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Aims and Scope

Asia-Pacific Journal of Rural Development is a peer-reviewed journal that provides a platform for publication of articles in all areas of rural development. The aim of this journal is to provide a platform for policy makers and academicians to promote, share and discuss various new issues and developments in different areas of rural development. The journal publishes conceptual, empirical and review papers in the form of research articles, reports of ongoing research, analyses of current and topical practice, policy issues relating to rural development field notes and book reviews. The journal is peer-reviewed and adheres to a rigorous double-blind reviewing policy in which the identity of both the reviewer and author are always concealed from both parties.

Subject areas include any thematic areas related to sustainable integrated rural development aligned with Sustainable Development Goals (SDGs). The thematic areas are including but not limited to the following:

- Sustainable use of natural resources
- Management of rural areas in transition
- Land and water resources management
- Agro processing and rural market
- Rural livelihoods and poverty reduction
- Education and skill development
- Entrepreneurship and financial inclusion
- Climate change
- Local governance
- Food and nutrition
- Health and hygiene
- ICT and geospatial technology for rural development
- Renewable energy for rural consumption
- Rural transportation
- Sustainable rural tourism

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Determinants of Livelihood Diversification Under Environmental Change in Coastal Community of Bangladesh

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Abstract

The life and livelihood of coastal farming communities in Bangladesh are highly vulnerable to climate and environmental change. Diversification of farmers' income sources beyond agriculture can be an effective way to cope with the adverse impacts of environmental change. The purpose of this study is to analyse the options and determinants of livelihood diversification (LD) strategies adopted by farmers in the coastal region of Bangladesh. Multiple linear regression technique along with Simpson index, Herfindahl index and priority index have been used for the analysis. Simple random sampling and multistage sampling have been used to select the sample and the study area, respectively. The magnitude of farming household diversification is at medium level. A significant share of annual income comes primarily from fish and rice production, domestic bird rearing and working as agricultural labour. The adoption of diversified activities is strongly influenced by age and education of household head, number of earning family members, social network and government donation. The frequent occurrence of natural disasters, inadequate infrastructure and lack of financial capacity are the critical constraints to LD.

Keywords

Livelihood diversification, adaptation, OLS, coastal region, Bangladesh

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Introduction

Livelihood diversification (LD) plays a crucial role in promoting economic growth and reducing rural poverty in developing countries (Loison, 2019). It is the process of combining both agricultural and non-agricultural activities to survive and improve the standard of living (Ellis, 1998; Niehof, 2004; Martin & Lorenzen, 2016; Pritchard et al., 2019). Households across the developing countries are trying to diversify their livelihood activities to secure from risks and cope with economic and environmental shocks (Baird & Hartter, 2017; Gautam & Andersen, 2016; Martin & Lorenzen, 2016). By providing alternative non-farm job opportunities, LD marks a vital role in sustainable ecological development and rural poverty reduction (Liu & Lan, 2015). Climate change has emerged as a threat to natural life and livelihood systems (Rahman et al., 2018).

To cope with the changing situation, smallholder farmers in the coastal regions are adopting both on-farm (planting drought-tolerant crops and mixed farming) and off-farm (selling household assets, migration of the entire households and decreasing food consumption/changing diets) diversification strategies. These diversified activities allow farming households to manage risk and improve their lives (Aniah et al., 2019; Baird & Hartter, 2017). There are several factors, such as education level, number of livestock, farming experience, etc., that affect the adoption of diversified activities (Akhtar et al., 2019). Most importantly, the age of the household head, along with possession of cropland and distance from markets, are essential determinants of LD strategy (Corral & Radchenko, 2017; Ismail et al., 2018; Tesfaye et al., 2011).

Despite having a little contribution to global emission, Bangladesh is to experience the adverse impact of global warming in terms of changing climate (Collins, 2014). Farmers in the coastal regions of the country are forced to alter or diversify their agricultural activities to cope with climate-driven hazards (Burchfield & Poterie, 2018). Besides, several natural disasters, such as cyclones, floods, tidal surges, droughts, salinity intrusion and waterlogging, pose severe threats to their lives and livelihoods (Bernier et al., 2016; Hasan & Kumar, 2020; Shameem et al., 2014). Each year, they experience a massive loss of productive land and damage to other natural resources, such as freshwater estuary, grassland, forests, etc., that threaten their livelihoods and food security (Alam, 2017; Pouliotte et al., 2009). They have been adopting both on-farm (planting saline resilient crops, changing cropping time, livestock rearing, etc.) and non-farm (wage employment, short-term migration, tertiary jobs, etc.) adaptation strategies to reduce loss from farming activities (Kabir et al., 2017).

In the context of Bangladesh, some studies have been conducted to explore the patterns and determinants of livelihood strategies of riverine households (Alam et al., 2017; Brouwer et al., 2007). In addition, similar studies have also been carried out covering on fishing communities alone by the works of Paul and Vogl (2013), Ahmed (2008), Hossain et al., (2018), Deb and Haque (2016) and Islam et al. (2011). However, a study on investigating the options and determinants of LD strategies of smallholder farmers especially in southwestern part is not covered by most of these studies. Hence, Satkhira district (one of the southwestern coastal

districts and highly vulnerable to environmental change) has been chosen as the location of our study. Correspondingly, the objective of this study is to identify the extent and determinants of LD strategies of the coastal farmers and provide useful insight into the sustainable disaster risk reduction strategies in the context of Bangladesh.

Literature Review

To reduce the disaster-induced risk and damage of the farmers, an in-depth analysis of their income-earning sources along with the factors that influence them is essential. A couple of research works have been conducted on similar grounds. Among them, Deb and Haque focused on how small-scale fishers in coastal Bangladesh managed their stress on reconstructing their livelihood strategies. They found that a complex set of overlapping actions constitutes the copping strategies that depend on the fisher's capabilities, socio-cultural conditions and various undesirable situations (Deb & Haque, 2016). Similarly, Islam et al. (2014) concluded that geospatial and socio-cultural factors, such as physical characteristics of climate and sea, lack of modern boat, signal system and credit, act as barriers to adaptation activities of fishers. However, Islam et al. (2011) proposed that a community-based fisheries management scheme can be a suitable option to enhance fisheries-dependent household income as well as easy access to different social and economic assets.

Another contribution (Brouwer et al., 2007) across the large flood-prone area along the River Meghna at southeast of Bangladesh indicated that household having low income and limited access to natural resources tend to be most vulnerable and exposed to flooding. The similar findings have been reported by Alam et al. (2017) among the riverbank households of Bangladesh. They argued that the poor livelihood strategies of the vulnerable households are highly influenced by the inaccessibility to food, water and health facilities, leaving them in vicious circle of poverty. Lázár et al. (2015) proposed a simulated model to determine the relation between agriculture-based livelihood and poverty in the coastal region of the country.

In search of sustainable livelihood mechanisms for the shrimp farmers in the southwest coastal region of Bangladesh, Paul and Vogl (2013) identified that organic shrimp cultivation could be beneficial in increasing farmers' assets and effective for reducing their vulnerability from different natural hazards. Applying a similar approach, Ahmed et al. (2008) pointed out that mixed fish and crop production can also strengthen the sustainable livelihood of the coastal shrimp farming households. In addition, adaptive responses, including species diversification and fattening of crab, have also been considered as an effective way of sustainable LD approach (Hossain et al., 2018).

Using a large sample data set based on the north-western region of Bangladesh, Rahman and Akter (2014) attempted to identify the socio-economic determinants of livelihood choices of the rural household. They concluded that wealthy

households are highly diversified, and female-headed households are less diversified. Their study provides useful insights for the policymakers to concentrate on rural infrastructural development and women empowerment. Uddin (2012) concluded that most of the marginal farmers in the coastal area who are vulnerable to storm surges are often victim of food insecurity and their livelihood coping strategies mainly depend on primary activities such as crop and fish production, livestock farming, etc. In a similar study conducted in the northwest region of Bangladesh, Rashid et al. (2006) opined that household copping strategy depends on the financial capacity. Households with higher education and assets tend to be more diversified and secured.

Methodology

Study Area Selection

A multistage sampling technique has been applied to select the study area. In the preliminary stage, Satkhira District, one of the southwest coastal districts of Bangladesh, has been chosen as the primary sampling unit (PSU). Later, Shyamnagar Upazila (sub-district) under Satkhira district has been selected as a secondary sampling unit (SSU) (Figure 1). This Upazila is situated between 21°36′ and 22°24′ north latitudes and between 89°00′ and 89°19′ east longitudes, covering an area of 1,968.24 km^2. The reason for selecting the Upazila is that it is located near the coastal belt and is highly vulnerable to natural disasters such as cyclone, flood, salinity intrusion, etc. (Grant et al., 2015; Rahman et al., 2017). In addition, to the best of our knowledge, we found no prior studies have been conducted on options and determinates of LD of smallholder farmers in this district. We, therefore, considered Shyamnagar Upazila to provide a general overview of the diversification strategies adopted by the farmers in the face of environmental change.

Local smallholder farmers in the study area have been chosen as the sample. Smallholder, in the current study, is referred to the famers who operate on farm size (0.02–1) hectare or farmland less than 2.5 acres. This definition of smallholder farmers is adopted from studies conducted by Ali (2003), Nabi (2008) and Schreinemachers et al. (2016) in the context of Bangladesh with relevance to coastal region. The number of smallholder farmers is smaller compared with other professionals in the study area. Among the total population, on average, about 33 per cent are currently engaged in agricultural activities (Didar-Ul Islam et al., 2015). A total of 60 smallholder farmers (n = 60) from Burigoalini, Munshigonj and Atulia unions out of 11 unions of Shyamnagar Upazila have been selected using a simple random sampling technique to minimise the inference biasedness occurred from the small sample size. These unions are located adjacent to the coastal belt and fully exposed to any natural events that occurred in the area.

The primary data were collected through a questionnaire survey, focused group discussion (FGD), key informant interview (KII) and observation

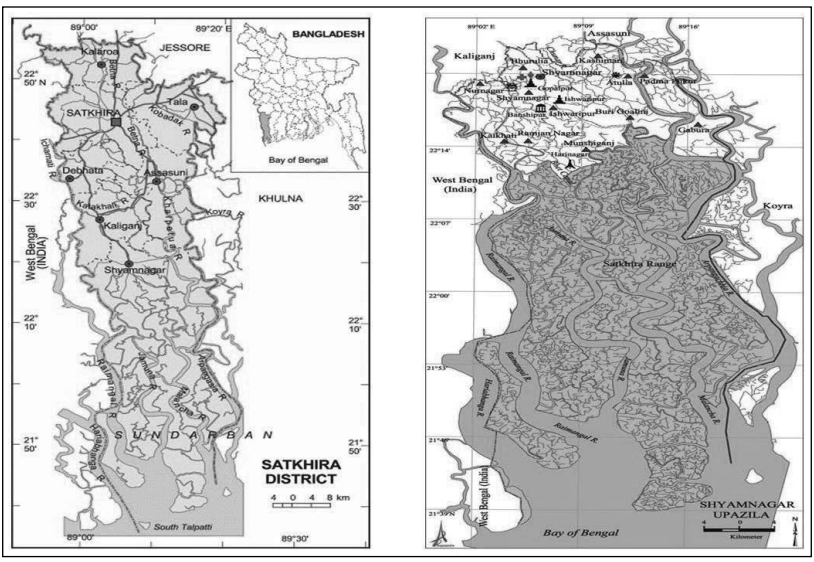

Figure 1. Location of the Study Area: The Shyamnagar Upazila

Source: Authors' compilation based on Banglapedia.org.

methods. Before initiating the final data collection, a pilot survey was conducted to test the validity and reliability of the questionnaire. Both open-ended and closed-ended questions were included in the questionnaire. Open-ended questions were used to get perceptions of the respondents on the impacts of environmental change on their livelihood style. Besides, closed-ended questions are maintained to get specific information such as household information, different occupation types, return from these occupations, etc. After the pilot survey, the pretested 60 structured questionnaire containing both open-ended and closed-ended questions has been used to collect data using face-to-face interview between February and March 2019. Although a structured questionnaire is an efficient way of getting in-depth quantitative data, it has some limitations on collecting qualitative data (Cheung, 2014). Hence, some popular qualitative data collection tools such as FGD, KII and observation methods have been employed to overcome the limitation.

A total of three FGD sessions (one in each union) were conducted on three unions from 15–30 March 2019. On average, 20 farmers have participated in each FGD session with approximately 1 h per session. We contacted the farmers the day before each session and requested them to gather in prespecified locations such as farmers' house backyard, school premises and village market for the FGD. Farmers with an experience of at least 10 years of direct farming were selected to participate in the session. They were asked to discuss the key questions such as how they lead their day-to-day livelihood style and their perceptions on risks of starting new economics activities. In addition, they were questioned on how they think of the quality of rural infrastructures and their view on change in

environmental condition and its impacts on livelihood activities. Issues like what are the potential strategies they think will be useful to create new job opportunities for them were also asked in the session. We also sought expert opinion from six key personnel working in government body (Agricultural Extension Offices) and non-governmental organisations (BRAC and Uttaran) in the study area to cross-check our data collected from the respondents. In addition, from the field observation, we gathered first-hand information on how different types of diversified activities are maintained by the farmers.

Estimation Method

A set of statistical and econometric tools has been used to analyse the collected data. Descriptive statistics such as mean, standard deviation, minimum and maximum has been used to examine the socio-economic status of the respondents. Simpson index (SI) and Herfindahl index (HI) have been used to measure the extent of LD. Priority index (P.I) is used to rank the constraints to adopting diversified activities. A multiple linear regression model using ordinary least squares (OLS) estimation technique is applied to identify the determinants of LD. The assumptions of OLS have been carefully checked and maintained before establishing causality between the dependent variable and explanatory variables in this study. For instances, the variables in the model have been acquired from random sampling procedure and the parameters are assumed to be linear. In addition, the conditional mean value of the error term is assumed to be zero with no linear correlation with the explanatory variables. Besides, we assumed that there is no multicollinearity among the independent variables and existence of homoscedasticity in the error terms. The general form of the regression model is given in Equation (1):

$$D_{ij} = \beta_0 + \beta_i X_i + \mu \tag{1}$$

Here, D is the dependent variable indicating diversification of household i measured in the number of activities j, β_0 is constant, β_i is the vector of parameters, X_i is the vector of independent variables and μ is the disturbance term. The description of the independent variables has been presented in Table 1.

Simpson Index

Several indicators and indices, such as SI, HI, Ogive index, Herfindahl–Hirschman index, entropy index, composite entropy index, etc., have been used to measure the household LD. Among them, the SI is commonly used for its simple calculation procedure and wider acceptability. This research adopts the SI from Khatun and Roy (2012) formulated in Equation (2):

$$\mathrm{SI} = 1 - \sum_{i=1}^{n} \left(P_i^2 \right) \tag{2}$$

where n denotes the total number of income sources and P_i indicates income proportion of the ith income source. The value of SI lies between 0 and 1. When

there is a full specialisation the value of SI becomes 0, and when it moves towards 1 there is an increase in diversification level. The level of diversification has been categorised based on the SI value. Here, (SI ≤ 0.01) = no diversification, (SI = 0.01–0.25) = low level of diversification, (SI = 0.26–0.50) = medium level of diversification, (SI = 0.51–0.75) = high level of diversification and (SI = 0.51–0.75) = very high level of diversification (Ahmed et al., 2018; Sarker et al., 2020).

Herfindahl Index

Another popular and widely used index to measure economic diversity is the HI (Woerheide & Persson, 1992). The HI can also measure the level of household diversification formulated in Equation (3) (Kassie, 2017; Sharma, 2008):

$$\mathrm{HI} = \sum_{i=1}^{n} \left(S_i^2 \right) \tag{3}$$

Here, S_i represents the share of each livelihood activity i in the overall income of the household. The value of HI ranges from 0 (when the household has a lot of economic activities or high diversity) to 1 (when the income of the household comes from a small number of economic activities or full specialisation).

Table 1. Description of Variables

Serial	Variable Name	Unit of Measurement	Operational Definition
1	Age (X_1)	Years	The age of the household head
2	Education (X_2)	Years of schooling	The education status of the household head
3	Family member (X_3)	Number	Total family member of a household
4	Earning member (X_4)	Number	Total earning member of a household
5	Educated family member (X_5)	Number	Family member who completed 10 years of schooling
6	Distance (X_6)	Kilometres	The distance from home to the nearest town
7	Loan (X_7)	Dummy (1= yes, 0 = otherwise)	Whether loan/credit taken by the household in the last 3 years
8	Training (X_8)	Dummy (1= yes, 0 = otherwise)	Whether the household head has taken any professional training
9	Social work participation (X_9)	Dummy (1= yes, 0 = otherwise)	Whether the household head has participated in any social works, such as repairing roads, houses, dams, etc.

(Table 1 Continued)

(Table 1 Continued)

Serial	Variable Name	Unit of Measurement	Operational Definition
10	Health/financial problem (X_{10})	Dummy (1= yes, 0 = otherwise)	Whether a household head has any financial or health-related problems
11	Forest resource use (X_{11})	Dummy (1= yes, 0 = otherwise)	Whether the household uses resources from the adjacent forest
12	Government donation (X_{12})	Dummy (1= yes, 0 = otherwise)	Whether the household has got any government donation

Source: Authors' compilation.

Constraint Analysis

The number of diversified activities adopted profoundly by household is highly influenced by the socio-economic and environmental factors. A set of constraints has been identified and ranked using the P.I given in Equation (4) (Karmokar et al., 2015):

$$\text{P.I} = \sum S_i f_i / n \ (0 \leq \text{P.I} \leq 1) \quad (4)$$

Here, S_i is the scale value of *i*th priority, f_i is the frequency of *i*th priority and n is the total number of observations. A five-point scale has been applied to construct the index, where the scale values range from 1 to 0 with the priority of 1–5, respectively.

Results and Discussion

Socio-demographic Characteristics

Table 2 demonstrates the general characteristics of the respondents. It has been found that the average age of the respondents is around 46 years, with a minimum of 27 years to a maximum of 70 years. More than 50 per cent of the respondents belong to the age group 36–50 years. The size of the family varies from household to household. Survey data reveal that nearly 60 per cent of a home has a family member of 4–6 people.

Table 2. General Profile of the Respondents

Characteristics	Frequency	Per cent (%)
Age		
15–35	8	13
36–50	32	53
51–64	17	29
64+	3	5
Mean	46.52	–

(Table 2 Continued)

(Table 2 Continued)

Characteristics	Frequency	Per cent (%)
Education (household head)		
Illiterate	1	2
Primary	20	33
Secondary	31	53
Higher secondary	3	5
Graduate	4	7
Mean	6.93	–
Education (family member)		
0	12	20
1–3	45	75
4–6	3	5
Mean	1.47	–
Family size		
0–3	12	20
4–6	38	63
6+	10	17
Mean	4.95	–
Earning member (except the household head)		
0–2	47	78
3–4	13	22
Mean	1.8	–
Household land holding (acre)		
0–2	41	69
3–4	9	15
5–7	8	13
7+	2	3
Mean	2.19	–

Source: Authors' compilation based on field survey.

The survey data indicates that more than half (53 per cent) of the household head completed the secondary school. On the other hand, only 33 per cent of them have been able to finish primary schooling. Seventy-five per cent of households have at least 1–3 members who have completed at least 10 years of schooling. In general, the household head is the main earning person of the family. The surveyed data reveal that 77 per cent of households have at least 1–2 earning person(s), including the household head. However, the amount of cultivatable land holding possessed by the families is minimal. Most of the respondents (69 per cent) own only 0–2 acres of land, whereas the average possession of property remains 2.19 acres per household.

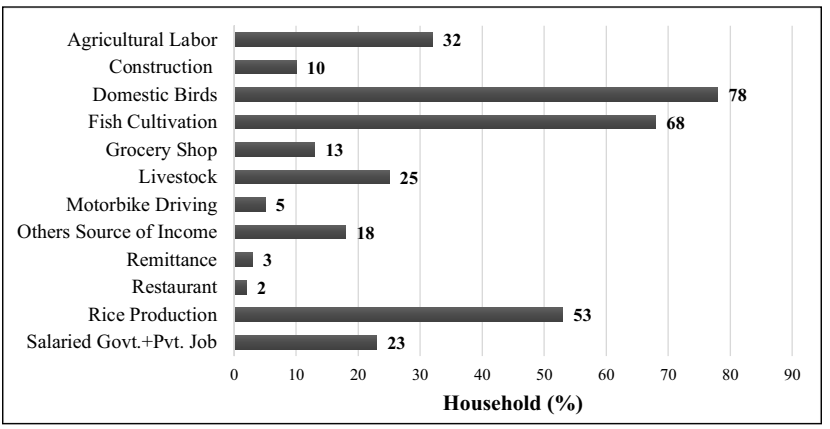

Figure 2. Economic Activities of the Household.

Source: Authors' compilation based on field survey.

Types of Diversified Economic Activities

Figure 2 presents the diversified economic activities adopted by the household to secure their income flow. A total of 12 diversified economic activities has been identified and categorised as primary, secondary and tertiary activities (Avila-Foucat & Rodríguez-Robayo, 2018). Since agriculture is associated with risk and uncertainties, farming households rely on both agricultural and non-agricultural activities to secure their livelihood (Asmah, 2011; Martin & Lorenzen, 2016). Principal economic activities are generally agricultural based, such as the production of rice and fish, rearing livestock and domestic birds and working as agricultural labour (Melketo et al., 2020). Side by side, non-agricultural activities (secondary and tertiary) also provide an important source of income for the households in rural area. Family members of some household are engaged in secondary economic activities like working in the construction sector. Some economic activities have been identified as tertiary level activities, such as running grocery shop, restaurant, driving motorbike, working in governmental and non-governmental organisations and receive money as a remittance.

It is seen from Figure 2 that a large share of the annual income of the respondents comes from farm activities. The survey results also indicate that more than half of the respondents receive income from rice production (53 per cent), domestic bird rearing (78 per cent) and fish production (68 per cent). The similar findings are also reported in the work of Gani et al., (2019) where they noted that majority of the rural households in Nigeria diversify their income from cropping, fishing, livestock and poultry production. On the other hand, a negligible portion of the respondents (10 per cent) secure income from the construction sector. Besides, grocery shop is operated by 13 per cent of the respondents, and 23 per cent are engaged in salaried governmental and non-governmental organisations. This

finding clearly depicts the growing contribution of non-farm sectors in the income basket of rural households.

