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Socio-economic determinants for the adoption of riverbed farming in Deukhuri valley of Western Nepal

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Abstract

Riverbed farming (RbF) has emerged as an alternative form of agriculture. This farming supports the poor and marginalized farmers' adaptation to climate change, especially in degraded lands because of floods and flood-induced riverbank erosions every year. The government and non-government organizations (GOs/NGOs) have supported and built capacities of farmers to adopt this as an effective adaptation strategy in the region. This study aims to analyze the determinants of riverbed farming at the household level mainly in the Deukhuri valley of the Western Terai, Nepal. A total of 150 households were selected randomly for the study in Sisahaniya rural municipality for the household survey. The determinants of the adoption of riverbed farming have been analyzed utilizing independent variables such as age, gender, education, occupation, ethnicity, family size, and others. Education and occupation are positively significant for the adoption of riverbed farming whereas the family size is negatively significant. Agriculture is the main occupation in the area. Education has helped them to understand the concept and procedures of RbF as alternative farming in degraded lands. However, not all the family members have actively contributed to the RbF. This is an interesting study that could be expanded with the support of GOs/NGOs.

Keywords: *Adaptation*, Agriculture, Riverbed farming, Terai, Nepal

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1. Introduction

Multiple adaptation strategies and practices have been adopted and promoted to address the impacts of climate change (Naz et al. 2018). However, one adaptation strategy may not be applicable to all affected sites. Thus, farmers need specific adaptation strategies and practices to deal with the specific impacts in flood-prone areas. Multiple risk management and adaptation practices/strategies adopted by the farmers themselves and with the support of public, private, and civic institutions to address the specific and general issues and impacts of climate change. These strategies and practices are categorized as informal practices and formal strategies accordingly. The informal practices have included income and crop diversification and resource management at the farm level, whereas the formal strategies include government policies/plans including agricultural credit, crop insurance, information systems, etc. (Saqib et al. 2016). These strategies and practices may vary from region to region, area to area, and farmer to farmer based on the specific exposure, sensitivity, and adaptive capacities, including the farmers' expertise, and technical and financial capacity (Naz et al. 2018).

Riverbed farming (RbF) is one such practice/strategy in the Terai region of Nepal, which is gaining popularity as an alternative form of agriculture in degraded and deteriorated land because of increased floods and flood-induced riverbank erosions in the region. This form of farming is supportive and attractive among the poor and landless farmers in the region. It has huge potential in such degraded and wastelands in the region. It is considered as an alternative source of income and family nutrition, supporting livelihood and food security (Maharjan 2017; Mor et al. 2018). Schiller et al. (2013) considered leasehold riverbed vegetable farming as an innovative farming technology, especially for the livelihood and food security of the landless and marginalized farmers. They further emphasized it as the economically, ecologically, socially, and technically efficient form of agriculture for the marginal farmers. This form of agriculture uses the degraded wastelands in the riverbanks for growing vegetables as the source of livelihood and income for the farmers (Mor et al. 2018). This form of farming is found across South Asia, including India and Bangladesh. It is believed to have been introduced in Nepal by immigrants from India (SATNET Asia, 4 October 2014).

Rivers have had significant importance in people's livelihood, culture, and welfare since human history. "All the civilizations from ancient times in the world were grown on the bank[s] of rivers" (Mor et al. 2018, pp 3423). However, the settlements and agricultural lands in the riverbanks are highly sensitive, with more exposure to the riverbank erosions in recent days due to

proximity to the rivers. Many ethnic nationalities and poor and marginalized people live in the riverbanks in Nepal. There are an estimated 6000 rivers in Nepal, including the rivulets and tributaries, with a drainage density of 0.3 km/km2 (WEPA, 2019). The people living on the riverbanks have comparatively less adaptive capacities to deal with the climatic shocks and stresses as well. Erratic and unpredictable heavy rain leading to floods and flood-induced riverbank erosions have changed the cultivable agricultural lands into uncultivable and degraded riverbeds in the Terai plains of Nepal. The significant mass of agricultural lands converted due to riverbank erosion has been increasing over the years (Gurung et al. 2012). The RbF has emerged as an option for the farmers and landless poor to maintain and support their livelihood by utilizing the available resources who have lost their agricultural lands from riverbank erosion due to floods and flood-induced erosion. Thus, it is a climate-smart agricultural practice to adapt to climate impacts for rural, poor, and landless households to generate income and sustain their livelihood (SATNET Asia, 4 October 2014). Mainly cucurbits are cultivated in the riverbeds (Gurung et al., 2012; Mor et al. 2018) since these crops can thrive even in the harsh climate and soil conditions (Maharjan, 2017), especially because of sand deposits in the banks due to floods and erosions (TECA N.D.). Furthermore, these crops can easily be harvested and sold in the local markets for family income.

