irrigation. In this regard, proper irrigation, either by maintaining and developing new canals or from several alternative irrigation options as mentioned above, provided to the farmers from the government and concerned authority could help them to cope with changing climate without any damage of their production. It is found government authorities has provided subsidies on irrigation and development (maintenance of canal, boring and damage of such irrigation channels) are provided to them farmers and villagers. But, majority of the rural rice farmers denied from the fact that requires more serious action should be taken from the government for transparent work. With successful implementation of irrigation (regardless of its nature), more production is possible with same land area due to economies of scale. Successful implementation of the given intervention, rice production will increase which in turn will improve the food security of the country.

4. Concluding Remarks

Climate change on farm practice is major concern that affects thousands of farmers in Nepal. Due to the alarming rate of decrease in rice production and productivity in Nepal, farmers are implementing alternative

adaptation as a coping strategy. They are adapting various adaptation options to prevent their rice farmland among which alternative irrigation is found one of the best adaptation strategies. But, the cost of alternative irrigation is significantly higher as compared to other available adaptation options. To manage sustainable irrigation, which is considered as life blood in rice farming, Nepalese farmers have been adopting water sharing system. Such water sharing is communal in Nepal; where farmers share communal farm practice in all respect that it helps to share water among the farmers as per their need and requirement. Such practice is observed more in Hilly area as compared to Terai due to topological and other complexities on farm practices. The study concludes that a good understanding and harmony between the water users can be the win-win situation to combat with alarming climate change.

Acknowledgement

The earlier version of this paper was presented in an International Conference on Water, Environment and Climate Change at Yak and Yeti, Kathmandu, Nepal on April 10-12, 2018. We are thankful to the conference participants and anonymous reviewers for their comments and insightful suggestions to develop this paper in the present form.

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Annex 1

Hypothesis, Summary Statistics and Logit Regression Result

Variables	Hypothesis	Summary Statistics		Regression Result	
				use_alternative_irrigation	
		Mean	Std. Dev.	Coefficient	Odds Ratio
Age	±	47.74	13.14	-0.0109 (0.0143)	0.9892
Gender	±	0.71	0.45	0.726*** (0.250)	2.0658
Level of Education	+	0.77	0.27	-0.0972 (0.392)	0.9074
Total Farmland	+	0.68	0.78	0.391*** (0.130)	1.4779
Total Income	+	20171.52	22235.46	7.3800* (4.05e-06)	1.0000
Irrigation Facilities	-	0.45	0.50	-2.693*** (0.301)	0.6768
Credit	+	0.14	0.34	1.756*** (0.328)	5.7883
Farm Experience	±	29.01	13.28	0.00176 (0.0141)	1.0018
Training	-	0.53	0.22	-1.064* (0.605)	0.3452
Extension Service	+	0.32	0.46	0.274 (0.220)	1.3146
Constant	+	-	-	-1.275*** (0.443)	0.2795
Pseudo R^2				0.2111	
Observations				773	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1