Household Yearly Income Share from Diversified Economic Activities

Table 3 represents an annual average income share from various economic activities of the households. The analysed data show that among the broad economic activities, a small number of them provide high returns to the households. It is reported that annual average earning of BDT3,734 came from domestic bird rearing which is adopted by 78 per cent of the respondents. The underlying reason is that it takes a small investment to domestic bird rearing, and almost every household prefers to produce small-scale domestic birds for earning money by selling them. Another important income for the farmers is livestock rearing. Almost 26 per cent of the respondent reported raising livestock with average annual revenue equal to BDT37,000. This livestock and birds can be liquidated easily; hence, it is considered as the safety net for poor households (Pant et al., 2014).

For the coastal communities, fish cultivation is very common as a source of income. They mostly depend on the fishing for their livelihood. The estimated result shows that 68 per cent of households in the study area are engaged in commercial fish production and the average earning per year becomes BDT1.34 lakh. The adoption of fishing is one of the important occupations in coastal areas reported in many research works (Martin et al., 2013; Olale & Henson, 2013).

The gradual increase in soil and water salinity in the coastal region of Bangladesh leads to decline in the rice productivity day by day (Dasgupta et al., 2018). As a result, the share of income of the farmers falls along with the number of rice producers. This scenario is reflected in the estimated results where it has been seen that only 53 per cent of the respondents now produce rice and get on average BDT24,000 per year. Besides, by working as agricultural labour, some of the respondents (32 per cent) also receive an average of BDT48,000 per year.

Income from non-farm activities plays a crucial role in determining total income and expenditure in rural areas. The annual earnings from the salaried job and grocery business are higher than the other professions (construction, motorbike driving, restaurant and remittance).

More than 50 per cent income of a rural household in developing countries comes from non-farm activities (IFAD, 2011). Salam et al. (2019) also reported that any non-farm activities also significantly increase the household income as well as well-being in the context of northern rural Bangladesh. In a study conducted by Yizengaw et al. (2015), they found that almost 60 per cent income of the household comes from non-farm activities. Gautam and Andersen (2016) also stated that salaried job played a positive role in household well-being, although the capacity to get a job depends mostly on the higher literacy level. Along with the salaried job, remittance also plays a significant role in securing the income for many households (Asfaw et al., 2017). Over the last few decades, remittance (domestic and foreign) has emerged as one of the important safeguards

for environmental uncertainty for many rural households in Bangladesh (Sikder & Ballis, 2013). Households involved in primary activities have a more diversified source of income compared with those who are engaged in secondary and tertiary activities. On the other hand, return from the primary sector is less than the tertiary sector, although a small number of the household have access to tertiary activities (Saha & Bahal, 2016).

Table 3. Share of Annual Income from Various Economic Activities

Type of Activities	Average Earning (BDT)	Frequency	Per cent (%)
Domestic birds	3,734	47.00	78.33
Fish production	1,34,619	41.00	68.00
Rice production	24,575	31.00	53.00
Agricultural labour	48,105	19.00	32.00
Livestock	37,062	15.00	25.00
Salaried government + private job	1,46,357	14.00	23.00
Others source of income	2,33,545	11.00	18.33
Grocery shop	1,72,500	8.00	13.33
Construction	42,666	6.00	10.00
Motorbike driving	80,000	3.00	5.00
Remittances	75,000	2.00	3.33
Restaurant	50,000	1.00	1.67
Overall	2,47,358	60	100

Source: Authors' compilation based on field survey.

Note: US$01 = 84 BDT as of March 2019.

Table 4. Distribution of Respondents on the Extent of Diversification

	Simpson Index		Herfindahl Index	
Range	Frequency	Per cent (%)	Frequency	Per cent (%)
0	1	2	0	0
0.01–0.25	16	27	1	2
0.26–0.50	22	37	22	36
0.51–0.75	16	26	17	28
0.76–1.00	5	9	20	33
Total	60	100	60	100
	Mean = 0.39; SD = 0.24		Mean = 0.62; SD = 0.23	

Source: Authors' compilation based on field survey.

Extent of Diversification

Table 4 demonstrates the estimated results from the SI and HI to measure the degree of household LD. It has been seen that 27 per cent of the households have poor diversification level where 37 per cent of them are under a medium level of diversification. On the contrary, only 26 per cent of them have a high level of diversified source of income. Overall, the mean value of SI is 0.39 indicating a medium level of diversification across all households. Rural households having a low level of income diversification has also been reported by the other researchers. For instance, Negeri and Demissie (2017) found that the rural farmers (78 per cent) in the African region have diversification level below 38 per cent. In addition, the average SI diversification level among the farmers in West Bengal is 0.46, which is marked as below the high level of diversification (Saha & Bahal, 2016). In the context of Bangladesh, farmers in parts of the north, middle and west regions have an average SI of 0.42 indicating a medium level of diversification level (Ahmed et al., 2015). A similar finding has been reported by Agyeman et al. (2014) and they found that farming households in Western Ghana have SI diversification index value of 0.33 that is below the average level. Factors affecting the adoption of diversification level of the farmers should be carefully examined to increase the diversification level. Rahman and Akter (2014) suggested that investment in the development of rural infrastructure including road connectivity, market access, irrigation facility, access to education/skills, women empowerment can be a viable way to promote rural household diversification level. In addition, Khatiwada et al. (2017) and Gebreyesus (2016) also asserted a similar opinion along with recommending, reconstructing, landholding policy and increasing access to credit.

Table 5. Determinants of Livelihood Diversification

Variable	Coefficients	Standard Error	t	P > |t|
Age (X_1)	0.009	0.02	0.44	0.66
Education (X_2)	0.023	0.05	0.45	0.65
Family member (X_3)	0.018	0.12	0.15	0.88
Earning member (X_4)	0.451*	0.25	1.84	0.07
Educated family member (X_5)	0.230	0.17	1.34	0.18
Distance (X_6)	0.086	0.07	1.30	0.20
Loan (X_7)	−0.177	0.38	−0.46	0.64
Training (X_8)	−0.220	0.40	−0.55	0.58
Social work participation (X_9)	0.560*	0.33	1.69	0.09
Health/financial problem (X_{10})	0.515	0.46	1.13	0.26
Forest resource use (X_{11})	0.299	0.50	0.60	0.55
Government donation (X_{12})	0.999**	0.38	2.66	0.01
Constant	−1.357	2.16	−0.63	0.53
R^2	0.41	–	–	–

(Table 5 Continued)

(Table 5 Continued)

Variable	Coefficients	Standard Error	t	P > |t|
F value	2.74***	–	–	–
Observation	60	–	–	
Mean VIF	1.87	–	–	–

Source: Authors' compilation based on field survey.

Notes: * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level, VIF = variance inflation factor.

Table 6. Ranking of Barriers to Adopting Diversified Activities

Indicator	First (S = 1)	Second (S = 0.75)	Third (S = 0.50)	Fourth (S = 0.25)	Fifth (S = 0)	Σf_i	PI	Rank
Disaster frequency	38	9	13	0	0	60	0.85	1
Risk on new job	5	44	6	5	0	60	0.70	2
Road condition	2	43	14	1		60	0.69	3
Source of job	1	15	38	3	3	60	0.53	4
Access to bank loan	0	9	40	7	4	60	0.48	5
Scope of new job	2	7	38	8	5	60	0.47	6
Money for new venture	1	2	48	4	5	60	0.46	7

Source: Authors' compilation based on field survey.

Determinants of LD

Some key determinant factors have been identified to influence the LD activities among the respondents by using a multiple linear regression analysis (Table 5). Results of regression analysis show that the estimated coefficient of age and education of the household head has a profound influence, although statistically insignificant on the magnitude of adopting LD activities. Educated household head, along with other knowledgeable family members, can easily distinguish the best alternative economic activities for the well-being of the family by integrating on-farm and off-farm activities. However, their estimated coefficients have been found statistically insignificant. Besides, farming experience in the previous years helps to adopt suitable economic activities that are supported by the findings of Mentamo and Geda (2016).

The households having many family members enjoy the benefit of additional human resources. They can use other members to engage in non-farm activities to

secure their future income streaming. The estimated coefficient of the number of earning members provides statistically positive evidence that an increase in household income-earning number leads to an increase in the number of diversified activities. This result is consistent with the findings of Mottaleb and Ali (2018). Participation in various social welfare activities increases the social capital (association and networks) among the farmers. As a result, support from society is available to take new ventures. In the study area, the level of diversification is higher among the farmers who frequently take part in social activities. A similar notion is also postulated by Ellis (2000). Since the government is the provider of all the necessary social facilities, the role of government support (financial and directional) is highly effective in increasing diversified activities (Smith et al., 2001), and the decisive role of government donation is found to be statistically significant for the coastal farming community.

Constraint to Adopt Diversified Activities

Table 6 represents some significant constraints to adopting diversified economic activities estimated by P.I. Estimated data analysis shows that the occurrence of frequent disasters ranks first position as the barrier to household diversification level (P.I = 0.85). Since the study area is highly prone to natural calamities, the frequency and intensity of natural disasters have a strong influence on the LD activities (Cinner & Bodin, 2010). The respondents have emphasised the risk of a new job as the second most important constraint. The perception of the respondents reveals that there is a high risk in adopting new activity in the area they live in. Also, poor road condition, low source of job, limited access to the bank loan, the little scope of the new job and insufficient reserve for the new ventures are the other essential constraints reported by the farmers (Khatun & Roy, 2012).

The findings are consistent with the findings of other researches as well. Dinku (2018) argued that adoption of diversified economic activities is constrained by lack of basic infrastructural facilities and natural disasters such as cyclone, drought, flood, etc. In a recent study based on the riverine island of Bangladesh, Sarker et al. (2020) reported that low level of diversification among the dwellers is mainly caused by the lack of job opportunities and suggested for programme-specific job creation facility in the area. Besides, in a cross-sectional study on the Patuakhali district of Bangladesh, Mittra and Akanda (2019) identified some key constraints to adopt diversification. They reported that lack of capital and job opportunity, limited access to road facility, lack of education and training, lack of market and access to credit are main barriers to increase diversification level and it is consistent with the findings of this research.

Conclusion

In recent years, the coastal farming communities are living under the threat of climate-induced natural disasters to secure their income and livelihood. Several

diversified economic activities (primary, secondary and tertiary) are adopted by them to cope with the damage from the hazards. The significant share of their income comes from primary activities, leaving them less diversified and unsecured against the future uncertainties. Although the income from the tertiary level is secured, a few of them can manage to afford it. Some economic and environmental factors, such as limited access to capital and frequent disasters, are responsible for the decrease in diversification level. Although farmers are trying to adapt diversified activities amid the limitations, supports from the government can be a great help to increase the diversified economic activities for improving economic levels and resilience measure to disaster.

Due to the nature and scope of the objective of this study, this research was based on a specific region and occupational group. Since the study area is situated in the coastal part of the country, it was hard to incorporate many samples within the study time period. In addition, our sample group consisted of only smallholder farmers that also limited our focus on a certain community. Further research could be accomplished covering other professional groups of the society to get an overall idea. In addition, a cross-comparison study focusing on the respondents from both coastal and inland areas could also shed light on patterns of diversification practice of different groups from different parts of the country.

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Article

Perception of Climate Change and Farmers' Adaptation: An Analysis for Effective Policy Implementation

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Abstract

Divergence in the actual practices and policy goals often leads to ineffective policy implementation. Shedding light on this issue, this study intends to enrich the debate on the adaptation to climate change, which includes farm-level adaptation practices in the Dry Zone of Sri Lanka and enabled policies. The study involved analysing the farm level adaptation practices and the factors influencing actual adaptation practices adopted by employing a Multinomial Logit Model. The study used primary data collected from Sri Lanka Environmental and Agricultural Decision-Making Survey. The impact of perception of climate change on adaptation techniques was measured by developing an index on Climate Change Perception. The index was generated as a composite of multiple statements related to climate change by utilising Multiple Correspondence Analysis. The results revealed that cultivating other field crops and short duration seed varieties increased with climate change awareness. Further income, education, age, cost, and irrigation scheme affect choosing the adaptation practices. A comparison of climate change adaptation practices adopted by farmers with the program goals shows a mismatch between farmers' perceptions and the adaptation practices promoted by the government. This study proposes to consider the grassroots level scenario before developing policies and that programs have to be developed and implemented based on adaptation practices preferred at the ground level.

Keywords

Climate change, adaptation policy, multinomial logit model, adaptation practices in Sri Lanka

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Introduction

Climate change in Sri Lanka is apparent when observing the changes in rainfall patterns, frequently occurring floods, landslides, drought conditions, and an increase in temperature (Aheeyar, 2012). Numerous studies have suggested that climate change can have adverse impacts on agriculture as it is a nature-based system. Apart from the physical losses, the yield of crop and livestock, food prices, input prices, and resource availability are affected by changes in climatic factors. Temperature and precipitation are highly changing climatic factors and they increase the frequency and severity of extreme events like droughts, floods, and wind storms (Melillo et al., 2014). In Sri Lanka, the concern about climate change is high due to the dependency in the agricultural sector for the country`s economy and livelihoods. Agriculture contributes 7.9 per cent to the GDP of the country, but the importance of the agriculture sector cannot be judged only by its contribution to the GDP, as its contribution to the socio-economic development, employment opportunities, food security, and the ecology are high in Sri Lanka (Food and Agricultural Organization of the United Nations [FAO], 2018; Weeraratna, 2010).

Nearly 77.4 per cent of the people in Sri Lanka live in rural areas and are engaged in farming activities (Department of Census and Statistics, 2012). Almost all the food crops such as cereals, legumes, field crops, fruits and vegetables produced in the country, valued at around Rs. 150 billion, is cultivated in the rural area (Gunawardana & Somaratne, 2000). The major produce of the domestic agricultural sector is rice, and it is the staple food of Sri Lankans. About 92 per cent of the rice consumed by Sri Lankan is produced domestically. If climate change impacts unfavourably on the agricultural activities it could seriously hinder the country's sustainable development. Following the Intergovernmental Panel for Climate Change (IPCC) report (2007a), the projections for an increase in mean annual temperature for Sri Lanka will span between 0.5–1.2 °C by 2020, 0.88–3.16 °C by 2050 and 1.56–5.44 °C by 2080. On the other hand, rice yields are expected to decline by 0.75 tons/ha if the temperature increase traverses between two and four degree Celsius. It would result in 9–25 per cent reductions in the net revenue of farmers (Knox et al., 2012). Despite agriculture contributing to 7.9 per cent of GDP, the country will face an average economic loss of around 2 per cent of their collective GDP by 2050 and it will increase up to 9 per cent by the year 2100 due to climate change lead yield losses (Asian Development Bank, 2015; Truelove et al., 2017). Hence, climate change is likely to be one of the most significant developmental challenges faced by Sri Lanka. Thus, to ensure future food security and livelihood of the farmers, it is important to transform current agricultural practices into climate-resilient agriculture practices and strengthen farmers' adaptive capacity to climate change. Therefore, climate change adaptation has gained attention in research and policy development.

Sri Lanka has endorsed the Rio+20 outcomes and focused on achieving the embraced sustainable development goals, specifically with climate change and food security through actualising resilient agricultural practices and strengthening the capacity for adaptation. Further, under the developed national policy on

climate change, the government implemented several programs and projects to motivate the farmers to achieve sustainable development through coping with the adverse climate change impacts. Sustainable production in the agriculture sector needs to be supported by farming practices. Several adaptation practices such as; planting hazard resilient crop varieties, dry seeding, crop diversification, and so forth are proposed by experts. However, policies and programs aimed at promoting adaptation practices are still constrained by poor resource bases, income inequalities, weak institutions, and limited technology. Consequently, it is required to revisit the current policies and strategies to become more resilient to climate change and ensure the food security of the country.

Due to recurring and prolonged climate-induced disaster experiences in Sri Lanka, climate change adaptation has become a requirement. Adaptation is defined as modification in systems in reaction to climatic stimuli or their effects (IPCC, 2007). Adaptation can be achieved in many ways and it is promoted through engaging in the climate change adaptation practices throughout the cultivation season. The government of Sri Lanka implements several promotional programs to uplift the farmers' adaptation level under the major National Adaptation Plan. Even though the programs are well defined and strategically planned at the higher level, when it comes to the implementation stage current programs are following the same promotional processes for the entire Dry Zone without recognising differences in the ongoing adaptation practices. There could be differences among farmers at the grass-root level which could affect the climate change adaptation failing to understand which could hamper the effective implementation of these programs. We posit that it is important to understand the difference in actual scenarios and implemented programs for the effective implementation of programs.

Even though climate change has been extensively studied in many decision-making situations, there are only a few studies that have identified the importance of identifying the difference in the grass-root level and high-level policy goals in terms of climate change adaptation (Senaratne & Rodrigo, 2014; Samarathunga, 2010). Several studies carried out on climate change adaptation by farmers in Sri Lanka neglected the importance of climate change perception and did not consider the need for policy development based on grassroots level perceptions (Gunda, et al., 2016; Truelove, et al., 2017; William & Carrico, 2017). Identifying this research gap in understanding the adaptation practices, this study thus aims to analyze the farm level adaptation practices and farmers` perception of climate change in the Sri Lankan context as understanding the grassroots realities is fundamental in proposing reforms to the existing programs in promoting climate change adaptation practices at the field level. The results will help in designing programs for effective climate change adaptation to reduce adverse effects of climate change and to reform the programs such as a way that supports self-sufficiency and food security through climate change adaptation practices.

The paper is organised as follows. First, it gives an account of the adaptation practices in the Dry Zone of Sri Lanka and previous knowledge on the factors affecting climate change adaptations. It is followed by a description of the development of the climate change index and employed methodology. Next, the

results are presented with a discussion. Finally, conclusions and policy implications are presented.

Literature Review

Climate Change Impact in Dry Zone of Sri Lanka

A large extent of land area in the Dry Zone is utilised for the paddy cultivation where the extents of the cultivation in the major, minor and rain-fed systems for both Maha and Yala seasons in 2010 were 440,000, 65,000 and 40,000 ha, respectively (Weerakoon et al., 2011). At present, the Dry Zone significantly contributes to the nation`s economy. Over 800,000 metric tons of paddies were produced annually in this zone (Manthrithilake & Liyanagama, 2012) and the Dry Zone area in Sri Lanka contributes to 70 per cent of national paddy production (Withanachchi, et al., 2014). Out of the total harvested crop area (including paddy, other field crops (OFC) and vegetables), Dry Zone contributes to 67.2 per cent and it contributes to 83.11 per cent of the national paddy harvested area. Since the contribution of Dry Zone to the agricultural economy is high, the impact of climate change on Dry Zone has been identified as a critical issue. At present, the Dry Zone agriculture is facing severe losses due to climate change. According to the statistics, the failures in two consecutive monsoonal drops of rain (2016/2017 Maha and 2017 Yala) had a detrimental effect on Dry Zone agriculture and the water storage of some reservoirs. Accordingly, many reservoirs in the Dry Zone have failed to supply the demanded irrigation water for the upcoming season (Ministry of Disaster Management and World Food Program, 2017).

Farmers' Adaptation Practices

From ancient times onwards, Sri Lankan farmers practice several agricultural practices that could be useful for them in reducing the adverse impacts of climate change (Chithranayana & Punyawardena, 2013). Several evidences from the literature provide details on these different farm-level adaptation practices. For an instance, Mohamed and Garforth (2013) indicate that the Dry Zone farmers adapted to climate change stress by cultivating drought-tolerant crop varieties, reducing irrigation depth, involving micro-irrigation, diversifying crops, changing planting time, mulching, shortening of cultivation season, and planting shade trees. These adaptation practices intend to avoid the dry spell overlapping with the cultivation, mainly changing planting time, changing crop type, shortening of the growing season, and crop rotation (Williams & Carrico, 2017). To cope with the water shortage, Sri Lankan farmers select short duration paddy varieties, dry seeding[1], cultivation of other field crops, rainwater harvesting, using groundwater, employing soil water conservation techniques such as mulching, planting shade trees and so on (Mohamed & Garforth, 2013).

Non-traditional drought-tolerant crops were highly promoted by the government and non-government institutions as one of the major agriculture adaptation practices to support the livelihood of the farmers (Morton, 2007; O'Brien et al., 2004). Farmers utilise novel farming practices to continue with local crops with high yield (Morton, 2007). Besides, low-cost innovations such as the cultivation of locally developed hybrid seeds help to increase the yields of traditional crops (Ceccarelli et al., 2010; Wassmann et al., 2009). Further, farmers are practicing a new method of paddy transplantation called 'parachute method', which consumes a low amount of water and produces higher yields (Thilakasiri, et al., 2015)

One of the ancient communal adaptation practices is 'bethma'[2]. If the water is scarce, individual paddy ownership would be suspended, and those closer to the water source required to allow those further away to share portions of their land. The permanent field boundaries are abolished and the land is divided among farmers who cultivate in the common area. Usually, equal sizes of land were given to all households and all of the work will be regulated by government bodies such as the irrigation department, agrarian service centers, etc. (Burchfield, 2017; Spiertz & de Jong, 1992; Thiruchelvam, 2010). In the recent past, the use of agro-wells became more into practice and it causes a significant reduction in bethma cultivation. Besides, agro-wells help farmers to shift for OFC (Other Field Crops)[3] cultivation during water scarce periods (Burchfield, 2017).

Factor Affecting Adaptation Practices

The factors can be classified into broader groups named as the factors established through the social groups, demographic factors, institutional and management factors, environmental factors, and characteristics of adaptation practices (Agrawal, 2008; Dhanapala 2006; Gunda et al., 2016; Masuku & Manyatsi, 2014; Tran Cao Uy et al., 2015; Williams & Carrico, 2017). Burchfield and Gilligan (2016) classified the factors as dynamic and structural factors.

There are significant variations in the level of productivity between minor and major irrigation schemes due to the level of variability in adaptation to water stress (Aheeyar, 2013). Credit support and guaranteed crop cultivation are high in major schemes compared to other schemes (Begum, 1987). Further, the management level is varying between schemes. Mostly the government institutions, Mahawali Development Authority, and the Department of Irrigation regulate the activities of major irrigation schemes and the other schemes are managed by communities or individual farmers (Aheeyar, 2013; Begum, 1987; IWMI, 1986). Mostly major projects and researches were done in the major schemes because of the easiness of analysing, conducting, accessing, and regulating; other than that several projects are legally approved only for major irrigation schemes such as Participatory Irrigation Management (PIM) (Aheeyar, 2013). These facts result in variation in the adaptation level between irrigation schemes.

The lack of resources also constrains the adaptation level of farmers, among villages, communities, and Grama Niladhari Divisions, and so on For example, on low lying riverbanks and steep lands, low adaptation to changing conditions were observed due to the lack of resources in the natural soils (Murray & Little, 2000). Several studies found that the communities under village irrigation systems show low levels of adaptation than their neighbours in Dry Zone, which have access to water from major irrigation schemes (Aheeyar, 2013). Poterie et al. (2018) reported that efforts at adaptation are more likely to be successful if governments target farmer organisations and communities as a whole rather than individual farmer.