It is important to understand the household responses to riverbank erosion, including the factors that influence the response. There are merely a few empirical studies done on riverbed farming in South Asia, including Nepal, though it has been promoted as the alternative source of agriculture, livelihood, and food security in the region by the private and civic sectors, especially by international and national non-governmental organizations (I/NGOs) including International Center of Integrated Mountain Development (ICIMOD), Helvetas Nepal, Mercy Corps, GIZ Nepal, Forum for Rural Welfare and Agricultural Reform for Development (FORWARD-Nepal), and riverbed farming alliance in Nepal (SATNET Asia, 4 October 2014). These organizations have motivated and supported the poor and landless farmers and households severely affected by the riverbank erosions in the region as supplementary livelihood options. The local riverbed farming promotion policy (2070 B.S.) was also finalized in 2013 (SATNET Asia, 4 October 2014). Some of the studies found in South Asia, including India and Bangladesh are by Gurung et al. (2012); Alam et al. (2017); Naz et al. (2018); Mor et al. (2018); Alam et al. (2019) in recent years. This study aims to analyze the socio-economic determinants of households associated with the RbF in Deukhuri valley of Western Nepal.

2. Methodology

2.1. Study Site

The study site is in the Deukhuri valley of Dang district in Mid-western Nepal, which borders India in the south. It is one of the largest districts in Nepal situated in the Inner Terai. The total area coverage by the district is 2,955 Km2 with an altitude range from 213 to 2058 meters above sea level with tropical, subtropical, and temperate climates. However, the study was concentrated in Sisahaniya Rural municipality. Agriculture is the main source of livelihood and economy in the district, with 2/3rd of its population engaged directly in it. The major stakeholders supporting agriculture are government offices, mainly agriculture, livestock, and forestry offices, non-governmental organizations, agricultural banks, multipurpose cooperatives, local-level community-based organizations, forest user groups, farmers' groups etc. The support of non-governmental organizations and cooperatives is important in the RbF. Rapti and Babai are two major rivers with many small streams and tributaries for water resources and irrigation, which also destroy the agricultural lands through riverbank erosions, particularly because of heavy and erratic rains in monsoon every year (DDC-Dang 2071 B.S.).