Demographic and socio-economic factors that affect the level of adaptation include the household economic and demographic characteristics as well as the community's demographic characteristics. Gender of the household head (Tran Cao Uy et al., 2015), occupation of household head (Herath & Thirumarpan, 2016), age (Farid et al., 2015; Herath & Thirumarpan, 2016), household size, less formal education (Farid, et al., 2015; Herath & Thirumarpan, 2016) ethnic homogeneity (Tran Cao Uy et al., 2015), high proportion of paddy land at the tail-end of a canal, engagement in off-farm labor, small-scale farmers, economic constraints (Herath and Thirumarpan, 2016), lack of assets (Herath & Thirumarpan, 2016; Tran Cao Uy et al., 2015; Udmale et al., 2014), wealth and livelihood security (Burchfield & Gilligan,2016), income (Tran Cao Uy et al., 2015) tenure status (Farid et al., 2015), credit use (Burchfield & Gilligan, 2016), high incidences of crop pests and diseases, high input prices, high food prices, land ownership (Farid et al., 2015; Udmale et al., 2014), poverty (Farid et al., 2015; Udmale et al., 2014), lack of savings (Herath & Thirumarpan, 2016), farm size, lack of technical skills and off-farm employment (Tran Cao Uy et al., 2015), livestock ownership (Herath & Thirumarpan, 2016), and storage capacity of irrigation tanks (Burchfield & Gilligan, 2016) are the major factors identified by the previous studies as affecting climate change adaptations that come under the demographics and socio-economic classification.

Government Programs and Farmers' Practices

The intervention of the government and non-governmental institutions on farmers' decision-making process is high. Therefore, the impacts of the intervention have to be identified clearly when analysing the adaptation practices. For example, the following factors are identified in the literature as coming from institutional involvement and support. In Sri Lanka under the settlement schemes, lands are governed by the government organisations such as Mahaweli Development Authority, Department of Irrigation, and Department of Agrarian Development. According to the governing institution, the farmers' control on those lands also varies. There is an identified difference among lands not fed by the state-managed irrigation systems and lands fed by these systems (Udmale et al., 2014). Further farmers' connections to formal institutions (Udmale et al., 2014; Herath & Thirumarpan, 2016; Burchfield & Gilligan, 2016), agricultural extension programs (Herath & Thirumarpan, 2016; Tran Cao Uy et al., 2015; Udmale et al., 2014),

institutional involvement (Farid et al., 2015; Herath & Thirumarpan, 2016; Tran Cao Uy et al., 2015; Udmale et al., 2014), management regimes (Farid et al., 2015), no subsidy programs (Udmale et al., 2014), received drought information, political or market instability (Axelsen, 1983; Burchfield & Gilligan, 2016; Herath & Thirumarpan, 2016; Tran Cao Uy et al., 2015) are some of the factors that are affecting the adaptation level related to the involvement and management of the institutions.

Even though the government and non-governmental organisations promote several adaptation practices in the Dry Zone, factors such as villages, districts, irrigation schemes, other geographical delineations, and so on, alter the farmers' ability to adapt proactively to drought (Berkes & Jolly, 2002; Dhanapala, 2006; Kumari et al., 2011; Uphoff & Wijayaratna, 2000; Valdivia et al., 2010). Accordingly, a comprehensive review was done to identify the elusive causes of such variation in the farmer`s adaptation level. For instance, the government has involved in promoting OFC cultivation in many regions of the country. The villages which are still following traditional skills are reluctant to switch to OFC cultivation. For them, the adaptation is rooted in their conventional wisdom, consequently, they perceive having a stock of rice as a source of food security since OFCs are difficult to store (Emily & Jonathan, 2016). Such instances reveal the government`s negligence on promoting adaption strategies and show that the decision on the adaptation had made on the island level and not at the grass-root level (Samarathunga, 2010; Senaratne & Rodrigo, 2014).

Methodology

Study Area and Data Collection

The analysis is based on survey data from the Sri Lankan Environmental and Agricultural Decision-making Survey (SEADS) collected as part of the Agriculture Decision Making and Adaptation to the Precipitation Trends in Sri Lanka (ADAPT–SL) project. The project focused on smallholder farmers located in the Dry Zone of Sri Lanka, the region most vulnerable to drought consequences. SEADS employed a questionnaire survey designed to collect data on farm-level adaptation practices, which address the farm level resilience to climate change. The data were collected among 1,148 farming households in 30 Grama Niladhari Divisions in nine districts of the Dry Zone, across certain major and minor irrigation schemes[4] in Sri Lanka during the 2015/2016 production season.

Estimation Method

Multinomial Logit Model (MNL) has been applied to determine the choice probabilities for different adaptation practices. As the study employed a binary variable which is the choice of adaptation practices as the dependent variable and due to more than two adaptation practices MNL was chosen for the study. The

Table 1. Farmers' Adaptation Practices

Variable	Percentage of Respondents Who Engage in Adaptation Practices
Planting other field crops	18.71
Dry seeding	34.34
Bethma/sharing land	31.61
Planting short duration seed	11.23
Practicing two practices	3.57
Practicing more than two practices	0.54

Source: Author's calculations.

multinomial logistic regression is generally effective where the dependent variable is composed of more than two levels or categories (El-Habil, 2012; Yamaguchi, 2000). In the MNL model, the categorical dependent variable is important and it should satisfy the Independent Irrelevant Alternative Assumption (IIA) (Petrucci, 2009; El-Habil, 2012; Yamaguchi, 2000). In this study, adaptation practices were categorised and as a base outcome, 'no adaptation practice' was chosen, and adoption of other adaptation practices was compared with 'no adaptation practice'.

To describe the MNL model, let y denote a dependent variable taking on the values {1, 2, …, n} n, a positive integer, and let x denote a set of independent variables. In this study, y denotes adaptation practices (Table 1) and x contains different household attributes and climate change perception index (CCPI)[5]. The MNL model has response probabilities; a general expression of the likelihood in the model is described below. If x is a 1*k vector, the model yield probabilities.

$$P(y = n/x) = \frac{e^{xbn}}{\sum_{k=0}^{n} e^{xbm}} \quad (1)$$

Y = adaptation practices,
N = no of categories in the adaptation practices,
X = independent variables (Socio-economic factors and CCPI),
b = set of coefficients,
m = reference category,
$P(y = n \mid x)$ = probability of choosing one adaptation practices over reference category.

Further, to understand the mismatch between the adaptation practices proposed by the government and the practices seen in the ground level, climate smartness values, and the adoption rate of farmers were compared. Climate smartness values are developed by the Ministry of Mahaweli Development and Environment for National Adaptation Plan 2016–2025 for several adaptation practices. The adoption rate of farmers was calculated by way of dividing the number of farmers adopting particular adaptation practices by the total number of farmers.

Developing Climate Change Perception Index (CCPI) Using Multiple Correspondence Analysis (MCA)

To develop the constructs, Multiple Correspondent Analysis (MCA) was used, where the categorical outcomes were scaled according to the relatedness to the construct. MCA was particularly designed to analyse the categorical variables. Compared to other dimension reduction methods such as Factor analysis and Principal Component Analysis (PCA), MCA does not require data that are normally distributed and this supports the data used in this study as the index was calculated based on categorical variables. Moreover, it specifically identifies the relatedness of each category to the construct rather than giving one weighted value for the variable. It is highly used in socioeconomic studies by several researchers due to its suitability in developing constructs (Abdi & Valentin, 2007; Costa et al., 2013). Due to the abovementioned reasons and nature of variables as multiple categories, MCA is preferred over PCA and Factor Analysis. The surveyed farm households were asked questions about their perception of the changes in temperature and rainfall (Table 2). The questions addressed in Table 2 were used to develop CCPI through MCA which provides weighted values for each category and the following equation was used to develop CCPI. Weighted values form MCA is obtained from the coordinates of MCA analysis. Coordinates are computed based on the indicator method. The standard row coordinate for the tth dimension for the ith observation with indicator matrix elements, Z_{ih} is computed as

Table 2. Farmers' Perception of the Changes in Temperature and Rainfall Since Their Childhood

	% Response			
Environmental Changes	**Has Decreased**	**Has not Changed**	**Has Increased**	**Can't Say**
1. Changes in the environment temperature	9	7	83	1
2. Changes at the beginning of the rain in Maha	22	21	42	15
3. Changes in the rainfall during Maha season	25	20	44	10
4. Changes in the spread of rain during the Maha	30	24	38	8
5. Changes in heavy rain within a short period in Maha	19	19	51	11
6. Changes at the beginning of the rain in Yala	33	22	33	12
7. Changes in the rainfall during Yala	39	19	34	8

(Table 2 Continued)

(Table 2 Continued)

Environmental Changes	% Response			
	Has Decreased	Has not Changed	Has Increased	Can't Say
8. Changes in the spread of rain during the Yala	42	22	27	9
9. Changes in heavy rain within a short period in Yala	33	19	36	12
10. Changes in the predictability of rainfall	20	23	17	41
11. Changes in the frequency of drought	16	16	55	13

Source: Author's calculations.

$$R_{it} = \sum_{h=1}^{J} \frac{Z_{ih} A_{ht}}{q\sqrt{\varphi_t}} \tag{2}$$

where A is the matrix of standard coordinates, q is the number of active variables in the analysis and φ_t is an eigenvalue of the CA on the Burt matrix.

The mathematical formula of the MCA model for CCPI is shown in Equation (3). The accuracy of the MCA results was analysed through the coordination of the answers by checking whether they are giving the value for the answers which have a high positive relationship with the main construct. The option 'Can't say' was coded as '0' so the coordination of this option was neglected. With increasing confidence the coordination also increases.

$$P_i^{MCA} = R_{i1} W_1 + R_{i2} W_2 + \ldots + R_{iJ} W_J \tag{3}$$

where
P_i^{MCA} = CCPI for the ith individual,
R_{ij} = response of ith individual to the category j,
W_j = MCA weight applied to the jth category.

Results and Discussion

Descriptive Statistics of the Variables Used

Socio-economic factors, the average cost for the adaptation practice, irrigation schemes, district, and climate change perception were used in the analysis as independent variables and adaptation practices were used as the dependent variable.

Farmers' adaptation practices were shown in Table 1 with the percentage of sample engages in each adaptation practices. Due to the engagement in multiple adaptation practices, practicing two and more than two adaptation practices were categorised as separate categories. Based on the frequencies of adaptation

practices farmers are mostly practicing dry seeding and bethma whereas cultivation of short duration seed variety is practiced by less amount of farmers. Four per cent of farmers among the farmers who are at least engage in one adaptation practices, practicing more than one adaptation practices.

Distribution of income and education level across the sample as shown in Figures 1 and 2 while descriptive statistics of other variables were shown in Table 3. The study sample consist 543 major irrigation scheme farmers and 475 minor irrigation scheme farmers. Most of the farmers' monthly income ranged between Rs. 15,858 and Rs. 50,000. Majority of the farmers' education level was between grade 6 and grade 11. Same scenario was observed in major and minor irrigation scheme in terms of education and income level.

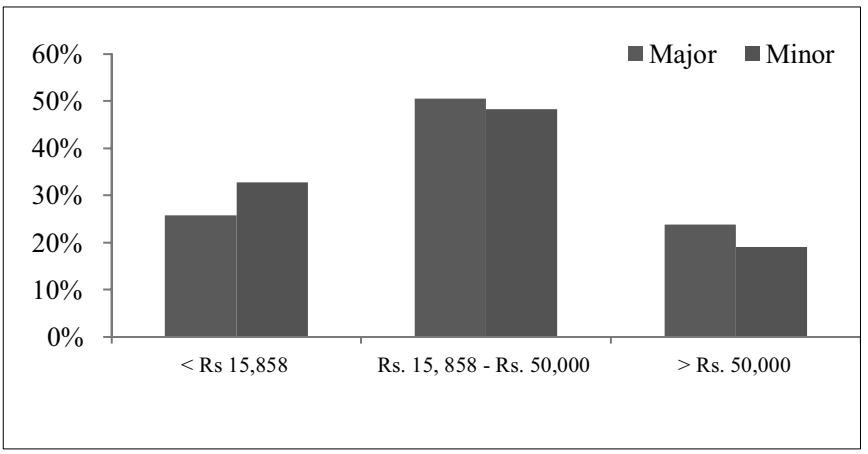

Figure 1. Income Distribution of Farmers across Irrigation Schemes

Source: Authors' calculations.

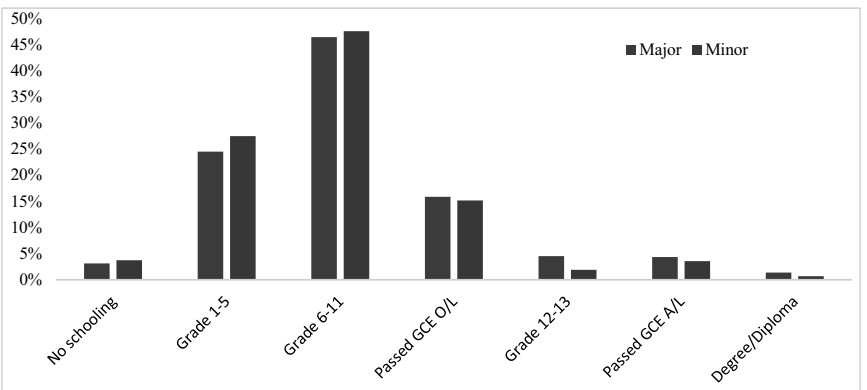

Figure 2. Education Level across Irrigation Schemes

Source: Authors' calculations.

Table 3. Descriptive Statistics of Variables Used in MNL

Continuous Variables	**Mean (SD)**
CCPI	0.48 (0.26)
Age	49.98 (12.09)
Total cost of cultivation	170,653.00 (55,567.23)
Annual non-farm income	209,537.4 (232,420.7)
Categorical variables	**Frequency**
Irrigation scheme	Major – 543 Minor – 475

Source: Authors' calculations.

The impact of socio-economic factors on choosing selected adaptation practices over the 'no adaptation' category was explained hereinafter through marginal values and marginal plots. Principally, climate change perception of farmers and irrigation schemes considered as the most important factor and unique from existing literature. Therefore, this section unfolds an in-depth discussion on the impact of climate change perception index (CCPI) and irrigation schemes.

Table 2 displays the variables used for the construction CCPI with percentage of respondents. According to Table 2 more than 50 per cent of farmers perceived the changes correctly regarding changes in temperature, changes in the frequency of drought and changes in heavy rain within a short period in Maha season. While majority of farmers are unsure about changes in the predictability of rainfall.

Table 4 indicates the marginal values of choosing adaptation practices with CCPI and socio-economic factors. Figures 3–8 show the trends of adopting Other Field Crops (OFC), bethma (Sharing land for cultivation), planting Short Duration Seed Variety (SDSV), and dry seeding with varying levels of the climate change perception index (CCPI).

Impact of the Cost of Cultivation on Adaptation

When considering the cost of cultivation, while other variables are in the mean values, the probability of cultivating OFC is reduced by 0.5 per cent if the cost of cultivating is increased by 1 per cent. In contrast, other adaptation practices are increased with increasing costs. Due to the high expenses, farmers abandon the cultivation of OFC. As paddy is considered as the main food crop in Sri Lanka, when OFC cultivation cost is increased there is a higher potential to shift to paddy, and further because of the subsidies provided for paddy the cost of cultivation is low, unlike OFC. Regarding the dry seeding, the probability of practicing dry seeding is increased by 4.1 per cent if the cost of cultivating is increased by 1 per cent. When the cost of cultivation is increasing in other inputs (Fertilise, seeds, and pesticides), farmers tend to shift to dry seeding to minimise the cost of land preparation. For the dry seeding, paddy seeds are sown without land preparation like puddling and flooding so farmers can reduce the cost for land preparation.

Table 4. Marginal Values of Regression Results

Dependent variable	OFC	Dry seeding	Bethma	SDSV	Practicing two practices	Practicing more than two practices
Irrigation scheme	−0.071 (0.043)***	0.031 (0.046)*	−0.05 (0.05)*	−0.063 (0.066)*	0.098 (0.06)*	0.061 (0.04)*
CCPI	0.030 (0.071)*	−0.01 (0.092)	−0.262 (0.107)***	0.028 (0.124)	0.051 (0.12)*	0.165 (0.09)**
Log non farm income	0.008 (0.016)*	0.062 (0.027)***	0.009 (0.022)*	−0.054 (0.02)***	−0.022 (0.02) *	−0.002 (0.01)
District	0.008 (0.003)***	0.007 (0.003)***	−0.039 (0.006)***	0.022 (0.004)***	−0.001 (0.005)	0.001 (0.003)
Age	0.001 (0.001)	0.003 (0.002)*	0.002 (0.002)*	0.0002 (0.002)	−0.003 (0.003)*	−0.002 (0.001)*
Education	0.002 (0.016)	0.025 (0.028)	0.004 (0.033)	0.006 (0.033)	0.034 (0.034)*	0.004 (0.22)
Log cost of cultivation	−0.005 (0.02)	0.041 (0.028)**	0.027 (0.036)*	−0.044 (0.04)*	0.024 (0.04)*	−0.041 (0.026)*

Source: Authors' calculations.

The probability of practicing bethma is increased by 2.7 per cent with an increase in the cost of cultivation. Cost could be higher in owned land than share cultivated land. This is due to more long-term investment in soil and water conservation in owned land. The reason why share cultivators do not invest in long term investments may be due to change in land quality in the next season. Since farmers know the contract is expiring at the end of the season, they would apply less organic manure and other soil conservation practices (Thiruchelvam, 2010). The probability of cultivating SDSV is reduced by 4.4 per cent if the cost of cultivating is increased by 1 per cent. Comparative to traditional and long term seed varieties, SDSV is costly so with the increasing cost of cultivation, preference of SDSV is reduced. The probability of practicing two adaptation practices is increased by 2.4 per cent and practicing more than two adaptation practices reduced by 4.1 per cent if the cost of cultivating is increased by 1 per cent. Even though the cost of adopting several adaptation practices is high due to the climate change impacts, farmers are willing to engage in adaptation practices but if the cost is too high they restrict their adaptation with two practices.

Impact of Irrigation Schemes

Regarding the impact of irrigation schemes on the selection of adaptation practices, Table 5 depicts the probability difference between irrigation schemes in the selection of adaptation practices. Based on the farmers' responses there were

many promotional programs related to climate change adaptation carried out by the government in major irrigation schemes and fewer programs were carried out in minor irrigation schemes. Major irrigation scheme is relatively high in extent and production which demands greater attention of government officials. The probability of choosing OFC is high when farmers belong to a major irrigation scheme. The probability difference between the two irrigation schemes is high and this is due to the promotion programs on OFC in the major irrigation scheme. As a result of water scarcity and inadequate extension programmes about new adaptation practices in minor irrigation schemes, a higher number of farmers are adopting dry seeding in the minor irrigation scheme compared to major irrigation schemes (Aheeyar et al., 2012). Dry seeding is a traditional practice (called 'Nava Kekulan') that helps minor irrigation farmers to tackle the climate change issue in the absence of knowledge on new adaptation practices. The probability of adopting dry seeding is 3.8 per cent in major irrigation schemes and 5.4 per cent in the minor irrigation scheme. Bethma is highly practiced in major irrigation schemes. The probability of practicing bethma in a major irrigation scheme when other variables are in the mean value of 2.2 per cent. According to Marambe et al. (1996) unlike major irrigation schemes, land fragmentation is high in minor irrigation schemes and it leads to scattered smallholdings. Land fragmentation is mainly due to the inheritance and as a consequence, many social problems had arisen including low social cohesion. Moreover, the strength of institutions that are monitoring minor irrigation systems is lower than that of the monitoring authorities of major irrigation schemes, thus it could be that they are unable to enforce bethma effectively under minor irrigation schemes.

Short duration seed varieties are cultivated in major irrigation schemes than minor irrigation schemes. The probability of choosing SDSV in major irrigation schemes is 15 per cent but it is 11 per cent in minor irrigation schemes due to the low extension programs on new adaptation practices in minor irrigation schemes (Aheeyar, 2012). Major irrigation farmers practiced more adaptation practices than minor irrigation farmers as more programs on adaptation practices are conducted in major irrigation schemes by the government (Aheeyar, 2013).

Table 5. Marginal Values for Irrigation Schemes

Adaptation Practice	Major Irrigation Scheme	Minor Irrigation Scheme
OFC	0.0138	0.0036
Dry seeding	0.0381	0.0540
Bethma	0.0220	0.0047
SDSV	0.1502	0.1123
Two adaptation practices	0.4265	0.2468
More than two adaptation practices	0.4736	0.2621

Source: Authors' calculations.

Impact of Climate Change Perception

The impact of CCPI on adapting different practices is evident in all the Figures 3–8. Further choosing OFC, SDSV and bethma are low in minor than major irrigation schemes.

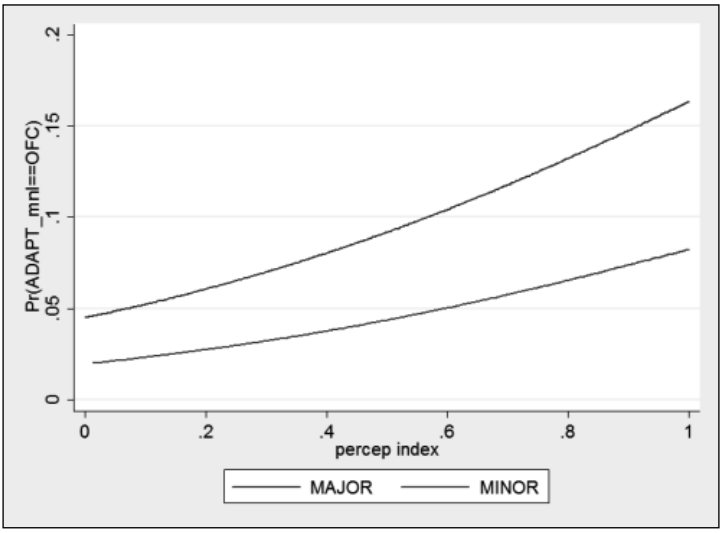

Figure 3. Trend of Marginal Value for Choosing OFC with Climate Change Perception Index

Source: Authors' calculations.

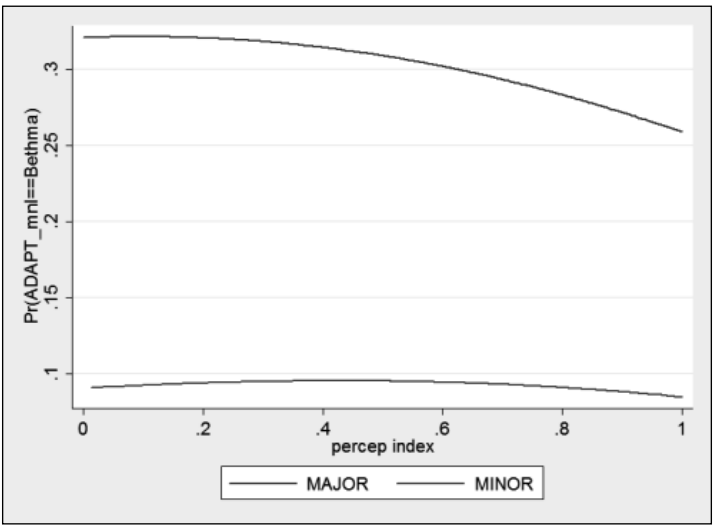

Figure 4. Trend of Marginal Value for Choosing Bethma with Climate Change Perception Index.

Source: Authors' calculations.

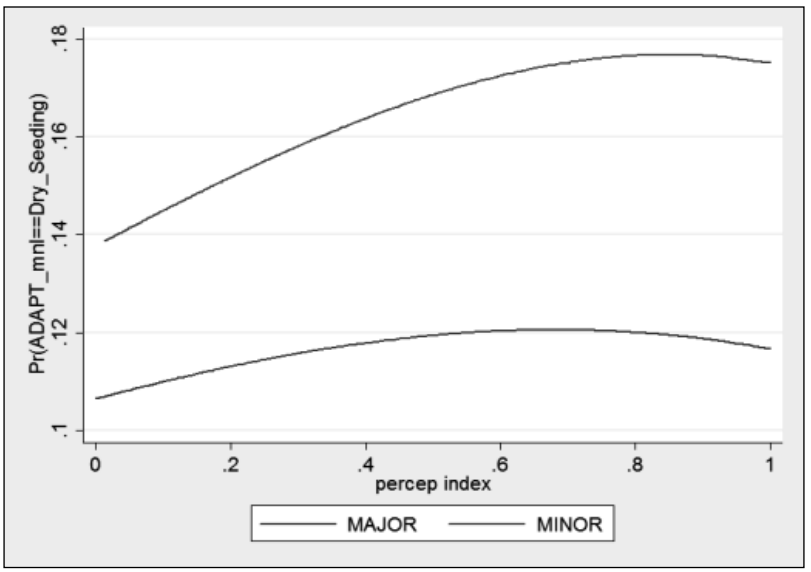

Figure 5. Trend of Marginal Value for Choosing Dry Seeding with Climate Change Perception Index

Source: Authors' calculations.

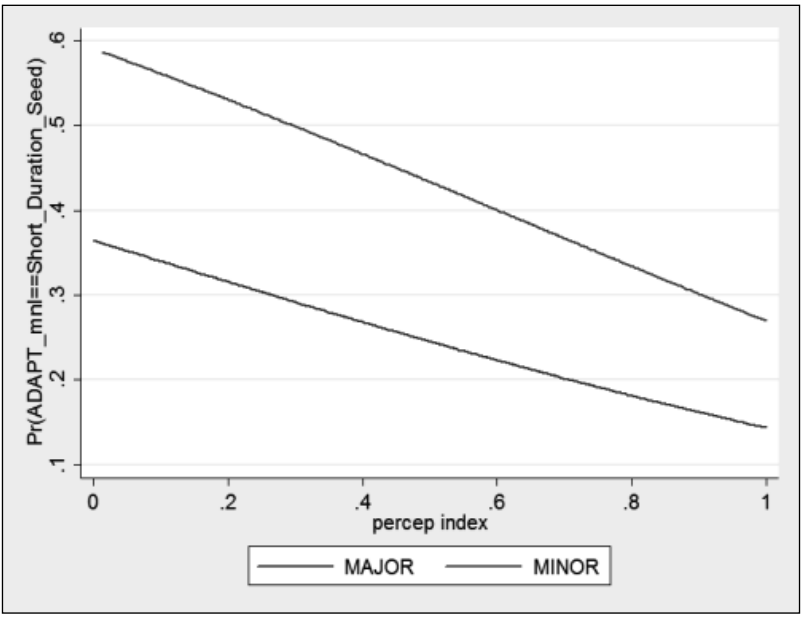

Figure 6. Trend of Marginal Value for Choosing SDSV with Climate Change Perception Index

Source: Authors' calculations.

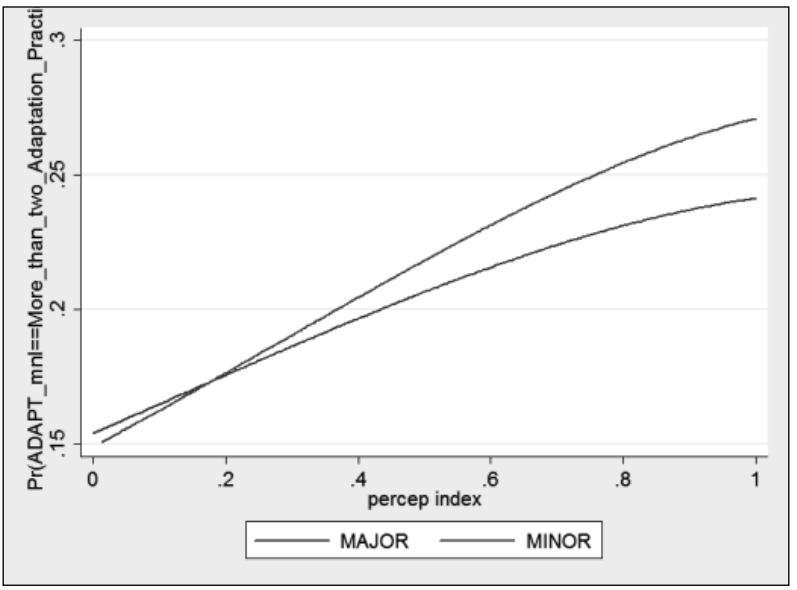

Figure 7. Trend of Marginal Value for Choosing Two Adaptation Practices with Climate Change Perception Index

Source: Authors' calculations.

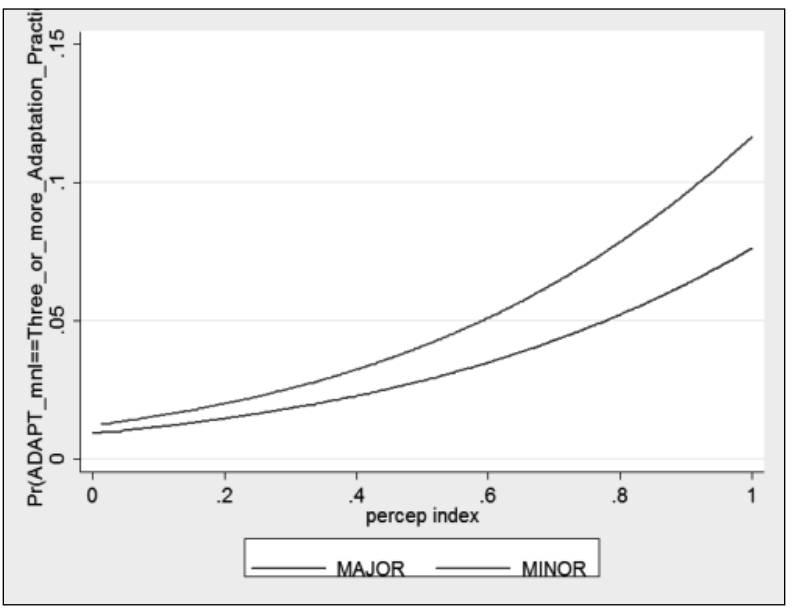

Figure 8. Trend of Marginal Value for Choosing more than Two Adaptations with Climate Change Perception Index

Source: Authors' calculations.

With increasing CCPI, the estimated probability for the willingness to cultivate OFCs is increasing in both major and minor irrigation schemes as shown in Figure 3. OFC cultivation is one of the accelerated projects of Sri Lankan government to cope up with climate change, to achieve self-sufficiency in supplementary food crops, achieve high production in the Yala season, and promote third season cultivation. For instance, chili cultivation in Mahawali zone H, onion cultivation in Dambulla, potato, vegetable, and banana cultivation in different parts of the country are few successful projects implemented to improve the OFC cultivation. The awareness programs on OFCs accelerated the farmers' intention to choose OFC with increasing CCPI but comparatively the percentage of choosing is less with other practices.

Figure 4 explains the changing trend of practicing bethma with CCPI. Many stakeholders such as government agents, officials from the Department of Irrigation, Mahaweli Authority, and the Department of Agriculture, and so forth, are involved in the decision making process for the seasonal bethma practice. Even though the perception of climate change is low, farmers are highly engaged in bethma in Major irrigation schemes. With increasing CCPI, the farmers adopt bethma less; it is because each farmer gets a small portion of land for cultivation after the division under the bethma practice. Thus it is not possible to generate economically viable income out of an allotted small piece of land. In a minor irrigation scheme, due to some cultural appropriateness such as low social cohesion, the likelihood of practicing bethma as a communal activity is comparatively low and the reasons for low level of practicing bethma is explained in the section, impact of irrigation scheme.

Figure 5 explains that the farmers with a higher climate change perception have a higher likelihood of practicing dry seeding but a changing trend is observed after the highest likelihood of adaptation. Specifically, in the rain-fed rice system, dry seeding is practiced when initial rain gets delayed. However, losses are high in the dry seeding which requires a higher seed rate (150 kg/ha) than transplanting, and stress and physical damage are also high in the dry seeding method (International Rice Research Institute, 2008). Farmers prefer dry seeding for short duration varieties and transplanting for long-duration varieties but the main objective of practicing dry seeding is water scarcity and that is evident by the response given by the farmers. However, there is a fewer number of programs implemented to promote dry seeding due to the high loss and less effectiveness (Weerakoon et al., 2011; Institute of Policy Studies, 2002). This analysis indicates the expectations and perceptions of farmers about the dry seeding and the trend of practicing with CCPI. The change in the trend is due to the highest perception of climate change that leads the farmers to shift from paddy cultivation to other crops. So the shifting pattern from paddy cultivation results in a low likelihood of practicing dry seeding. Further, the underlying phenomena for the change are explained by the reasons given by the farmers on why they are not practicing dry seeding. Most of them are of the view that it is not an effective practice (32.9 per cent) while some think that there is no need to practice dry seeding (15.5 per cent). Thus farmers who have high knowledge of climate change tend to opt for better adaptation practices than dry seeding.

Figure 6 shows the declining trend in the likelihood of choosing short duration seed varieties (SDSV) for cultivation with an increasing perception of climate change. Even though planting SDSV is considered as a climate change adaptation practice, in the farmers' point of view use of traditional varieties scored high among adaptation measures. Particularly 38.1 per cent of farmers out of total farmers reveal that they are practicing SDSV cultivation due to the water scarcity and 23.1 per cent of farmers reveal that they practicing it for income generation. However, SDSV is highly susceptible to pest attacks and water stress. The duration of irrigation is low for SDSV but the total water requirement of SDSVs is more than that of traditional varieties (Chithranayana & Punyawardena, 2013; Dhanapala, 2006). The contradicting results and perception of farmers towards SDSVs and traditional varieties result in a reduction in the likelihood of adaptation of this technology with climate change perception. Moreover, the yield reduction in SDSVs due to the high susceptibility is mentioned as the foremost problem in planting SDSV by 40.9 per cent farmers and 24 per cent of farmers specify that this practice is not effective due to the above-mentioned reasons.

The trend in practicing two and more than two adaptation practices was shown in Figures 7 and 8 for both major and minor irrigation schemes. Both are displaying an increasing pattern where minor irrigation scheme shows a high probability of adopting compared to major irrigation scheme.

Overall the practices such as OFCs and dry seeding were perceived as good adaptation practices by farmers when they perceive high climate change whereas SDSVs and bethma are less considered by farmers. Moreover, major and minor irrigation schemes show a different pattern in practicing selected adaptation practices.

Limitation of Current Programs

Sri Lanka developed the National Climate Change Policy in 2012 to give direction to all the stakeholders to handle the adverse impacts of climate change efficiently and effectively. There are several key areas addressed regarding climate change which are vulnerability, adaptation, mitigation, sustainable consumption and production, knowledge management, and general statements. Under adaptation, food production and food security were addressed to cope up with the negative impact of climate change and ensure a sufficient level of production. Particularly National Adaptation Plan was prepared to attain the policy goals under the agriculture adaptation statement. Climate-smart agriculture programs were introduced to cope up with climate change.

Moreover, the following programs are implemented in the field level to promote the adaptation practices among farmers. They are National Climate Change Research Program, National Capacity Needs Self-Assessment Action Plan, Haritha Lanka Programme, Yaya Block Demonstration Project, Research on Flood and Salinity Tolerant Rice Varieties and Plant Breeding Program, Program on Promoting OFC cultivation, Program on Promoting Mulching and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

(Climate Change Secretariat, Ministry of Environment; National Science Foundation, 2016; Eeswaran, 2017; Ministry of Mahawali Development and Environment, 2015; National Building Research Organization; 2017;).

When considering these goals of these programs and farmers' perceptions and constraints which are derived by the in-depth analysis, there is a mismatch between them in the Sri Lankan context. To understand the deviation between farmers' actual practices and recommended practices by government, climate smartness values, and farmer adoption rate based on the sample were compared. Climate smartness value is proposed in the National Adaptation Plan in terms of water usage, nitrogen leachate, energy consumption, climate adaptation, and knowledge by the Ministry of Mahawali Development and Environment (2015) for selected adaptation practices. The climate smartness values range between 1 and 5 and are displayed in Table 6 (Ministry of Mahawali Development and Environment, 2015). The level of adoption is the level of actual practice among farmers in the Dry Zone according to the selected sample. According to the National Adaptation Plan, SDSVs have to be a high adaptation practice compared to dry seeding. But at the farmers' level, the perception of dry seeding as an adaptation practice is more favourable than the SDSVs. Bethma and dry seeding have been practiced over the past several years, therefore farmers easily adopt these practices more than that of the practices currently proposed by the government.

To achieve food security, climate change adaption is highlighted. It is planned to be carried out through developing stress-tolerant varieties to heat, drought, and floods, promoting water-efficient farming methods, and adjusting cropping calendars according to weather forecasts. However, from the farmers' point of view, they are reluctant to cultivate resistant varieties due to its low yielding character. Therefore, in a plant breeding program, a high yielding trait also has to be incorporated for effective adaptation of such varieties.

Table 6. Comparison of Climate Smartness Value and Actual Level of Farmer Adoption

Adaptation Practices	Climate Smartness Value	Level of adoption	Energy Water Climate Carbon Knowledge Nitrogen
Dry seeding	3.0	High adoption (42%)	
OFC	4.0	Low adoption (22.9%)	
Bethma	3.2	High adoption (36%)	
Short duration seed variety	4.2	Low adoption (15.1%)	

Source: Climate Smartness Value - Ministry of Mahawali Development and Environment, 2015; Level of Adoption - Authors' calculation.

OFC cultivation is highly promoted by the government through promotion on home gardens projects, Haritha Lanka programs, and so on, but due to the high restrictions on importing seeds of high yielding varieties, strict regulations, monopoly behaviour, and so on, Sri Lanka is still cultivating low yielding varieties of OFC (Chandrasiri & Bamunuarachchi, 2015; Hirimuthugodage, 2014; Wickramasinghe, 2013). Therefore, the comparison between the revenue and cost of production of OFCs and subsidies and guaranteed price for paddy retain farmers in paddy cultivation. Other reasons include failures in addressing the soil degradation issue resulted from continuous and extensive cultivation and lack of consideration of interactions with other factors such as pests and diseases (Chandrasiri & Bamunuarachchi, 2015; Thiruchelvam, 2005).

Deviations between proposed adaptation practices and farmers' perception towards the adaptation practices caused ineffectiveness of policy when it was implemented as programs in the grass-root level. Thus, when developing the programs to support the national-level policies, the farmers should be considered as one of the important stakeholders. The programs need to be developed through participatory approaches and focus group discussions. Moreover, currently, blanket programs are implemented across the Dry Zone irrespective of irrigation schemes or different cropping systems. But the results of the in-depth analysis using farmer level data indicate the significant difference among farmers' perception between different irrigation schemes. Therefore, separate programs have to be developed for different irrigation schemes for implementation.

Conclusions

There is no doubt that the effects of climate change cannot be eliminated, but their impact on the society and country at large can be considerably minimised by taking proper remedial measures well in advance and in a planned manner. In this regard, adaptation measures should be a policy priority. This study analysed the farm level adaptation practices and farmers' perception of climate change in the Sri Lankan context. Irrigation schemes play a major role in Sri Lankan agriculture and based on the results of this study, the adaptation practices vary among irrigation schemes. OFCs and dry seeding were highly preferred by farmers with a high level of climate change awareness.

The policy implications are wide-reaching as changes in agriculture could affect food security, trade policy, livelihood activities, and water conservation issues, impacting large portions of the population. For effective policy implementation, understanding the grassroots realities is fundamental and according to the results found in this study, it is essential to reform the existing programs in promoting climate change adaptation practices at the field level. The results in this study clarified that policy implementation becomes a failure due to the improper understanding between the farmers' perspective and policy goals. Therefore, policymakers must consider the farmers' perception and their actual practices to motivate farmers to enhance their adaptive capacity through adaptation

practices. By capturing the factors that affect the farmers' engagement in the adaptation, policymakers can develop proper goals for effective implementation. The variation among irrigation schemes is understandable through the different trends obtained in this study. Therefore, appropriate programs have to be developed and implemented for different irrigation schemes. These findings help design programs for effective climate change adaptation to reduce adverse effects of climate change and to reform the programs in a way that supports climate change adaptation practices.

The study covered only the dry zone of Sri Lanka under two different irrigation schemes. Understanding the practices in rain-fed agriculture of Dry Zone, intermediate and wet zone will give a complete picture of designing policy. Further, farmers' perception is one side of the coin. We need to get the opinions and information from government officials which will give a better knowledge of climate change adaptation practices and their success rates as a whole system. This study considered only the farm-level agricultural adaptation behaviours. However, agricultural adaptations can include other household-level decisions outside of how land is cultivated, such as financial management strategies, purchasing insurance, livelihood diversification. Moreover considering individual farmer behaviour will also lead to a better understanding of the adoption of agricultural practices such as self-efficacy, risk-taking, and social cohesion, and so on.

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Notes

1. Dry seeding is one of the major adaptation practices promoted and followed by the farmers. In the dry seeding dry paddy seeds are broadcasted or drilled on unpuddled soil expose to tillage or no tillage operations.
2. Bethma is an ancient communal practice, if the water is scarce, individual paddy land ownership would be suspended, and owners of the land closer to the water body were required to share their land with those who are farther away.
3. Other field crops include millets, and other cereals, other than paddy, pulses, condiments, fruits and vegetables.
4. In Sri Lanka all irrigation works were divided into major and minor works by Ordinance No. 32 of 194.6 (Begum, 1987), based on the irrigation canal distribution, extent and management (International Irrigation Management Institute (IIMI), 1986). Minor scheme–Irrigated by a single canal, no field canals, managed by Department of Agrarian Services and maintained by farmers, predominantly lands are privately owned, designed for Maha season (North-East monsoon from September to March) cultivation , crop invariably rice under subsistence farming.

Major schemes–Irrigated by a complete distribution system with branch distributaries and field canals, managed by Irrigation Department or Mahawali Authority, predominantly lands are provided under Land Development Ordinance, designed for Maha and Yala (Monsoon spans between the months May to August) cultivation, mainly rice cultivation in Maha and end of Yala.

5. Climate Change Perception Index measured the awareness of farmers reading climate change and their knowledge on perceiving climate change

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Article

Micro-level Assessment of Rural Societal Vulnerability of Coastal Regions: An Insight into Sagar Island, West Bengal, India

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Abstract

Most of the villages in coastal blocks of West Bengal, India, are prone to both cyclones and coastal and river flooding. Very severe cyclones in recent time (e.g., Sidr, Aila, Fani, Bulbul, and Amphan) exposed the coastal population livelihood at stake. Displacement and migration are very much evident due to such extreme events. However, the existing study examines the nature of societal vulnerability mainly for the coastal villages that focus on the biophysical components. An 'integrated approach' was adopted to assess the societal vulnerability which is viewed as a function of exposure, sensitivity and adaptive capacity. A number of proxy indicators were considered to represent these components and a normalisation procedure was adopted in order to aggregate them into a single value. Three key observations emerged. First, components such as sensitivity and adaptive capacity were found to act as the major determinants of vulnerability. Second, eight mouzas were found to have a higher vulnerability score, and surprisingly, some of the mouzas are non-coastal. Third, factors such as demography, agriculture and economic capacity emerged as the major cause for increasing vulnerability. These results have policy implications in the context of prioritising limited resources among the vulnerable villages and determinants through the disaster risk management programme at the district and block levels.

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Keywords

Cyclone and flood, societal vulnerability, adaptive capacity, coastal region, Sagar Island

Introduction

Sagar Island (21°37′21″–21°52′28″N and 88°2′17″–88°10′25″E), a gargantuan low-lying archipelago setting on the continental shelf of the Bay of Bengal, is one of the most vulnerable deltas (Figure 1). Extreme climate-driven multifarious threats, including tidal gushes, deluge with seawater, permanent submergence of land, occurrence of droughts and water scarcity have taken a toll on food and environmental security of the island. Though the Sagar Island has tremendous economic potentiality, it lags behind due to emerging social vulnerability among the people living in the coastal region. Despite people living in this coastal region faces a significant vulnerability. This study emphasises on the micro-level assessment of societal vulnerability[1] of this remote Island. Societal vulnerability becomes apparent after a hazardous occurrence when different patterns of suffering and recoveries are observed among certain groups in the population (Cutter et al., 2003; Sharma & Patwardhan, 2008). While all people living in hazard areas become vulnerable, the social impacts of hazard exposure often fall disproportionately on the most vulnerable people in a society—the poor, minorities, children, the elderly and disabled. These groups are often the least prepared for an emergency, have the fewest resources with which to prepare for a hazard, tend to live in the highest risk locations in substandard housing, and lack knowledge or social and political connections necessary to take advantage of resources that would speed their recovery (Dunning & Durden, 2011).