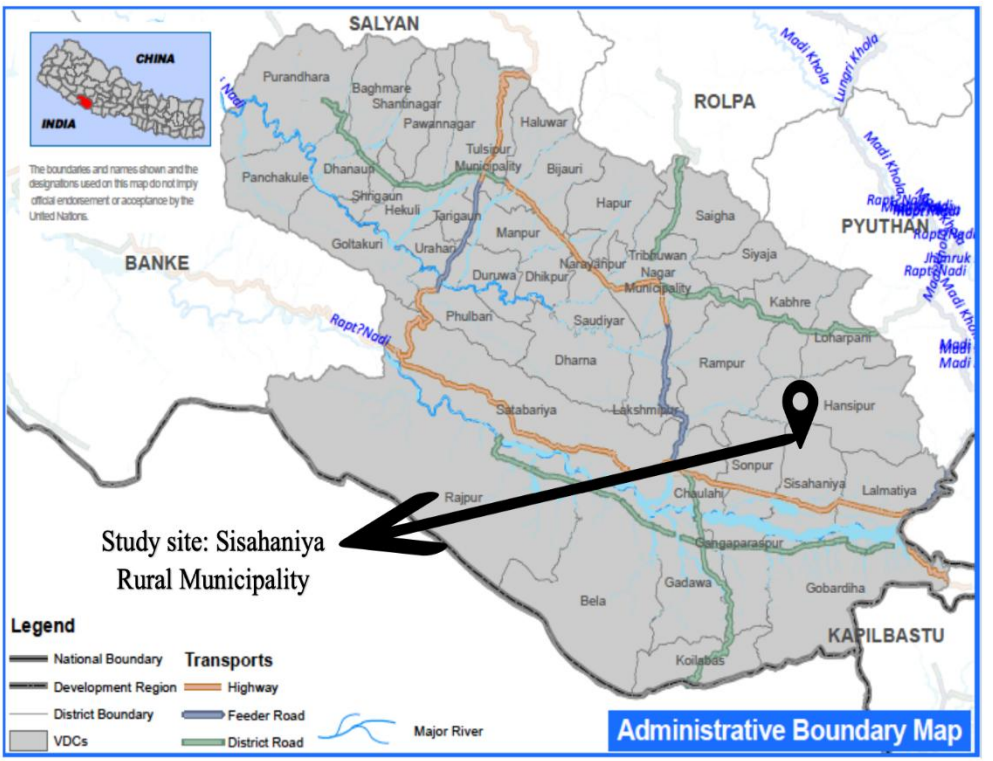

Figure 1: Map of Deukhuri-Dang District with administrative boundaries showing the study site

Based on the overall vulnerability index (VI) stated by the Ministry of Environment, Dang-Deukhuri is considered a low-vulnerable district (MoE 2010). However, the vulnerabilities, risks, impacts, and adaptation interventions vary even within the district due to the variations in altitude and climate including the difference in sensitivity, exposure, and adaptive capacities of the localities and communities living in the areas. Dang-Deukhuri, itself, has tropical, sub-tropical, and temperate climates within the district based on the elevation and the vulnerabilities, risks, impacts, and adaptation interventions as well. Figure 1 presents the administrative and climatic variations, particularly due to floods within Dang-Deukhuri district. The study sites are under high (more than 4 times) and moderate (2-3 times) floods in the years between 2006 to 2014 (UN-NIP 2017). As per the district and VDC profiles, Deukhuri valley faces the issues of flood, riverbank erosion,

drought, forest exploitation, reduced agricultural production and the emergence of new insects, diseases, and pests, and drying of the water sources (Sisahaniya VDC 2073 V.S.).

2.2. Empirical model and selection of the variables

Different research has shown that farm households have been attempting to deal with climatic hazards including riverbank erosion through multiple adaptation strategies including riverbed farming (Alam et al. 2019). Naz et al. (2018) emphasized the analysis of determinants that influence adaptation strategies and practices at the household level to address the impacts of floods and other climate impacts. Mittal and Maher (2015) used the Multivariate Probit Model (MVP) to analyze the determinants of farmers adopted in agriculture. Sebopetji and Belete (2009) used the binary probit model to analyze the factors affecting smallholder's decision to take credit, which is applied in this study as well. This model estimates the probabilities dependent variable between 0 for not adopting riverbed farming and 1 for adopting riverbed farming among the selected samples. The details of the independent variables are presented in Table 1.
The equation of the regression model is assumed to be:

$$Y_i^* = \beta 0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki} + v_i$$

And that $Y_i = 1$ if $Y_i^* > 0$ or $Y_i = 0$ otherwise.

That means Yi is the dependent variable of whether the farm household adopted riverbed farming or not, x_1, x_2, x_3 … xk represents vector of random variables, β represents a vector of unknown parameters and v represents a random disturbance term (Nagler, 2002).

Table 1. Variables for Probit Regression Model for factors affecting riverbed farming in Deukhuri valley

S.N.	Variables	Unit	Mean (Sta. Dev.)	Range	Expected Sign
1.	Age (age)	Number of years	38.66 (11.19)	16-70	+/-
2.	Gender (gender)	Dummy, =1, if female, 0 otherwise	0.49 (0.50)		+/-
3.	Education (edu)	Categorical, illiterate=1,	5.04 (2.52)		+

		literate=2, primary=3, lower secondary=4, secondary=5, higher secondary=6, bachelors=7, more than bachelors=8			
4.	Occupation (occu)	Dummy:=1 if Agriculture, 0 otherwise	1.71 (0.45)		+/-
5.	Family size (fam_siz)	Number of family members	6.25 (2.62)	2-20	+
6.	Economically active member (econ_active)	Number of members active economically	4.13 (1.91)	1-12	+
7.	Land holding (Plain_Acre) (Land-holding_PlAcre)	Land holding in acre (1ha=2.47 acre)	0.79 (0.87)	0.16-8.36	+
8.	Total Land holding (tl_land_acre)	Total Land holding in acre (1ha=2.47 acre)	1.05 (1.04)	0.16-10.3	+
9.	Land affected in acre (Landaffected)	Land affected by flood (1ha=2.47 acre)	0.26 (0.30)	0.2-1.67	-
10.	Crop Diversity (crop_div)	Number of crops cultivated per household	15.06 (2.75)	1-21	+