Social vulnerability[2] study has become a major area of concern as the numbers and intensity of these extreme events are constantly rising globally (Antwi et al., 2015). In the context of climate change, sea-level rise, increase in sea surface temperature and intensification of cyclonic storms in the Bay of Bengal, an assessment of coastal societal vulnerability is much more needed. With this backdrop, this study tries to measure societal vulnerability to cyclonic storms with coastal and river flooding in the Sagar Block located in the southern part of coastal West Bengal, applying the Intergovernmental Panel on Climate Change (IPCC, 2014) framework with the locally grounded quantitative technique. Most of the villages in coastal borders of West Bengal, India, are prone to both cyclones and coastal and river flooding. South 24 Paraganas, Purba Medinipur and Paschim Medinipur have a long stretch of coastal boundary along with Hugli, Matla, Gosaba, Saptamukhi, Harinbanga, Piyali, Raimangal and Ichhamati river. During last 30 years, the intensity of cyclones, number of cyclones, river flooding increases and unprecedented loss of life and property were recorded in the coastal blocks of West Bengal. However, the existing study examines the nature of societal vulnerability mainly for the coastal villages giving focus on the biophysical components. To understand the micro-level assessment of societal vulnerability

of Sagar Island we have taken three major components which are hazard and exposure, sensitivity and adoptive capacity. The above-mentioned components are supportive to find out actual situation of societal vulnerability of the study area. Specific objectives of the study are as follows:

1. To make a comparative study between hazard and exposure sensitivity and adaptive capacity
2. To find out the affecting determinants for the vulnerability of the region and
3. To examine the vulnerability of the region.

Background Information

Study Area

This Island (also known as Ganga Sagar) lies about 105 km (56.7 nautical miles) south of Kolkata, in West Bengal. The area of the island is about 282.11 sq km with 42 inhabited villages and a population of over 21,2037 with a density of 751 persons /sq km. (Census of India, 2011). The Island has scattered mangrove swamp, waterways and small rivers. The island is a famous Hindu pilgrimage. Every year on the day of Maker Sankranti (middle of January), thousands of Hindus gather to take a holy dip at the confluence of Ganga and offer puja in the Kapil Muni temple. The Sundarbans along the Bay of Bengal has thorough quaternary (began about 2 million years ago and extends to the present) sediments deposited mainly by the mighty river Ganges, Brahmaputra and Meghna, and their numerous distributaries. The building up of this estuarine area is not complete. The mangrove-dominated delta is a complex ecosystem comprising one of the three largest single tracts of mangrove forests of the world. The Sundarbans floor varies from 0.9 to 2.11 m above sea level.

Problems Associated with Coastal Areas

Extreme Weather Events

In the Bay of Bengal, over the past 120 years (1891–2010), disturbances such as depressions and cyclonic storms occurred at a rate of 10.79 per year. However, over the last 40 years (1971–2010), the total number of disturbances has reduced, but the frequency of severe storms and intensity increased remarkably. This increasing trend is reflected on an increasing trend in rainfall (Unnikrishnan et al., 2011). According to Singh (2007), severe cyclonic storms over the Bay of Bengal registered 26 per cent increase over the last 120 years, intensifying in post-monsoon. During the last part of the decade (2006–2009), the northern part of the Bay of Bengal registered four cyclones, namely Sidr, Nargis, Bijli and Aila. Cyclones bring high wind, heavy rain and storm surge, causing embankment failure and devastation through saline water inundation (Chittibabu et al., 2004; India Meteorological Department [IMD], 2008; Srivastava et al.; 2000). Floods

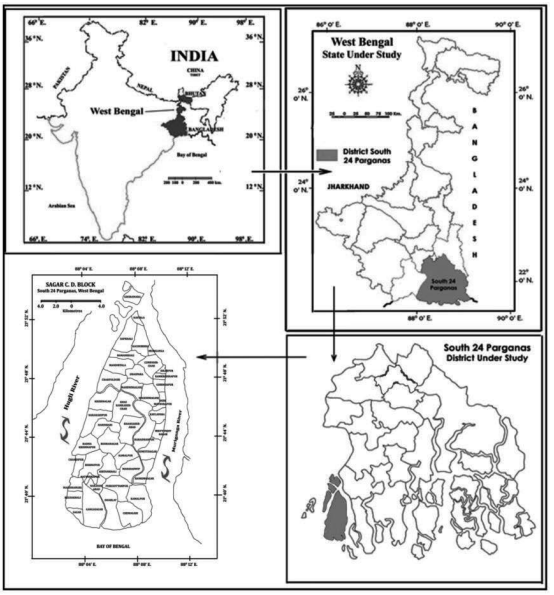


Figure 1. The Location of the Study Area

Source: Census of India, 2011.

damage houses, cultivable lands, and ponds and wash away domestic animals. Historical records of severe cyclones forming in the northern part of the Bay of Bengal during 1970–2009 have been found (Table 1). Several severe cyclones caused extensive damage in West Bengal during the recent past. A severe cyclone formed during 27 September–1 October 1971, then again on 13–20 August 1974, a cyclone crossed West Bengal coast near Contai with a maximum wind speed of 139 km/hr.

During 4–11 December 1981 Cyclone Three (3B), 23–30 November 1988 Tropical Cyclone 04B, and 23–27 May 1989 Severe Cyclonic Storm BOB 01/01B crossed 40 km northeast of Balasore. Another storm made landfall in Bangladesh on 15 November 2007, causing large-scale evacuations and 3,447 deaths (Paul, 2009).

Table 1. Frequency of Cyclones in the East-Coast States of India

State	Mandal[a]	GTECCA[b]	Mohanty and Gupta[c]	IMD[d,e]
West Bengal	69 (22.40)	67 (20.93)	49 (19.14)	149 (18.55)
Odisha	98 (31.81)	106 (33.12)	94 (36.71)	387 (48.19)
Andhra Pradesh	79 (25.64)	90 (28.12)	65 (25.39)	177 (22.04)

(Table 1 Continued)

(Table 1 Continued)

State	Mandal[a]	GTECCA[b]	Mohanty and Gupta[c]	IMD[d,e]
Tamil Nadu	62 (20.12)	57 (17.81)	48 (18.75)	90 (11.21)
Total	308 (100.00)	320 (100.00)	256 (100.00)	803 (100.00)

Source: Bahinipati (2014).

Notes. [a]Study period 1881–1989; [b]study period 1877–1995; [c]study period 1891–1994; [d]study period 1891–2007; [e]this includes low pressure, depression, deep depression, cyclonic storm, severe cyclonic storm, very severe cyclonic storm and super cyclonic storm. Figures in parentheses indicate percentage. GTECCA, Global Tropical and Extratropical Cyclone Climatic Atlas; IMD, India Meteorological Department.

The other cyclonic storms in the regions were Nargis during 27 April–3 May 2008 that caused the worst natural disaster in the recorded catastrophic destruction history of Myanmar and at least 138,000 fatalities. India, Sri Lanka and Bangladesh were also affected partly by this cyclone. The highest wind speed was 215 km/hr. During2009, the Cyclonic Bijli formed from an area of low pressure on 14 April. Affected areas from this cyclone were Eastern India, Bangladesh and Myanmar. The highest wind speed was 75 km/hr. A storm surge of 2.1 m (7 ft) was recorded in the Cox's Bazar District, Bangladesh. In the same year, Aila developed as a tropical depression on 23 May in the North Indian Ocean, south of West Bengal, India. Aila reached its maximum sustained wind speed near 120 km/hr on 25 May, becoming a severe cyclonic storm prior to landfall near the India–Bangladesh border later the same day. The storm brought heavy rain and strong winds to parts of eastern India and Bangladesh, claiming the lives of over 260 people and leaving half a million people homeless.

Breaching of Embankments

In coastal blocks, inhabited islands are protected by man-made embankments against the ingression of saline water. This makes agriculture and aquaculture possible in the islands (Danda et al., 2019). In the Indian side of the Sundarbans, out of total 3,500 km of embankment, 800 km is vulnerable to breach during high-intensity weather events (Mondal & Bandyopadhyay, 2014a). The present trend in the sea-level rise will have serious impacts on the embankments, making these more vulnerable and susceptible to breach and overtopping. The earthen embankments constructed in mid of the 19th century have already been worn out in several locations at the same time the river beds are raised through continuous siltation. The water level during high tide in most of the rivers remains above the adjacent inhabited areas. The crest height, slope including bottom and top width, alignment and materials used for the maintenance of the existing embankments are not considered to be the proper defence to the rising trend in sea level and to save the inhabited islands from inundation. There can be a total washout during cyclonic and storm surges. During such occasion, the river water rushes into the islands and ruins almost everything within minutes and an irreparable loss of assets, lives and livelihoods of the people is incurred.

Air Temperature

Earth's climate changes naturally. Throughout its long history, the Earth has warmed up, and hence the inhabitants of coastal blocks are experiencing extended and extreme summer and short winter. There has been an observable rise in the air temperature that may affect the overall physical and socio-economic processes of this region. The air temperature data in Sagar Island for 80 years (1891–1970) reveal a 0.6 °C increase in the average daily minimum temperature and a 0.1 °C increase in the average daily temperature. After 1970, the increasing trend in temperature is well marked and this has increased more after 2000. Another important observation is that the daily minimum temperature is rising faster than the daily maximum temperature, resulting in a gradual decrease in the diurnal range (Kumar & Tholkappian, 2006). Air temperature over the Bay of Bengal is rising at a rate of 0.019 °C per year. If this trend continues, the air temperature in this area is expected to rise by 1 °C by 2050 (Hazra et al., 2002).

Surface Water Temperature

The surface water temperatures (SWTs) in coastal blocks of West Bengal, especially in Sagar, Kakdwip, Namkhana and Patharpratima (eastern and western sectors), have shown significant rising trends for both pre-monsoon and monsoon periods. Quantitatively, these temperatures have risen by 6.14 per cent in the western sector and by 6.12 per cent in the eastern sector over the past 30 years (1978–2008) at a rate of approximately 0.05 °C/year (Mitra et al., 2009). In another study, the annual composite sea surface temperature of the Bay of Bengal near Sagar Island during the period 2003–2009 varied from 28.023 °C in the year 2004 to 29.381 °C in the year 2009. During the period, the sea surface temperature showed a rising trend at the rate of 0.0453 °C per year (Hazra et al., 2002). This observed rate is found to be in conformity with the estimation done by Singh (2007), which estimates a decadal rate of about 0.4 °C–0.5 °C. Rising sea surface temperature is directly related to the increased frequency and severity of cyclonic storms and depression in the Bay of Bengal. It is also reported that the increasing trend in SWT may result in changes to the chemical composition of seawater, leading to increased acidification and the low dissolved oxygen level.

Rainfall and Monsoon Pattern

The geographical location of the study area receives rain mainly from south-west monsoon which generally starts in the middle of June and withdraws during the second week of October. August is the rainiest month which contributes 21–22 per cent of the annual precipitation. The average annual rainfall is 1,625 mm (Mondal & Bandyopadhyay, 2014), but in the case of a high rainfall year, this may increase to 2,000 mm, whereas this may drop to 1300 mm in an exceptionally low rainfall year. The analysis looking at data over a period of 1981–2015 has shown a slight increase in monsoon, especially post-monsoon, rainfall in the said region. There is a trend of delayed monsoon and heavy rains at the beginning as well as the late recession and sometimes heavy precipitation during kharif (mainly during

the rainy season) harvest (Chaliha et al., 2012). The period of retreating monsoon is October and November. This season shares with about 10 per cent average annual precipitation which comes mostly with the passage of depressions and cyclonic storms. Onset of monsoon is being highly delayed, while the withdrawal remaining almost the same, thereby causing a reduction in the span of monsoon. The earliest (25 May 2009) and latest (26 June 1983) onsets of monsoon over this region have occurred within the period of the last 35 years.

Sea Level Rise

Sea levels in the Indian sub-continent are increasing at the rate of about 2.5 mm/year. But the studies reveal a relative mean sea level rise of 3.14 mm/year in Sagar Island and adjoining Bay of Bengal (Hazra et al., 2002). The tidal gauge data of Sagar Island observatory for the period of 2002–2009 indicated that a rise of relative mean sea level at the rate of 12 mm/year during the past decade (Hazra et al., 2002). Considering the record of past 25 years, the rate of the relative mean sea level rise comes close to 8 mm/year, which of course is significantly higher than the rate of 3.14 mm/year observed during the previous decade (Hazra et al., 2002). Since the coastal islands of West Bengal are formed due to gradual siltation, these are in consolidation mode, causing the subsidence of land. Depending on the location, a sinking nature of this delta has been manifest due to relative change of sea level rise with 3–8 mm/year century (Raha et al., 2014). The estimated rise in sea level will pose serious problems during the pre- and post-monsoon phases when most of cyclone storms occur vigorously.

Erosion and Accretion

There is a natural process of erosion and accretion in the coastal blocks of West Bengal. Few islands, namely Lohachara, Bedford, Kabasgadi and Suparibhanga have already vanished from the map. Most vulnerable islands to erosion are Sagar, Ghoramara, Dakshin Surendranagar, Mousuni, Namkhana, Dhanchi, Dalhousie, Bulchery, Bhangaduni and Jambudwip. In general, the western banks of rivers are more vulnerable to erosion than the east, and erosion is more along the sea facing sore lines where it is oblique. Marginal accretion is localised in the inner estuaries, particularly along the eastern and northern margins of islands and along the coast where it is mostly east–west oriented and sea facing. Study conducted during 2001–2009 reveals that a total land area of 6402.09 km of the Indian side of the Sundarbans in the year 2001 had reduced to 6358.05 km in 2009 (Ghosh et al., 2015). This amounts to net land loss of 44.04 sq km which includes the erosion of 64.16 sq km and the accretion of 20.12 sq km. The eastern matured islands are found to be comparatively more stable due to the presence of thick mangroves and lesser anthropogenic activities. Sagar Island has suffered the bulk of erosion with an area loss of 30 sq km and only marginal accretion. When considering the impact of above climate-related disasters, it is of paramount importance to study the following objectives to mitigate and nullify the climate change leading to disasters in this area.

Methodology

Choice of Indicators for Vulnerability Assessment

According to IPCC (2014), vulnerability is defined as

> The degree to which a system is susceptible to or is unable to cope with adverse effects of climate change including climate variability and extremes, and it is the function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.

From this, we can infer that vulnerability is the function of exposure, sensitivity and adaptive capacity. A number of proxy indicators were selected to represent these determinants. These indicators were selected based on the existing vulnerability studies and the availability of secondary data at the village level in the Sagar Block. The determinants of vulnerability are as follows.

Hazard and Exposure

Hazard exposure is a state of being in which a person or a group of people remain at an imminent risk of danger. Such dangers are related to the workplace health safety and environment or day-to-day life. Hazards are dangers or potential sources of dangers which pose direct threat to a single person or to a group of people's health and safety (Patnaik et al., 2013; Sahana & Sajjad, 2019). Hazard exposures are threats when no protective measures are taken. For example, an electrical distribution board is an electrocution hazard. If it is protected by a cover, locked out and a safety warning placed on it, its risk is reduced, and it poses fewer hazards. Employees need to be protected from any kind of hazard exposure at all times. Hierarchy of hazard control provides a guideline for the management to safeguard employees from the hazard exposure, including which has to be knocked out first.

Hazards and exposure indicators are the frequency of floods and cyclone in last 20 years, per cent of village population affected, per cent of kachha house damaged, crop land damaged in hazard and distance from the active channel coast.

Sensitivity

Sensitivity is the degree to which a given community or ecosystem is affected by climatic stresses (Chen et al., 2013; Feng et al., 2013). For example, a community dependent on rain-fed agriculture is much more sensitive to changing rainfall patterns than the one where mining is the dominant livelihood. Likewise, a fragile, arid or semi-arid ecosystem will be more sensitive than a tropical one to a decrease in rainfall, due to the subsequent impact on water flows.

Table 2. Determinants of Vulnerability, Components, Proxy Indicators and Their Data Sources

Determinants of Vulnerability	Components	Proxy Indicators	Data Source
Hazard and exposure	Characteristics of cyclones, floods and their effects	(a) Frequency of floods and cyclone in the last 20 years	Indian Metrological Department, 2011 and Wikipedia[a]
		(b) % of village population affected	Disaster Management Cell, Kakdwip S.D., South 24 Parganas
		(c) % of kachha house damaged	Disaster Management Cell, Kakdwip S.D., South 24 Parganas
		(d) Crop land damaged in hazard	Disaster Management Cell, Kakdwip S.D., South 24 Parganas
		(e) Distance from the active channel coast	Sagar Block map, 24 Parganas (South), Census of India, 2011
Sensitivity	Demographic	(a) Share of village pop to block population	Census of India, 2011
		(b) Population growth rate (2001–2011)	Census of India, 2001 and 2011
		(c) Population density	Census data 2011
		(d) % of female population	Census of India, 2011
		(e) % of 0–6 population	Census of India, 2011
		(f) % of >60 population of 2011	Socio-economic Caste Census, 2011
	Agricultural	(g) % of cultivators	Census of India, 2011
		(h) % of agricultural labour	Census of India, 2011
		(i) % of landless households	Socio-economic Caste Census, 2011

(Table 2 Continued)

(Table 2 Continued)

Determinants of Vulnerability	Components	Proxy Indicators	Data Source
	Economic capacity and equality	(a) % of unemployed population	Socio-economic Caste Census, 2011
		(c) Female work participation rate	Socio-economic Caste Census, 2011
		(d) Per households income	Socio-economic Caste Census, 2011
		(e) % of households irrigation facilities	Socio-economic Caste Census, 2011
Adaptive capacity	Information skill and infrastructure	(f) % of households sanitary facilities	Socio-economic Caste Census, 2011
		(g) % of female literates	Census of India, 2011
		(h) % of households electrified	House Listing Primary Census Abstract (HLPCA), 2011
		(i) % of households drinking water facilities	House Listing Primary Census Abstract (HLPCA), 2011
		(j) % of households banking facilities	House Listing Primary Census Abstract (HLPCA), 2011
		(k) % of kachha households	House Listing Primary Census Abstract (HLPCA), 2011

Source: Authors.

Note. ahttps://en.wikipedia.org/wiki/North_Indian_Ocean_tropical_ cyclone

Sensitivity indicators are share of village population to block population, population growth rate (2001–2011), population density, per cent of female population, per cent of 0–6 years population, per cent of above 60 years population (2011), per cent of cultivators, per cent of agricultural labour and per cent of landless households.

Adaptive Capacity

Adaptive capacity is the ability of a system (human or natural) to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities or to cope with the consequences (Aydın & Uysal, 2014; Balica et al., 2012). One of the most important factors shaping the adaptive capacity of individuals, households and communities is their access to and control over natural, human, social, physical and financial resources.

Adaptive capacity indicators are per cent of unemployed population, per cent of population in the primary sector, female work participation rate, per capita household income, per cent of households irrigation facilities, per cent of households sanitary facilities, per cent of female literates, per cent of households electrified, per cent of households drinking water facilities, per cent of households having banking facilities and per cent of kachha households.

Estimation Methods

Land Use/Land Cover Change Detection

Satellite images of 2000 and 2010 (Landsat 5 TM, path/row 138/045 for year 2000; Landsat 7 ETM+, path/row 138/045 for the year 2010) have been used for mapping and assessing the Land Use/Land Ccover (LULC). Satellite data have been downloaded from the United States Geological Survey earth explorer website,[3] and then all the datasets were processed in Erdas Imagine software. LULC maps for the years 2000 and 2010 have been generated using the supervised classification method by using the maximum likelihood algorithm. The occurrence of mixed pixels during the time of classification has been found and, hence, the images were reclassified to reduce error and improve the classification accuracy. Post-classification ground truth surveys have also been conducted, and after that, rectifications were made to the classified images.

Assessment of Vulnerability

There are two ways to analyse indicators: (a) giving equal weight to each indicator and (b) assigning a weight to each indicator with the help of expert judgement, principal component analysis and correlation between past disaster events and fuzzy logic. The present analysis has given equal weight to each indicator since the appropriateness of giving weights is still dubious as there is no standard weighting method against which each method is tested for precision. Since the indicators are measured in different units, a normalisation method was followed in order to aggregate them into a single value, which is shown in Equation (1):

$$\text{Index } X_{ij} = \left[\frac{\left(X_{ij} - \text{Min } X_i \right)}{\left(\text{Max } X_i - \text{Min } X_i \right)} \right], \tag{1}$$

where Index X_{ij} is the index value (i.e., 0–1) of the indicators for villages, X_{ij} represents the ith indicator of the village, and Max X_i and Min X_i manifest the

maximum and minimum values of the *i*th indicators among all villages, respectively.

A total of 25 variables have been selected for the construction of the vulnerability index at the village level (M_{ij}). All the proxy indicators from three determinants, namely hazard and exposure, sensitivity and adaptive capacity (Table 2) have been normalised prior to statistical analysis. The vulnerability score (M_{ij}) has been calculated by adding the scores of each component to arrive at the total M_{ij} scores. An equal weightage and additive method have been applied due to justified pieces of evidence for the weightage method as exercised by several scholars (Aksha et al., 2019; Cutter et al., 2003; Hummell et al., 2016). The vulnerability score has been calculated for each spatial unit (the 41 villages) by adding the proxy indicator values using Equation (2). After the standardisation of all the proxy indicators, the components and determinants of vulnerability and the aggregate vulnerability indices are calculated as

$$\text{Vulnerability Score } (M_{ij}) = \left[\sum\nolimits_{i=0}^{n} \left(\text{Index } X_{ij} / n\right)\right], \tag{2}$$

where M_{ij} is the vulnerability index value (higher the value, higher the vulnerability and vice versa) for each village, Index X_{ij} represents the summation value of proxy indicators of the village and n represents the number of indicators/components.

Before calculating the vulnerability score, hazard and exposure, demographic sensitivity, agricultural sensitivity, economic capacity and equality and information skill and infrastructure indices have been developed in the same manner as applied for the assessment of the vulnerability score. Further Pearson's correlation has also been calculated among the results of components to measure the strength (Pearson's correlation coefficient, i.e., '*r*') of the association of the variables.

Findings and Analysis

Changing Land Use with Accretion–Deposition Scenario

The entire Sundarbans region is very much influenced by tidal action, and Sagar Island is located at the southern tip of the Hugli estuary. Sagar Island has changed successively over time depending on the tidal action done by the Hugli River in the west and the Muri Ganga River at the east. Tidal ranges in this area vary up to 3–4 m, and some time it rises up to 6 m also. The average velocity of the tide has been observed 2–3 m/s (Paul, 2002). During Cyclone Aila in May 2009, the storm surge made a devastating effect in this area with breaching the earthen embankment. Due to the behead shoreline with the funnel shape river mouth, the southern area faces more damage of erosion during the advancement of storm-induced tidal surge. The extreme south-western low-lying sandy coastal belt has been exposed to higher erosion with long shore current during cyclones and tidal surge. Some

portion in the eastern and northern sides experienced deposition due to locational advantage (not facing towards the Bay of Bengal). Due to this accretion–deposition process, the coastal boundary area has become more vulnerable for the society living here. Their livelihoods are at stake during and after any extreme event. A displacement of settlement and out-migration is the common phenomenon in this area after any hazards. Education of children, mainly of the girl child, becomes more problematic due to such events.

The LULC classes have been identified (Figure 2) from the datasets after image processing and classification with an overall accuracy of 88.32 per cent and the kappa coefficient of 0.8508. During the study period 2000–2010, this island experienced numerous development-related works. Forest land was reclaimed for settlement, agriculture and aquaculture ponds. The increased areal configuration of settlement, agricultural land and aquaculture ponds in the entire study area was one of the major changes during the study period (Table 3). It seems that cyclonic storm and embankment breaching during 2000–2010 had also influenced the alteration of LULC of Sagar Island.

Table 3. Land Use/Land Cover Changes During 2000–2010 at the Sagar Block, West Bengal, India

Land Use Classes	Year 2000		Year 2010		Changes (in %) During Study Period
	(in sq km)	(in %)	(in sq km)	(in %)	
Mangrove forest	19.78	7.01	12.64	4.48	−2.53
Mangrove swamp	5.63	2.00	3.24	1.15	−0.85
Mudflats	14.92	5.29	10.75	3.81	−1.48
River	20.68	7.33	22.26	7.89	0.56
Sand beach	0.93	0.33	1.35	0.48	0.15
Open scrubs	8.19	2.90	7.00	2.48	−0.42
Settlements	59.59	21.13	71.00	25.17	4.05
Plantations	28.83	10.22	8.97	3.18	−7.04
Aquaculture	16.74	5.64	18.84	6.68	1.04
Waterlogged area	26.54	10.41	35.18	12.47	2.56
Agricultural land	78.25	27.74	90.86	32.21	4.47
Total	282.10	100.00	282.10	100.00	

Source: Landsat 5 and Landsat 7 ETM+ datasets.

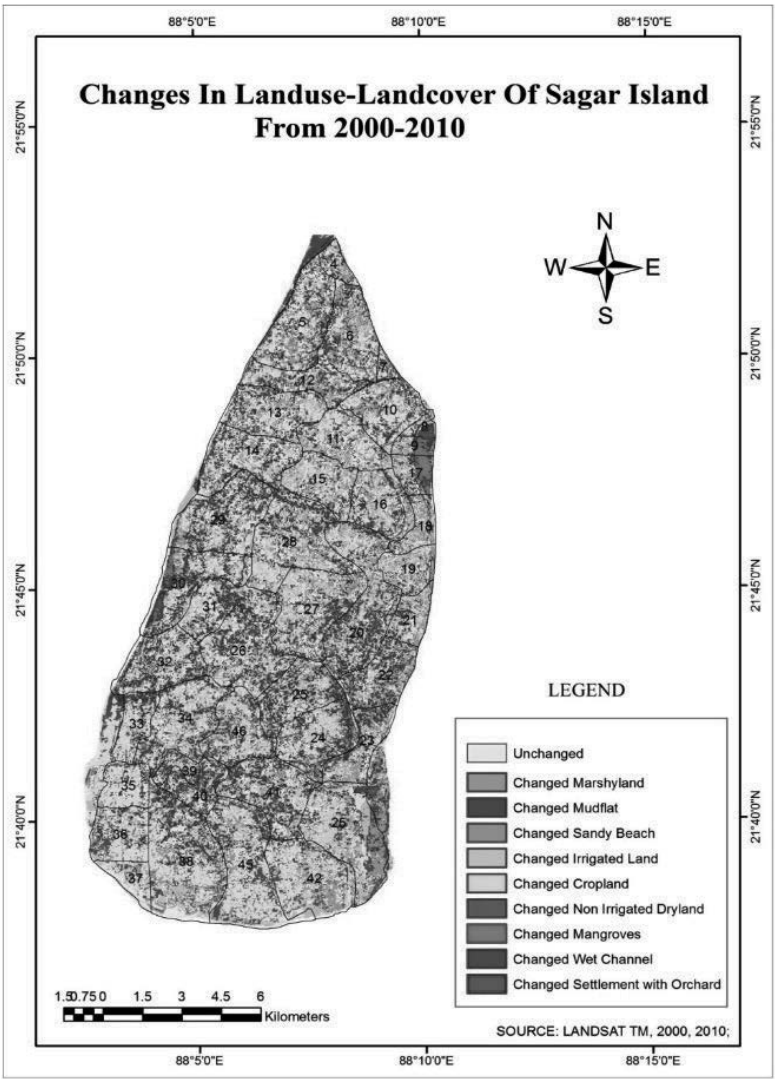


Figure 2. Changes in Land Use and Land Cover of Sagar Island from 2000 to 2010

Source: LANDSAT TM, 2000 & 2020.

During the study period, a rapid increase in mud flats, sand beach and waterlogged area was prominent, while mangrove forest and mangrove swamps reduced considerably which was also assessed by Thakur et al., (2020). A huge amount of mangrove and other vegetation class have been converted to a human settlement-related activity, whereas another important reclamation is agriculture land and aquaculture ponds. Due to change in the mangrove forest and mangrove swampy land along coastline, the stabilisation process has been turned vulnerable.

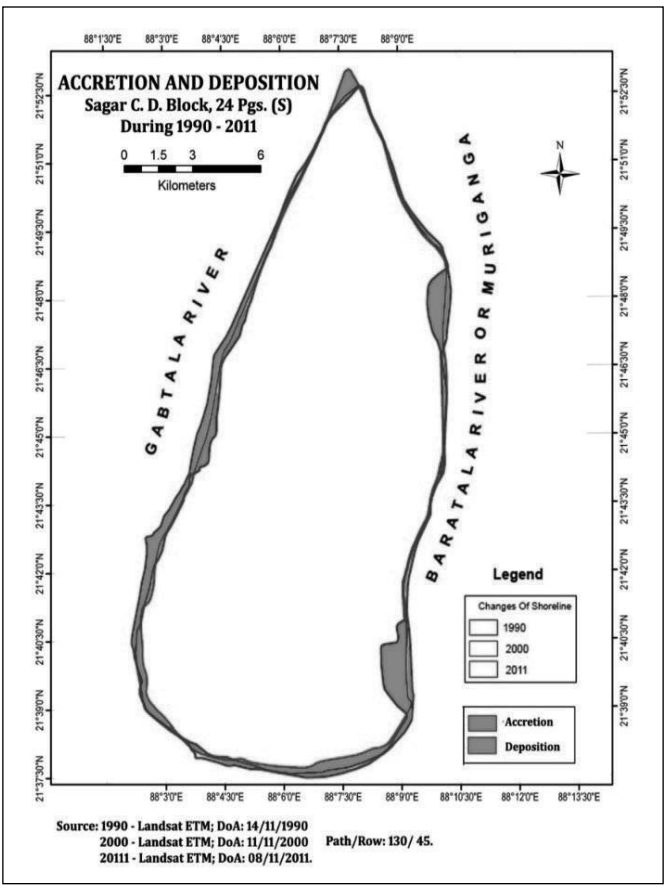


Figure 3. Accretion and Deposition from 2000 to 2010 in Sagar Island Along the Sagar Island Coast

Source: LANDSAT ETM (1990, 2000, 2011).

Table 4. Stability and Shoreline Changes in Sagar Block During 1990–2010

Area of Concern	Total Villages	Intensively Eroded Villages	Moderately Eroded Villages	Stable Villages	Moderately Deposited Villages	Highly Deposited Villages	Erosion (in sq km)	Deposition (in sq km)
Western boundary	11	8	2	–	1	–	10.39	2.85
Eastern boundary	9	2	1	6	3	3	1.05	8.39

Source: Calculated by Authors based on Figure 3.

From Figure 3, it is quite clear that the area which has been found as severely erosion effected were much stabilised prior to 2000. The eastern face of this island, which is exposed to the Muri Ganga River, found to be eroding at a slower pace to the western part where erosion has been found severe. Due to such variety of variation in the erosion rate (Table 4) on two sides of the island, the condition of coastal vegetation, especially mangroves, is found critical.

Assessment of Factors Determining the Vulnerability

Vulnerability has been calculated by summing up the components of three determinants based on their cardinality, and descriptive statistics has also been calculated. This portion of analysis tries to find out the interdependencies between the components selected for the study. Table 5 shows the vulnerability scores for all the mouzas of Sagar Island, West Bengal. Among the vulnerability indices and their determinants, a higher standard deviation (SD) is found in the case of vulnerability (1.51) than those of hazard (0.78), sensitivity (0.59 and 0.4), adaptation (0.48 and 0.88). But the average score of sensitivity (2.67 and 0.9) is less than that of exposure (2.10) and its other two determinants, that is, adaptation (02.64) and vulnerability (10.95).

From Table 5, particularly from the kurtosis analysis, a leptokartic (more than 3.0) has been found only for the economic components of adaptive capacity and vulnerability, whereas rest four components have been under platykurtic. Most of the components have been found of platykurtic nature; a descriptive measure needs to be very carefully and wisely interpreted. In geostatistics, skewness is an important concept because most of the variables measured in geographical studies generally show a higher degree of skewness which commonly ranges +3.0. The normal distribution is certainly symmetrical and hence the skewness value is zero. Therefore, the data are unsuitable for parametric tests. In this dataset, two out of four components have value above 3.0, which indicates the availability of variables taken to study the vulnerability is very much unequally distributed.

This suggests that the variation of exposure, agricultural sensitivity and infrastructural adaptive capacity level across all the villages of the Sagar Block is lower than the demographic sensitivity and economic adaptively, and hence, most of the villages are becoming non-vulnerable because of high sensitivity and low adaptive capacity. In addition, it is also found that sensitivity and adaptive capacity are highly correlated with vulnerability. This implies that sensitivity and adaptive capacity are vital components to derive vulnerability.

While calculating the correlation coefficient of different components of exposure, sensitivity and adaptation with vulnerability, it portrays a positive correlation was found in the case of agricultural sensitivity (0.84), societal adaptivity (0.96), vulnerability (0.618) and demographic sensitivity (0.67); these coefficients are significant at the 1 per cent and 5 per cent levels (Table 6). For example, mouzas such as Harinarayanpur, Mansadwip, Kamalpur and Khas Ramkarer-Char have a higher vulnerability value, even though they have lesser exposure to both cyclones and floods. In fact, some of the coastal villages such as

Table 5. Descriptive Statistics of the Components of Vulnerability Assessment

	Hazard and Exposure	Sensitivity		Adaptive Capacity		Vulnerability
		Demographic	Agricultural	Economic	Infrastructural	
Min.	0.3048	1.6029	0.1788	1.6070	0.9597	8.1629
Max.	3.4843	4.3989	1.8702	3.7544	4.6366	14.1415
Mean	2.1018	2.6712	0.9272	2.6398	2.6477	10.9586
SD	0.7825	0.5934	0.4022	0.4801	0.8880	1.5154
CV	37.2292	22.2159	43.3803	18.1880	33.5405	13.8285
Kurtosis	1.95	3.66	2.08	3.18	1.63	2.45
Skewness	0.79	0.56	0.39	3.12	1.34	3.45

Source: Authors.

Table 6. Pearson's Correlation Between Determinants and Major Components of Vulnerability

Components	Hazard and Exposure	Demographic Sensitivity	Agricultural Sensitivity	Societal Adaptivity	Information Skill and Infrastructure	Vulnerability
Hazard and exposure	1.000	0.246	0.843**	0.042	−0.376	0.328
Demographic sensitivity	0.246	1.000	0.517	0.963**	0.170	0.673*
Agricultural sensitivity	0.843**	0.517	1.000	0.022	0.228	0.618*
Societal adaptivity	0.042	0.963**	0.022	1.000	−0.213	0.526
Information skill and infrastructure	−0.376	0.170	0.228	−0.213	1.000	0.356
Vulnerability	0.328	0.673*	0.618	0.526	0.356	1.000

Source: Authors.

Note. *1% significant level, **5% significant level.

Sapkhali and Haradhanpur also have both higher exposure and vulnerability values than the remaining mouzas (Table B.1). This reveals the fact that exposure, demography and agriculture adaptivity are the major drivers of vulnerability. But it should be noted that the influence of demography and agriculture on the vulnerability outcome is higher than that of societal adaptivity. This is also the findings of Chen et al. (2013) in the Yangtze River delta region where social vulnerability to natural hazards is very much controlled by demographic and institutional sensitivity. Population living below poverty line are far reaching the meet of socio-economic and ecological implications in the coastal area (Mandal, 2013; Sahana & Sajjad, 2019).

Vulnerability at the Village Level

In general, the world's poorest people often have limited access to those livelihood resources that would facilitate adaptation. Access to and control over these resources also vary within countries, communities and even households. It is influenced by external factors such as policies, institutions and power structures. For instance, women are often particularly vulnerable to the impacts of climate change due to their limited access to information, resources and services. Similarly, pastoralist men may find it easier than women to adapt to changing rainfall patterns because their culture allows for greater mobility amongst men. In other societies, more men than women may survive a flood, as many poor women do not know how to swim. However, it is important to note that adaptive capacity can vary over time based on changing conditions and may differ in relation to particular hazards. The approach to integration of climate change is grounded in the identification of vulnerable groups and targeting of adaptation strategies, depending on both the human and natural ecosystem contexts (Gayathri et al., 2016; Ghosh, 2012).

A lower level of unemployment with high female work participation and high per capita income are the important issues which can reduce the vulnerability though higher adaptive capacity. Percentage of electrified households and safe drinking water facilities are the positive sign to cope with hazards and exposure. A lower percentage of kachha house and households having banking facilities in villages are also potential variables to regulate resilience power against hazard exposure.

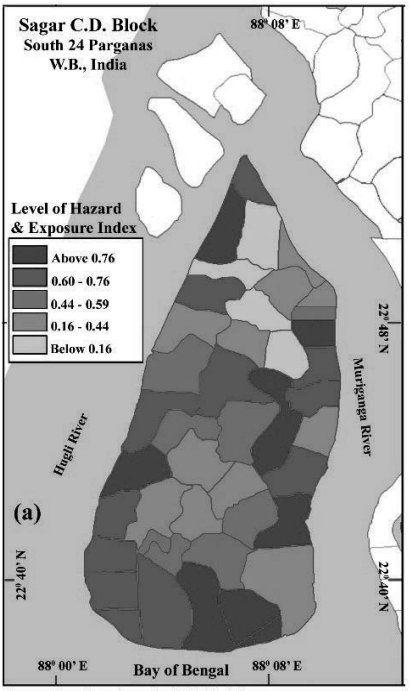
Based on the village-level vulnerability indices of Sagar Island, six villages have the vulnerability level of more than 0.74, namely Sapkhali, Khas Ramkarer-Char, Haradhanpur, Kamalpur, Mansadwip and Kirtankhali (Table 7 and Figure 4.f), out of which, four villages, namely Khas Ramkarer-Char, Haradhanpur, Mansadwip and Kirtankhali are non-coastal villages. In fact, these villages, except Jajpur, have less exposure. But they have high sensitivity and low adaptive capacity (Table B.2), making them more vulnerable.

Table 7. Classification of Villages in Sagar Block, West Bengal, Based on the Vulnerability Score (M_{ij})

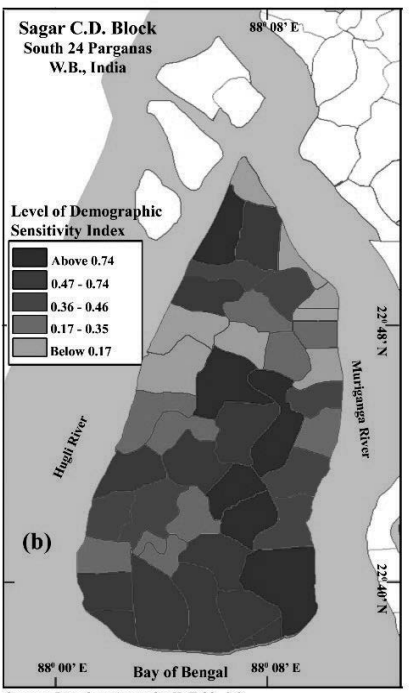
Level of Vulnerability	Vulnerability Score	Name of the Villages	No. of Villages (in %)
Very high	Above 0.74	Sapkhali, Khas Ramkarer-Char, Haradhanpur, Kamalpur, Mansadwip, Kirtankhali	6 (14.6%)
High	0.46–0.74	Kachuberia, Bamankhali, Krishnagar, Khansaheber Abad, Rudranagar, Radhakrishnapur, Chengmari, Dhoblat, Purushotammpur, Ganga Sagar, Sagar, Beguakhali	12 (29.3%)
Moderate	0.35–046	Bamankhali, Companir Char, Kayalpara, Sumotinagar, Bankimnagar, Chandanpur, Bishnupur	7 (17.1%)
Low	0.17–0.35	Gobindapur, Dashpara, Nagendranagar, Mrittujaypur, Narayanpur, Harinbari, Kirtankhali, Narayan Abad, Natindrapur, Maheshmari	10 (24.4%)
Very low	Below 0.17	Kastala, Chakuphuldih, Narendraganj, Sikarpur, Ramkrishnapur, Debmathurapur	6 (14.6%)

Source: Authors (see Table B.2 for details).

Notably, it has been found that some of the non-coastal villages are highly vulnerable compared to these coastal villages. This suggests that the District Rural Management (DRM) programme of the state should also cover the non-coastal villages. The present DRM programme in the state mainly focuses on the activities related to massive awareness campaign about preparedness for natural disasters such as cyclones and floods (e.g., organising mass meetings, different competitions like essay, debate and drawing among school students, school safety programmes and wall paintings), explaining dos and don'ts in various disasters, training programmes for village-level-selected volunteers. Since sensitivity and adaptive capacity are the major determinants, this study emphasises on activities to be undertaken through the DRM programme which will enhance the resilience of various households in West Bengal, that is, we should integrate both the development-based activities and the DRM programme (Gayathri et al., 2016; Hegde & Reju, 2007; Sahana & Sajjad, 2019). Further, 12 villages have the vulnerability levels between 0.46 and 0.74, and 7 villages have the moderate vulnerability levels, that is, less than 0.35 and 0.46 (Figure 5).



Source: Based on Appendix II, Table 2.2



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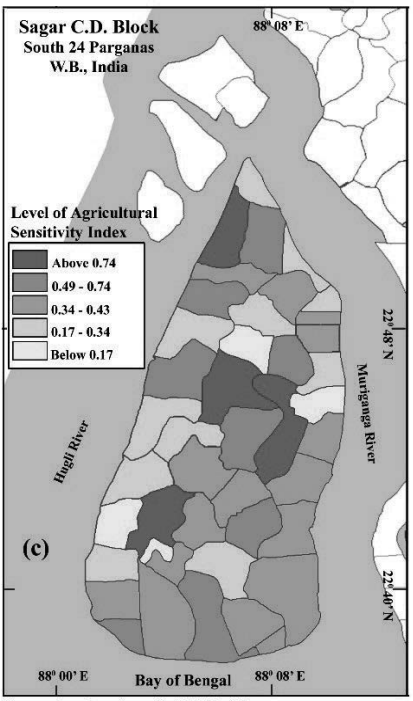

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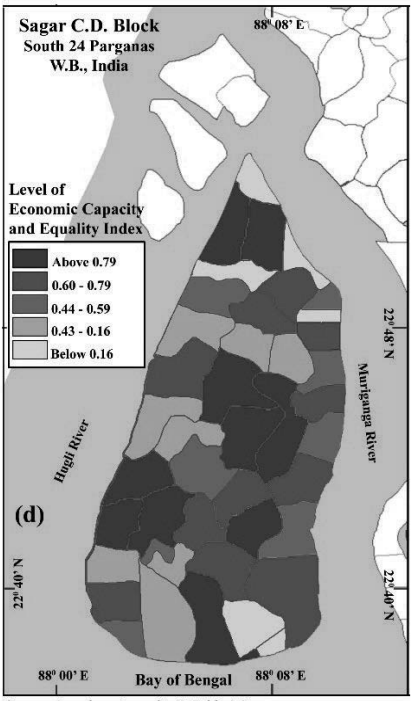

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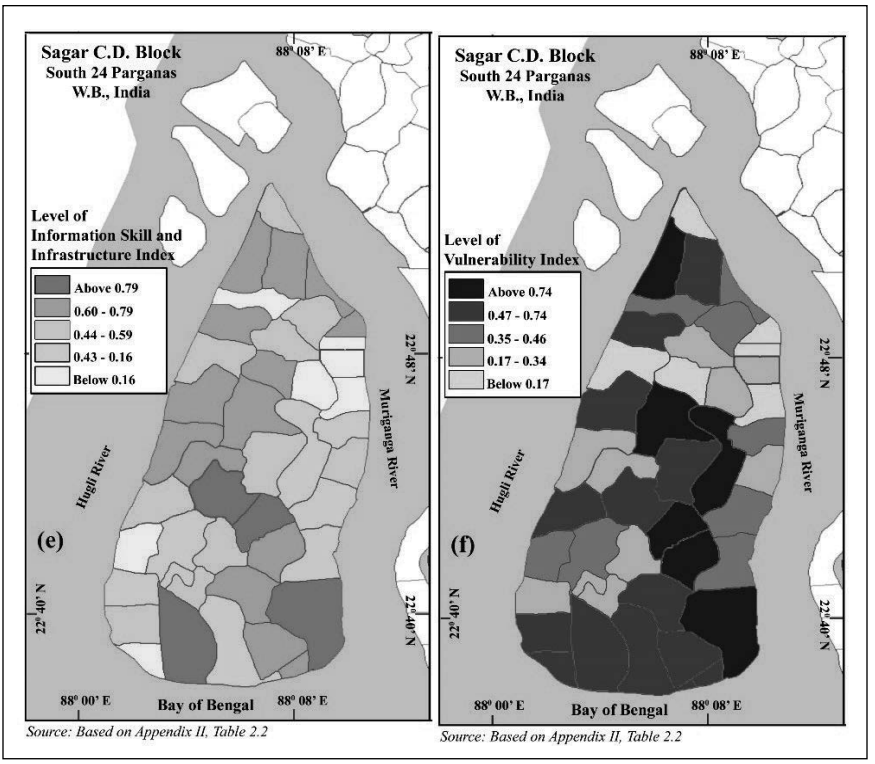
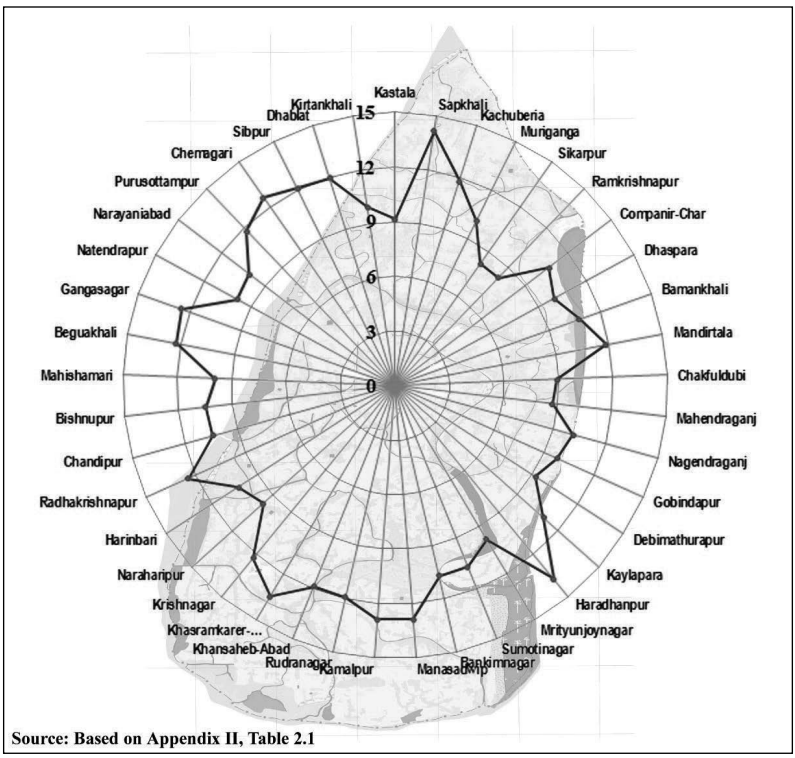


Figure 4. (a) Hazard and Exposure, (b) Agricultural Sensitivity, (c) Demographic Sensitivity, (d) Adaptivity on Economic Capacity and Equality, (e) Adaptive Capacity on Information Skill and Infrastructure and (f) Vulnerability Assessment of the Villages in Sagar, West Bengal

Source: Appendix Table B2.