3. Results and Discussion

During the empirical model and variables selection, we expected the variables such as education, family size, economically active members, land holding in plains and total land holdings (acre), and crop diversity to be positive, whereas variables such as age, gender, occupation could be either positive or negative based on the context and land affected variable is expected to be negative. The empirical results showed that the coefficient of economically active members is positively significant to the riverbed farming at 0.05 level as expected, whereas family size and land affected are negatively significant to the riverbed

farming among the total independent variables. The variable family size was expected to be positive whereas land affected (acre) was expected to be negative as the result has shown. The coefficient of factors such as gender, education, total land holding (acre), and crop diversity showed negative impacts on riverbed farming though most of these variables were expected to be positive, whereas the rest of the factors such as age and occupation showed the positive but not significant (Table 2).

Table 2: Probit Regression Model analysis for factors affecting riverbed farming in Deukhuri Valley

Riverbed farming	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
age	.0026704	.0157979	0.17	0.866	-.028293	.0336337
gender	-.1994556	.3156154	-0.63	0.527	-.8180505	.4191393
edu	-.0410019	.074857	-0.55	0.584	-.187719	.1057152
occu	.1325615	.0958199	1.38	0.167	-.0552421	.3203651
fam_siz	-.2258063	.1261595	-1.79	0.073*	-.4730744	.0214617
econ_active	.3349531	.1802855	1.86	0.063*	-.0184	.6883061
Land_holding_PlAcre	1.431611	.9194141	1.56	0.119	-.3704077	3.233629
tl_land_acre	-.9214202	.7703892	-1.20	0.232	-2.431355	.5885148
Landaffected	-1.097367	.635088	-1.73	0.084*	-2.342116	.147383
crop_div	-.0120196	.0569821	-0.21	0.833	-.1237025	.0996633

_cons	.1097355	1.134616	0.10	0.923	-2.114071	2.333542

The most possible reasons for these results as the economically active population contributes to riverbed farming as it is labor-intensive farming that is seasonal in nature. Since all the family members in the household are not engaged in the agriculture sector the coefficient of family size may appear to be significantly negative. Likewise, the land affected (acre) appeared to be significantly negative as most households reported the land affected by flood and flood-induced riverbank erosion. Most of the population (more than 90% of the local people) rely on agriculture for their livelihood, economy, and welfare. That is why, occupation is positive though not significant which may indicate that affected households most likely adopt riverbed farming as the alternative form of agriculture. We assumed that the occupation to be either positive or negative in this study, but the results already show that occupation in agriculture is supportive for them to adopt RbF farming. A similar study done in Malawi reports family size, occupation, education, market, and land holding size as important factors for adopting riverbed farming (Zidana et al. 2007). This was one of the government's strategies to promote and accelerate sustainable agriculture, economic development, and food security in Malawi. In this study, the crop diversity is negative towards the adoption of riverbed farming. The reason could be the limited species of cucurbits being cultivated in the riverbeds. The study carried out by USC Canada (2013) in Eastern Nepal indicated the significant importance of riverbed farming in enriching crop diversity, which revealed 21 species of plants and 31 types of wildlife in the riverbed farming areas since it is next to the community forests.

4. Conclusions and Way forward

RbF is gaining popularity among farmers, especially among the poor, ethnic, and landless farmers as the alternative form of agriculture which is also an effective form of adaptation practice/strategy. It is specially promoted by private and civic stakeholders in Nepal. Among the variables selected in the study, economically active members in the households are positively significant to the adoption of RbF whereas family size and land affected in acre are negatively significant to its adoption at a 0.05 significance level. This form of agriculture is important as a source of food and nutrition and as an effective adaptation strategy and practice in degraded lands. The government (public) offices should promote this farming in specific regions in addition to the private and civic sectors. This study could not capture the economic aspects of farming including the total costs incurred the economic returns and environmental and other social benefits, which is crucial to analyze the cost-

effectiveness and sustainability of this farming since mostly it is supported by the I/NGOs in the region. Furthermore, it is advisable to carry out studies on seeds and market accessibility and collective marketing systems in addition to access to credit and information.

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