Conclusions

The Sagar Block, West Bengal, India, consisting of 43 villages is located at the sea front on the right bank of the Muri Ganga River, left bank of Hugli and Bay of Bengal in South. Due to its geomorphologically vulnerable situation, the area is prone to frequent flooding, cyclonic storm and depression induced by hazardous processes that originate both from land and ocean. The analysis clearly demonstrates that the villages located along the river bank and those exposed to the sea, due to the absence of any natural barrier, have high risk of flooding, whereas the villages of interior locations are mostly of lower risk except four villages that lie with tidal creek crossed from the eastern to western part of the block. Storm surge during cyclone episodes and high astronomical tide lead ocean water to enter along tidal inlets that floods many of the villages under study. The villages also vary with respect to types of damages caused by floods.



Source: Based on Appendix II, Table 2.1

Figure 5. Showing Spider Diagram of Village-wise Vulnerability Indices

Source: Appendix Table B1.

The findings of the study are multifold and these are pointed out here. First, the vulnerability indices for the village have been calculated for a particular time period (i.e., 2011–2016), and this may change while we calculate it for any future time period. Second, the present vulnerability analysis is based on the combination of observed data and, in particular, has not estimated the districts that are likely to be vulnerable in the foreseeable future. Third, this study has given equal weight to each indicator for the components under study. Vulnerability scores identified villages which need immediate consideration for disaster mitigation and helped to focus the priorities for action with the help of index values of different components. Thus, the composite vulnerability index method with its three components of exposure, sensitivity and adaptive capacity can best be utilised for measuring specific disaster vulnerability. The methodology adopted in this work can be applied for large-scale vulnerability assessment (at the Panchayat/block/district level). However, the components and proxy indicators of vulnerability components may vary spatially, but the methodology can provide actionable evidence for policymakers at a local level for cyclone and flood disaster mitigation and management in the coastal areas.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Appendix A.

Table A.1. Indicators for the Assessment of Hazard and Exposure Score, Sagar Block

Name of the Villages	Hazard and Exposure				
	Frequency of Floods and Cyclone in the Last 20 Years	% of Village Population Affected	% of Kachha House Damaged	Crop Land Damaged in Hazard	Distance from Active Channel Coast
Kastala	22	31.52	73.71	57.35	1.66
Sapkhali	21	26.44	76.51	61.27	3.87
Kachuberia	15	18.07	74.49	62.16	1.72
Muri Ganga	15	36.28	75.11	28.81	2.24
Sikarpur	14	54.02	77.71	76.05	3.80
Ramkrishnapur	18	31.47	70.05	87.41	2.33
Companir-Char	25	30.34	62.83	89.27	2.56
Dhaspara	9	61.48	76.92	84.54	2.67
Bamankhali	15	68.54	75.82	74.16	0.48
Mandirtala	27	26.47	63.20	84.47	1.76
Chakfuldubi	16	35.23	73.70	73.47	1.02
Mahendraganj	19	31.48	67.67	83.33	0.90
Nagendraganj	28	45.07	64.15	81.63	2.58
Gobindapur	7	43.02	77.02	90.45	3.41
Debimathurapur	11	44.93	77.39	84.11	2.67
Kaylapara	12	47.95	66.32	77.88	1.95
Haradhanpur	12	39.92	64.94	87.54	4.26

(Table A.1 Continued)

(Table A.1 Continued)

Name of the Villages	Hazard and Exposure				
	Frequency of Floods and Cyclone in the Last 20 Years	% of Village Population Affected	% of Kachha House Damaged	Crop Land Damaged in Hazard	Distance from Active Channel Coast
Mrityunjoynagar	30	14.29	59.57	86.43	2.59
Sumotinagar	21	36.00	73.32	60.48	1.81
Bankimnagar	18	47.05	75.07	57.21	2.83
Mansadwip	36	52.66	65.76	76.23	1.12
Kamalpur	11	49.41	72.39	68.74	3.86
Rudranagar	20	21.55	74.58	63.32	4.21
Khansaheb-Abad	27	31.41	70.47	75.84	3.53
Khas Ramkarer-Char	20	39.16	72.39	60.97	3.12
Krishnagar	20	29.09	73.02	18.68	3.09
Naraharipur	17	45.67	75.26	60.96	4.15
Harinbari	11	58.16	76.62	67.47	2.69
Radhakrishnapur	10	43.96	74.75	61.06	1.63
Chandipur	12	43.19	75.55	59.70	2.65
Bishnupur	17	34.10	74.72	90.86	2.25
Mahishamari	13	9.81	74.01	75.41	2.60
Beguakhali	14	52.65	76.50	46.12	2.16
Ganga Sagar	18	45.52	74.82	74.57	2.39
Natendrapur	13	45.41	74.38	66.64	2.55
Narayaniabad	17	45.55	76.58	73.43	1.82
Purusottampur	18	36.75	70.55	84.99	1.96
Chemagari	11	31.06	76.34	88.82	1.43
Sibpur	14	36.47	79.52	88.94	2.54
Dhablat	20	46.78	44.33	75.89	0.78
Kirtankhali	25	39.25	23.19	87.88	0.25

Sources: Indian Metrological Department (2011), Wikipedia (North Indian Ocean tropical cyclone), Disaster Management Cell, Kakdwip S.D., South 24 Parganas, Sagar Block map, 24 Parganas (South), and Census of India (2011).

Table A.2. Indicators for the Assessment of Sensitivity Score, Sagar Block

	Demographic						Agricultural		
Name of the Villages	Share of Village Population to Block Population	Population Growth Rate (2001–2011)	Population Density 2011	% of Female Population	% of 0–6 Years Population	% of Above 60 Years Population	% of Cultivators	% of Agricultural Labours	% of Landless Households
Kastala	0.79	15.27	544	47.95	10.57	43.00	0.50	0.63	34.62
Sapkhali	3.26	11.84	768	47.91	12.76	38.29	4.87	6.35	28.57
Kachuberia	3.74	13.07	1046	48.52	12.90	30.93	2.57	4.96	31.67
Muri Ganga	1.32	9.05	547	48.95	12.55	42.21	1.18	1.13	31.91
Sikarpur	0.66	16.72	945	49.60	14.62	21.51	0.42	0.83	20.00
Ramkrishnapur	0.18	12.62	263	47.27	14.48	37.21	0.21	0.34	66.67
Companir-Char	2.55	10.33	990	48.60	13.07	38.65	1.72	2.07	30.00
Dhaspara	2.67	11.14	1103	49.18	13.01	42.03	0.44	0.27	40.00
Bamankhali	2.01	11.95	898	47.88	12.67	37.93	1.66	2.55	35.94
Mandirtala	2.97	29.64	900	48.59	12.03	31.11	1.45	4.35	28.21
Chakfuldubi	2.77	3.90	851	47.89	12.86	27.25	2.58	1.27	25.29
Mahendraganj	2.20	−1.51	992	47.91	11.03	28.31	0.33	0.21	21.05
Nagendraganj	2.20	104.95	898	48.31	14.07	41.84	3.62	2.06	38.24
Gobindapur	1.06	2.47	750	46.31	13.32	26.53	1.35	1.45	41.94
Debimathurapur	1.19	17.26	834	46.64	12.70	41.50	1.17	2.89	18.92
Kaylapara	1.69	-1.16	971	49.14	12.21	29.68	1.07	0.56	26.23
Haradhanpur	4.35	14.56	887	47.88	12.18	28.08	6.69	5.29	25.19
Mrityunjoynagar	1.52	12.78	622	47.90	12.41	25.21	2.43	2.41	29.17
Sumotinagar	2.27	14.09	689	47.79	12.05	30.81	2.87	2.52	22.54
Bankimnagar	1.88	16.65	597	47.59	11.76	20.79	1.86	1.90	31.58
Mansadwip	3.00	16.22	977	48.24	12.13	22.47	5.89	2.64	12.09
Kamalpur	3.19	17.98	1154	48.46	11.77	28.91	3.67	1.88	23.71

(Table A.2 Continued)

(Table A.2 Continued)

Name of the Villages	Demographic						Agricultural		
	Share of Village Population to Block Population	Population Growth Rate (2001–2011)	Population Density 2011	% of Female Population	% of 0–6 Years Population	% of Above 60 Years Population	% of Cultivators	% of Agricultural Labours	% of Landless Households
Rudranagar	3.45	10.77	928	48.39	10.31	27.89	3.22	2.36	20.72
Khansaheb-Abad	2.94	16.61	752	48.80	12.46	25.80	3.14	3.82	28.57
Khas Ramkarer-Char	3.65	12.68	807	48.35	11.74	33.49	6.01	6.23	17.76
Krishnagar	3.92	14.28	931	48.25	11.67	30.83	3.08	3.95	24.79
Naraharipur	1.77	15.32	522	47.49	11.30	28.46	1.56	1.86	21.57
Harinbari	2.64	13.35	991	47.69	10.78	26.76	1.03	1.86	25.30
Radhakrishnapur	2.46	13.85	689	47.67	12.21	33.98	2.94	0.72	27.03
Chandipur	1.31	21.98	917	49.12	14.35	19.89	0.82	1.05	26.47
Bishnupur	3.07	12.81	848	47.79	11.21	24.95	8.41	2.74	23.91
Mahishamari	1.40	23.11	650	47.77	15.71	26.47	1.44	1.22	32.43
Beguakhali	2.74	14.84	876	47.53	15.01	29.03	1.89	3.95	23.08
Ganga Sagar	5.00	21.60	822	48.58	12.81	27.04	2.09	2.65	30.67
Natendrapur	0.57	12.29	921	46.90	11.14	24.27	0.22	0.62	29.41
Narayaniabad	1.60	13.55	1130	48.41	10.71	25.21	1.28	2.72	26.92
Purusottampur	3.27	11.99	910	47.47	12.36	27.46	2.29	2.59	18.52
Chemagari	3.17	15.59	554	48.54	12.91	25.20	2.40	2.20	30.11
Sibpur	4.52	14.60	1047	48.28	12.25	27.75	2.21	5.61	17.56
Dhablat	3.28	9.98	546	48.19	11.07	23.63	3.08	3.35	38.17
Kirtankhali	1.80	13.18	686	48.46	12.04	26.16	4.32	1.92	23.73

Sources: Census of India (2001, 2011) and Socio-economic Caste Census (2011).

Table A.3. Indicators for the Assessment of Adaptive Capacity Score, Sagar Block

	Economic Capacity and Equity				Information Skill and Infrastructure						
Name of the Villages	% of Unemployed Population	% of Primary Sector Population	Female Work Participation Rate	Per Capita Income	% of HHs Irrigation Facilities	% of Households Sanitary Facilities	% of Female Literates	% of HHs Electrified	% of HHs Drinking Water Facility	% of HHs with Banking Facility	% of Kachha HHs
Kastala	24.56	61.4	5.15	3800	19.23	34.62	28.63	7.69	69.23	30.77	80.77
Sapkhali	27.94	66.18	28.11	3900	46.67	37.14	29.63	15.24	77.14	28.57	89.52
Kachuberia	26.71	63.05	23.96	4100	55.83	40	31.56	11.67	72.5	26.67	88.33
Muri Ganga	23.4	51.06	20.55	3900	41.86	48.84	30.00	37.21	18.6	32.56	83.72
Sikarpur	21.92	69.86	16.44	2600	40	35	27.33	0	30	15	85
Ramkrishnapur	18.52	62.96	6.36	3600	50	16.67	22.13	0	33.33	33.33	83.33
Companir-Char	19.48	69.81	19.79	4400	47.5	30	31.17	0	28.75	16.25	95
Dhaspara	15.11	72.81	25.98	4200	45	33.75	33.93	0	17.5	10	97.5
Bamankhali	13.89	63.1	13.18	5200	43.75	65.63	39.08	35.94	79.69	35.93	79.69
Mandirtala	13.71	67.22	14.39	5700	43.59	35.9	33.30	17.95	29.49	34.62	82.05
Chakfuldubi	15.36	65.81	16.25	4300	36.78	33.33	31.74	12.64	29.89	16.09	87.36
Mahendraganj	15.53	70.87	5.89	5200	40.79	38.16	36.17	6.58	27.63	21.05	90.79
Nagendraganj	17.99	64.03	21.27	3400	47.06	35.29	28.67	5.88	14.71	17.65	85.29
Gobindapur	20.41	63.38	32.20	3800	45.16	41.94	29.75	2.39	0	12.9	90.32
Debimathurapur	18.97	67.98	29.00	3900	40.54	24.32	29.65	4.82	0	16.22	83.78
Kaylapara	15.51	65.78	28.43	4300	62.29	47.54	32.98	6.56	0	32.79	83.61
Haradhanpur	18.57	71.03	29.09	5900	59.54	31.3	32.20	3.95	0	25.19	90.84
Mrityunjoynagar	13.03	68.07	24.80	4700	43.75	45.83	34.72	11.5	35.42	31.25	89.58
Sumotinagar	18.6	74.71	16.79	3900	47.89	45.07	33.14	13.6	0	32.39	88.73
Bankimnagar	20.43	67.03	16.45	5000	38.6	26.32	32.18	19.3	0	28.07	89.47
Mansadwip	13.88	67.84	31.83	5200	71.43	38.46	34.06	17.58	89.01	34.07	90.11
Kamalpur	10.5	66.73	20.31	5500	62.89	55.67	34.03	27.84	87.63	40.21	91.75
Rudranagar	10.53	65.44	15.52	5700	58.56	51.35	35.59	36.94	82.88	44.14	88.29
Khansaheb-Abad	25.59	61.62	33.03	5100	35.16	32.97	35.64	21.5	29.67	29.67	94.51
Khas Ramkarer-Char	13.64	73.02	32.43	5300	40.19	38.32	34.84	27.1	13.08	31.78	91.59
Krishnagar	12.39	72.12	32.31	4700	46.28	45.45	35.80	26.45	0	26.45	90.08
Naraharipur	18.22	58.43	25.17	4900	37.25	33.33	34.89	17.65	31.37	23.53	88.24
Harinbari	14.79	60.56	9.09	5700	49.4	38.55	35.00	30.12	40.96	22.89	89.16
Radhakrishnapur	19.89	65.19	25.70	5400	60.81	44.59	33.12	16.22	0	24.32	91.89
Chandipur	25.81	60.75	25.90	4700	50	29.41	32.35	11.58	0	23.53	85.29
Bishnupur	18.92	67.96	37.13	4700	39.13	32.61	34.47	33.5	0	29.35	90.22

(Table A.3 Continued)

(Table A.3 Continued)

	Economic Capacity and Equity						Information Skill and Infrastructure				
Name of the Villages	% of Unemployed Population	% of Primary Sector Population	Female Work Participation Rate	Per Capita Income	% of HHs Irrigation Facilities	% of Households Sanitary Facilities	% of Female Literates	% of HHs Electrified	% of HHs Drinking Water Facility	% of HHs with Banking Facility	% of Kachha HHs
Mahishamari	24.12	55.29	22.71	3600	37.84	20	30.65	21.4	0	27.02	94.59
Beguakhali	14.04	71.91	27.09	4500	41.03	41.03	30.24	10.25	57.69	30.77	93.59
Ganga Sagar	11.11	72.47	15.53	4900	27.33	37.33	32.73	21.33	89.33	29.33	94
Natendrapur	14.56	66.99	40.61	3700	35.29	70.59	34.61	29.41	0	52.94	82.35
Narayaniabad	18.38	66.67	14.09	4300	34.62	40.38	34.61	13.46	0	34.62	92.31
Purusottampur	12.06	67.53	19.04	5900	56.48	39.81	34.55	23.15	51.85	37.96	88.89
Chemagari	14.52	63.91	12.48	4300	46.24	35.48	33.58	22.58	72.04	38.71	90.32
Sibpur	22.1	61.56	10.87	5200	43.51	31.3	31.78	11.5	0	36.64	94.66
Dhablat	23.06	65.41	27.91	4700	58.49	30.19	33.76	14.15	0	24.53	91.51
Kirtankhali	16.13	63.44	31.69	5100	38.98	30.51	36.65	20.34	0	23.73	88.14

Sources: Census of India (2001 and 2011) and Socio-economic Caste Census (2011).

Appendix B

Table B.1. Village-wise Vulnerability Indices in Sagar Block, West Bengal, India

Villages	Hazard and Exposure	Combined Demographic Sensitivity	Combined Agricultural Sensitivity	Combined Societal Adaptivity	Combined Information Skill and Infrastructure	Total Vulnerability Score
Kastala	2.62	2.16	0.52	1.61	2.24	9.15
Sapkhali	2.91	3.08	1.87	3.21	3.08	14.14
Kachuberia	0.81	3.40	1.42	3.12	2.99	11.74
Muri Ganga	1.58	2.86	0.63	2.00	3.02	10.09
Sikarpur	1.40	2.93	0.27	2.17	1.40	8.16
Ramkrishnapur	2.23	1.95	1.02	1.89	1.12	8.21
Companir-Char	1.47	3.45	0.82	2.81	2.11	10.65
Dhaspara	0.56	3.93	0.55	2.75	2.21	9.99

(Table B.1 Continued)

(Table B.1 Continued)

Villages	Hazard and Exposure	Combined Demographic Sensitivity	Combined Agricultural Sensitivity	Combined Societal Adaptivity	Combined Information Skill and Infrastructure	Total Vulnerability Score
Bamankhali	0.30	2.92	0.99	2.19	4.37	10.78
Mandirtala	2.56	3.10	1.12	2.53	2.53	11.85
Chakfuldubi	1.49	2.53	0.70	2.07	2.12	8.91
Mahendraganj	1.34	2.23	0.18	2.35	2.59	8.70
Nagendraganj	0.82	4.40	1.20	2.21	1.55	10.17
Gobindapur	3.00	1.61	0.89	2.71	1.58	9.79
Debimathurapur	2.38	2.51	0.68	2.68	0.96	9.20
Kaylapara	2.70	2.77	0.42	2.91	2.14	10.93
Haradhanpur	3.39	2.91	1.86	3.75	1.84	13.75
Mrityunjoynagar	1.72	1.93	0.94	2.52	2.73	9.84
Sumotinagar	2.58	2.31	0.89	2.74	2.21	10.72
Bankimnagar	3.37	1.60	0.83	2.66	2.26	10.73
Mansadwip	2.04	2.60	1.09	3.44	3.72	12.90
Kamalpur	1.52	3.14	0.91	2.81	4.54	12.90
Rudranagar	1.31	2.53	0.88	2.60	4.64	11.95
Khansaheb-Abad	2.04	2.72	1.25	3.16	2.72	11.89
Khas Ramkarer-Char	2.42	2.95	1.79	3.10	3.20	13.46
Krishnagar	2.16	3.00	1.19	2.92	3.02	12.29
Naraharipur	2.37	1.70	0.61	2.36	2.68	9.72
Harinbari	1.85	2.28	0.61	2.28	3.27	10.28
Radhakrishnapur	3.35	2.48	0.69	3.36	2.62	12.50
Chandipur	2.53	2.81	0.47	3.10	1.47	10.39
Bishnupur	1.45	2.24	1.63	3.12	2.07	10.50
Mahishamari	2.66	2.66	0.69	2.11	1.80	9.91
Beguakhali	2.43	3.02	1.02	2.70	3.12	12.28
Ganga Sagar	2.31	3.32	0.97	2.09	3.84	12.51
Natendrapur	1.80	1.48	0.39	2.55	3.68	9.89
Narayaniabad	1.91	2.37	0.81	2.17	2.82	10.08
Purusottampur	2.03	2.56	0.76	2.89	3.53	11.77
Chemagari	3.48	2.51	0.92	2.01	3.70	12.63
Sibpur	2.78	3.24	1.22	2.52	2.30	12.07
Dhablat	2.97	1.95	1.34	3.36	2.32	11.94
Kirtankhali	1.52	2.21	0.99	2.73	2.45	9.91

Source: Computed by the authors from Appendix A (Tables A.1–A.3).

Table B.2. Village-wise Vulnerability and Component Scores in Sagar Block, West Bengal, India

Villages	Hazard and Exposure	Combined Demographic Sensitivity	Combined Agricultural Sensitivity	Combined Societal Adaptivity	Combined Information Skill and Infrastructure	Total Vulnerability Score
Kastala	0.727	0.233	0.201	0.000	0.348	0.166
Sapkhali	0.818	0.548	1.000	0.748	0.576	1.000
Kachuberia	0.160	0.658	0.734	0.706	0.552	0.599
Muri Ganga	0.401	0.473	0.266	0.182	0.560	0.323
Sikarpur	0.345	0.497	0.053	0.262	0.120	0.000
Ramkrishnapur	0.605	0.161	0.497	0.131	0.043	0.008
Companir-Char	0.367	0.675	0.379	0.561	0.313	0.416
Dhaspara	0.082	0.839	0.219	0.533	0.340	0.306
Bamankhali	0.000	0.493	0.479	0.271	0.927	0.438
Mandirtala	0.708	0.555	0.556	0.430	0.427	0.617
Chakfuldubi	0.373	0.360	0.308	0.215	0.315	0.125
Mahendraganj	0.326	0.257	0.000	0.346	0.443	0.090
Nagendraganj	0.163	1.000	0.604	0.280	0.160	0.336
Gobindapur	0.846	0.045	0.420	0.514	0.168	0.273
Debimathurapur	0.652	0.353	0.296	0.500	0.000	0.174
Kaylapara	0.752	0.442	0.142	0.607	0.321	0.463
Haradhanpur	0.969	0.490	0.994	1.000	0.239	0.935
Mrityunjoynagar	0.445	0.154	0.450	0.425	0.481	0.281
Sumotinagar	0.715	0.284	0.420	0.528	0.340	0.428
Bankimnagar	0.962	0.041	0.385	0.491	0.353	0.430
Mansadwip	0.545	0.384	0.538	0.855	0.750	0.793
Kamalpur	0.382	0.568	0.432	0.561	0.973	0.793
Rudranagar	0.317	0.360	0.414	0.463	1.000	0.634
Khansaheb-Abad	0.545	0.425	0.633	0.724	0.478	0.624
Khas Ramkarer-Char	0.665	0.503	0.953	0.696	0.609	0.886
Krishnagar	0.583	0.521	0.598	0.612	0.560	0.691
Naraharipur	0.649	0.075	0.254	0.350	0.467	0.261
Harinbari	0.486	0.274	0.254	0.313	0.628	0.355
Radhakrishnapur	0.956	0.342	0.302	0.818	0.451	0.726
Chandipur	0.699	0.455	0.172	0.696	0.139	0.373

(Table B.2 Continued)

(Table B.2 Continued)

Villages	Hazard and Exposure	Combined Demographic Sensitivity	Combined Agricultural Sensitivity	Combined Societal Adaptivity	Combined Information Skill and Infrastructure	Total Vulnerability Score
Bishnupur	0.361	0.260	0.858	0.706	0.302	0.391
Mahishamari	0.740	0.404	0.302	0.234	0.228	0.293
Beguakhali	0.668	0.527	0.497	0.509	0.587	0.689
Ganga Sagar	0.630	0.630	0.467	0.224	0.783	0.727
Natendrapur	0.470	0.000	0.124	0.439	0.739	0.289
Narayaniabad	0.505	0.305	0.373	0.262	0.505	0.321
Purusottampur	0.542	0.370	0.343	0.598	0.698	0.604
Chemagari	0.997	0.353	0.438	0.187	0.745	0.747
Sibpur	0.777	0.603	0.615	0.425	0.364	0.654
Dhablat	0.837	0.161	0.686	0.818	0.370	0.632
Kirtankhali	0.382	0.250	0.479	0.523	0.405	0.293

Source: Computed by the authors from Appendix B (Table B.1).

Notes

1. Vulnerability is a concept which describes factors or constraints of economic, social, physical or geographic nature, which reduce the ability to prepare for and cope with the impact of hazards. It is currently a very much debated term and concept, among others in the context of climate change and natural hazards, resulting in various definitions and approaches to its operationalization (Adger, 2006; Bohle & Glade 2008; Cutter et al., 2003; Gilberto, 2006; Kuhlicke et al., 2011). The Third and Fourth Assessment Reports of IPCC define vulnerability to climate change as the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes. According to IPCC, vulnerability is a function of the character, magnitude and rate of climate change to which a system is exposed, its sensitivity and its adaptive capacity (IPCC, 2014; World Bank, 2008). This definition implies three important concepts: exposure, sensitivity and adaptive capacity.
2. In this study, vulnerability is understood as the degree to which a community, a household or a person is 'likely to experience harm due to exposure to a hazard, either an exogenous perturbation or an endogenous stress or stressor' (Turner et al., 2003). Using this adapted definition in combination with the associated vulnerability framework for human–environment systems (Patnaik et al., 2013; Turner et al., 2003) gives consideration to the complexity of vulnerability and makes clear that it consists of multiple interacting social, economic and environmental factors operating on different spatial scales. In many schools of thought, it is agreed that the concept of vulnerability comprises three fundamental dimensions, namely exposure, susceptibility and resilience/adaptive capacity (Adger, 2006; Birkmann et al., 2010; Gilberto, 2006). Vulnerability is not only scale and time-specific and socially, economically and environmentally contextual but also it is historically embedded (McCarthy et al., 2001; Wisner et al., 2008).
3. https://earthexplorer.usgs.gov/.

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Article

Impact of Climatic Shocks on Household Well-being: Evidence from Rural Bangladesh

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Abstract

Climatic shocks often jeopardise the well-being of rural households in many developing countries like Bangladesh. Due to lack of risk-sharing arrangements or formal insurance mechanisms, life and livelihood of households living in geographically challenged areas of Bangladesh are vulnerable to such shocks. These shocks increase households' vulnerability to poverty and reduce their prospects of coming out of poverty. It is important to have a clear understanding of the impact of such shocks on the level of well-being to design policies to protect them from negative economic impact of such shocks. How such shocks affect the welfare of households relies on their ability to cope with the shocks. Using household-level survey data collected from remote areas of Bangladesh, this study investigates the impact of climatic shocks on household well-being. The study finds that climatic shocks have a negative impact on the level of well-being measured by total consumption as well as non-food consumption expenditures. However, the impact of shocks on food consumption is rather weak. The study also documents some evidence that climatic shocks negatively impact non-food consumption of not only the poorest but also the relatively wealthier households in the rural remote locations of Bangladesh.

Keywords

Climatic shocks, consumption smoothing, household well-being, rural Bangladesh

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Introduction

A set of risk factors often cause fluctuations to income and consumption of households in developing countries. The extent of such fluctuations depends on several factors, including household endowments, their level of exposure to such risks and their ability to cope with these shocks. The set of household endowments includes factors such as asset holdings (e.g., land, livestock), educational attainments, skill, experience, etc. The set of risk factors households face comprise both idiosyncratic (death of or illness of household head) and covariate components (e.g., damage due to flood). Finally, households' ability to cope with the shocks depends on their access to formal and informal insurance mechanisms (for instance, borrowing from friends and moneylenders), which bear important implications for their future consumption prospects, thereby increasing their vulnerability to poverty. In this study, using a data set of 1,909 households from a survey focusing on shocks and coping mechanisms, we investigate the impact of climatic shocks like agricultural loss (e.g., crop damage) or property damage caused by natural disasters on household well-being. We investigate the impact of such shocks across different wealth categories of households.

Household income volatility along with other factors, in the event of a shock, adversely influence household consumption. Consequently, households face an ex post trade-off between insuring food and non-food consumptions. The significance of such trade-offs becomes particularly crucial in the context of rural and geographically challenged settings in developing countries. The reasons for this phenomenon are twofold, with poverty being the first. The second one is the lack of formal insurance and risk-sharing mechanisms. While results vary across countries, the risk-sharing literature suggests that households, in general, manage to insure food consumption in the face of idiosyncratic shocks over non-food consumption (Asfaw & von Braun, 2004; Skoufias & Quisumbing, 2005). In this context, due to the lack of adequate informal risk-sharing mechanisms to mitigate the adverse impacts of a shock, households try to smooth their ex post food consumption by adjusting their non-food consumption.

However, this feature is not so straightforward for households facing covariate shocks. In a shock-coping analysis on rural Ethiopia, Yilma et al. (2014) argue that risk-averse households' response to natural and economic shocks causes both reduction in food consumption and depletion of savings. Such downward adjustments in food consumption are also likely to be greater for female-headed households as Kumar and Quisumbing (2013) report in their study on Ethiopian households. They show that during a large food price crisis in Ethiopia, female-headed households, on average, reduce food consumption to a larger extent compared to their male counterparts. Iqbal and Roy (2015), in another study, focus on how uncertainties induced by weather variables (namely rainfall and temperature) affect human migration in Bangladesh through agricultural productivity channel. They find that a decline in agricultural income, induced by weather fluctuations, leads to an increase in migration rate.

The coping mechanisms adopted to bear the cost of shocks and to ensure the level of current consumption determine the overall welfare effects of the shocks. In low-income developing economies, where the formal insurance mechanism is

largely absent, households may mitigate consumption risks of adverse incidents through adopting a single or a portfolio of informal coping strategies. Households may make adjustments in their ex post income and consumption by engaging in multiple low-income-generating informal activities (Kochar, 1999; Morduch, 1999). Households may be forced to engage children in the informal wage-earning sector instead of sending them to schools (Jacoby & Skoufias, 1997). Households may adopt investing in low-risk, low-yield crops and assets (Rosenzweig & Binswanger, 1993). Households may resort to using their savings (Paxson, 1992), borrowing from friends and relatives or moneylenders with high interest rates. Households may be compelled to sell their productive assets and livestock (Deaton, 1992; Hoddinott, 2006). All these risk-mitigating arrangements can contribute towards smoothing the current level of household consumption in the short term in the aftermath of a shock.

However, coping strategies like borrowing and divesting productive assets bear very high long-term detrimental consequences for households. Such approaches to risk mitigation can lead households to indebtedness, causing their future consumption levels to fall and churning of households in and out of poverty. The repercussions of selling productive assets can range from increased opportunity cost of quality human capital accumulation to falling into intergenerational poverty traps (the latter can be observed in more severe cases for the poorer households) (Carter & Zimmerman, 2000; Mogues, 2011). A considerable amount of empirical evidence shows that households sell assets to buffer consumption. For instance, in a sample of Zimbabwean households, Hoddinott (2006) finds that in the aftermath of a drought shock in 1994–1995, which led to a significant fall in crop production and income, households reporting sales of oxen increased to 36.3% in 1996 from 15.3% in 1995. Notably, almost half of these transactions took place in order to purchase food for the households.

Bangladesh is a low-lying riverine delta plain spanning 147,570 square kilometres. It is located in South Asia between 20°34′ to 26°38′ North latitude and 88°01′ to 92°41′ East longitude, with a coastline on the northern littoral of the Bay of Bengal. Bangladesh is one of the most disaster-prone countries in the world, and it is highly vulnerable to climate change due to its unique geophysical location. With its long history of natural disasters, every year, such calamities wreak havoc into people's lives in this densely populated country. Despite this, since its independence in 1971, the country achieved remarkable success in poverty reduction, improving literacy rate, enhancing access to safe drinking water and sanitation, reducing infant mortality rate and in terms of other socio-economic indicators (Bangladesh Bureau of Statistics [BBS], 2017b). The rate of poverty at the national level on the basis of head count ratio declined to 24.3% in 2016 from as high as 31.5% in 2010. In rural Bangladesh, the percentage of households receiving benefits from social safety nets programmes (SSNP) increased from around 30.1% in 2010 to 34.5% in 2016 (BBS, 2017b). However, this statistic does not reflect the regional disparity of poverty levels and the severity of poverty in rural areas. In 2016, the rate of poverty was as high as 47.2% in Rangpur division with a maximum poverty rate of 48.2% in its rural areas. This region is vulnerable to food insecurity, emanating from seasonal variation in crop income (Khandker & Mahmud, 2012).

During the past 30 years, Bangladesh has endured over 200 natural disasters (Bangladesh Disaster-related Statistics, 2016, hereafter BDRS). Natural disasters such as floods, cyclones, water logging, storm, tidal surge, etc., cause massive damage to agricultural production, rural infrastructure and property. Data from BDRS (2016) show that between 2009 and 2014, various types of natural disasters in Bangladesh caused a loss of BDT 184.25 billion. Multiplicity of rivers, coastal erosion and land subsidence along with its topographical position and adverse climatic conditions expose Bangladesh to extreme levels of disaster risk and vulnerability. Among the different types of disasters, flood is the main source of loss, contributing 23.3% of the damage, followed by coastal or river erosion (19.76%), cyclone (15.41%) and water logging (8.72%). The other categories, namely drought, tornado, storm or tidal surge, thunderstorm, landslides, salinity, hailstorm, etc., together account for 32.30% of the household livelihood and asset damages. Recently, two major tropical cyclones, Amphan (in 2020) and Bulbul (in 2019), caused serious destruction to infrastructure in the affected areas. Amphan affected around 2.2 million households with an approximate loss of USD 3.25 billion and Bulbul affected around 722,674 households and caused infrastructure damages worth USD 5.5 million (IFRC, 2019, 2020). Experts predict that the frequency and the severity of these types of natural catastrophes are likely to increase with climate change.

In the first stage of the analysis, we show the incidence of different types of climatic shocks across household wealth quintiles. In general, around 23.3% of the households faced at least one shock in the past 1 year of the survey. The likelihood of facing at least one climatic shock is also high among the sample households: 16.6% of the households experienced at least one incidence of crop damage, and 6.3% of the households faced at least one livestock or fisheries loss shock due to natural disaster in the past 1 year of the survey. However, there is no systemic pattern in the distribution of incidence of shocks in terms of wealth status of the households, suggesting that households, located in remote areas, irrespective of their economic status, can experience adverse natural events. In the second stage, we document that climatic shocks have significant negative impact on both total and non-food consumption expenditures of households. Finally, considering the wealth status of the households, it appears that climatic shocks negatively affect the well-being, measured in terms of non-food consumption, of both the poorest and the relatively wealthier segments of the society in remote areas of Bangladesh.

The remaining sections of the article are organised as follows: the second section provides a review of the related literature. The third section describes the data, and the fourth section presents a shock profile of the sampled households. The fifth section presents the econometric method, and the sixth section shows the regression results. Finally, the seventh section provides concluding remarks.

Literature Review

A growing body of empirical evidence points to the adverse effects of natural shocks on the households' well-being brought about by causing unpredictable

household income and consumption volatility. For example, Bui et al. (2014) examine how natural disasters affect household earnings in Vietnam and find a 6.9% drop in income due to such shocks. Mottaleb et al. (2013) argue that rice farmers encounter negative income shocks in the face of significant natural disasters. Such income shocks have adverse impacts not only on rural households' consumption levels but also on their education and health expenditures. They focus on the cyclone-affected rice farmers living in the coastal region of Bangladesh. Similarly, in Nicaragua, the households involved in firm-specific income-generating activities experience lower income as a result of natural disasters like hurricane (van den Berg, 2010). Asiimwe and Mpuga (2007), in their paper, report that greater than normal rainfall levels cause a drop in household agricultural income in the agricultural seasons in Uganda. Finally, there exists evidence that ex ante regional socio-economic situation plays a significant role in determining the degree of impact a natural shock can have on a household's income variability and its response mechanism's efficiency (Masozera et al., 2007). While examining the impact of Hurricane Katrina on the population of New Orleans, USA, Masozera et al. (2007) find that lower-income earners are significantly more exposed to natural disasters compared to other income groups due to their lack of resources and restricted mobility.

A very common measure of welfare of a household is its consumption expenditure (Meyer & Sullivan, 2003; Moratti & Natali, 2012). Household consumption can be significantly affected by natural shocks and by the coping mechanisms adopted in response to the shocks, especially in case of the poor households in the less developed countries (Auffret, 2003; Karim & Noy, 2016; Santos et al., 2011). For example, Dercon (2004) finds a significant long-term negative impact of rainfall shocks on household consumption growth in rural Ethiopia. The study shows that the Ethiopian villages experience substantial consumption shrinkage in the absence of formal coping and support mechanisms due to rainfall shocks. In reference to Dercon's (2004) research, Foltz et al. (2013), in their study, argue that being poor increases an Ethiopian household's exposure to natural shocks compared to being situated in a vulnerable area. Skoufias et al. (2012), in their study, report reduction in farming productivity of agrarian households due to rain shortfall in rural Indonesia. Their research finds that such natural shocks have particularly damaging impact on non-food expenditure: rural households reduce their non-food consumption in order to insulate their food consumption from the adverse effects of such low rainfall shocks.

Auffret (2003) explores the impact of natural disasters on consumption volatility in 6 Caribbean countries and 10 Latin American countries. The author documents that the Caribbean countries that are covered in his study suffer from high consumption instability, which leads to decreased household welfare. Moreover, Auffret reports that the state of private consumption in the event of catastrophic disasters suffers considerably in all the 16 countries. Pandey et al. (2007) conduct a cross-country comparative analysis on the effects of droughts on agrarian communities of southern China, eastern India and northeast Thailand. Their study finds considerable negative welfare consequences on the poor

households who largely adopt ineffective coping mechanisms. Empirical studies document similar findings in the context of Bangladesh as well. A study that investigates the coping strategies adopted by rural households, during the 1998 flood in Bangladesh, records the damaging impact of such natural shocks on household consumption levels (Khandker, 2007). This study advocates the ex post efficacy of supporting mechanisms like microfinance in helping the rural households to alleviate their sufferings and to expedite their recovery process. Likewise, studies, documenting the adverse impacts of natural shocks on the less well-off households, recommend increasing the efficiency of formal support and coping mechanisms in Bangladesh (Paul, 1998).

There is a growing literature that focuses on the nexus between natural shocks and household assets (Carter et al., 2007). Devesting assets as an ex post recovery response to natural shocks can lead to consumption smoothing for rural agrarian households in the short run. However, such responses can have seriously negative long-run implications, leading to far greater losses in the overall household well-being (Markhvida et al., 2020). In countries like Ethiopia and Honduras, the poorest agricultural households, in the absence of formal supporting and recovery mechanisms, frequently resort to selling productive assets (e.g., cattle) to shield themselves from the detrimental effects of natural disasters (Carter et al., 2007; Mogues, 2011). Similar trends can be observed in West African countries as well, where households use livestock as buffer stocks to insure household consumption from income fluctuations in the wake of natural disasters (Fafchamps et al., 1998). Likewise, in Zimbabwe, rural households adopt selling of livestock as a recovery response to droughts (Kinsey et al., 1998).

However, resorting to recovery responses that involve selling of productive assets can become impossible to adopt in the event of loss of such assets due to catastrophic natural disasters, which, in such situations, can only exacerbate further the destituteness of the already poor households, as seen in the case of Philippines (Anttila-Hughes & Hsiang, 2013). Brouwer et al. (2007) explored similar dynamics in a study conducted in the floodplain regions of south-eastern Bangladesh. In this study, the researchers argue that the rural households, that have comparably limited access to assets, are more exposed to natural disasters. They report that these households' ex ante preparedness and ex post ability to cope with shocks are very limited, and community-level supporting mechanisms are still not as efficient as they should be.

Data

We use the Developing Inclusive Insurance Sector Project (DIISP) survey data set for our analysis (Ahsan, 2012). The DIISP, which was administered in 2011, is a unique household survey conducted by the Palli Karma-Sahayak Foundation (PKSF). The survey was administered under the DIISP project funded by the Japan Fund for Poverty Reduction (JFPR) and administered by the Asian Development Bank (ADB). This survey records information regarding education, income, consumption, expenditure, wealth, health-seeking behaviour, shocks (both idiosyncratic and covariate), shock-coping mechanisms, micro-insurance

and microcredit for the poorer income brackets in urban and rural areas of Bangladesh. The objective of the survey is to devise and pilot appropriate micro-insurance services that will reduce vulnerability to poverty of the disadvantaged people, especially women, leading them out of the poverty trap.

Even though the survey focuses on the poorer income groups in both urban and rural settings, emphasis is placed on gathering systematic information from the underprivileged population who live in the geographically challenged areas. These topographically challenged locations are divided into four broad categories within the data set, namely coastal, island, *haor*[1] and *char*[2] areas. These locations are largely occupied by the rural sub-population in Bangladesh. Therefore, owing to the geographically challenging nature of these regions, the population is more susceptible to natural shocks compared to other regions of the country. The rural economy in Bangladesh is still largely based on agriculture. Around 43% of the employed population aged 15 years or older work in the agricultural sector, and of that almost 92% live in the rural areas of Bangladesh (BBS, 2017a). The attributes of the survey discussed earlier emphasise both the extreme vulnerability of a household and the functional inefficiency of critical and basic service delivery mechanisms, especially in the rural geographically challenged locations.

The DIISP household survey covers 3,490 households from both urban and rural areas of Bangladesh. The rural sample includes households from the hard-to-reach areas: coastal, *char*, *haor* and island. In this study, we consider only the rural sample, as our main objective is to evaluate the impact of climatic shocks on household consumption. Areas included in the household survey are Gaibandha, Patuakhali, Sunamganj and Swandip, which, by their geographical features, cover *char*, coastal, *haor* and island areas, respectively. The survey is designed to cover mainly the households that have memberships in microfinance organisations. In the first stage, to identify the MFI member households, a partner MFI of PKSF is chosen from each location. In the next step, two suitable branches are selected for each MFI and a sample frame is constructed from the list of member households under each MFI branch. The final rural sub-sample comprises 1,909 households from rural areas. Table 1 provides the distribution of the sampled rural households. The highest number of households (696) belong to coastal areas, followed by *char* (521), island (406) and *haor* (286) areas. In the regression analysis, we use a sample of 1,902 households only, as some of the information was missing for a few households.

Table 1. Distribution of Sample Households (Rural).

Rural	Freq.
Char	521
Coastal	696
Haor	286
Island	406
Total	1,909

Source: Developing Inclusive Insurance Sector Project (DIISP) survey dataset.

Table 2. Characteristics of Sampled Households (Rural).

Panel A: Characteristics of household heads	
Gender (female %)	9.0
Average age (in years)	44. 6
Primary occupation (%)	
Labour (daily and transport)	12.0
S.E./D.L. agriculture	48.0
S.E. industry and service	7.5
S.E. business	14.8
Salaried employee/professional	4.5
Other workers	13.2
Education (%)	
No schooling	51.0
I–IV	22.2
V–IX	20.7
SSC+	6.1
Panel B: Characteristics of households	
Average household size	4.8
Have electricity (%)	21.6
Floor (mud) (%)	96.3
Roof (tin) (%)	96.9
Wall (*katcha*) (%)	27.5
Wall (tin or wood) (%)	72.7
International migrants (%)	4.2
MFI member households (%)	86.0

Source: Authors' calculation based on DIISP survey data.

Note: The table summarises important attributes of the household head (panel A) and their corresponding household (panel B) based on the rural sample. The characteristics of household heads include gender, average age, occupation and educational attainment. The key household characteristics include average household size, availability of electricity, house construction materials, presence of international migrants and, finally, MFI membership status. S.E. = Self-employed and D.L. = daily labour.

As we consider only rural sample for the purpose of this study, we show some summary statistics in Table 2 for the sample of households located in rural areas only. More than 90% of the households are headed by males, and the average age of the heads is around 45 years. About half of the households (48%) are engaged in the agricultural sector (either as self-employment or as agricultural labour).

Other main occupations of household heads include self-employed business activities (14.8%) and employed as daily or transportation labour (12.0%). About half of the household heads have no formal schooling. Furthermore, over one-fifth (22.2%) of the household heads have education level below the primary level, and another 20.7% have schooling below the secondary level. The households consist of five members on average. Around 86% of these sampled households are members of microfinance institutions (MFIs). Only around 4% of the households have at least one member who works as an international migrant. Notably, only 21.6% of households have electricity, showing a low incidence of rural electrification. Almost 96% of the rural households' floors are made of mud, and roofs are constructed using tin.

Profile of Shocks in the Sample Households

Shocks are defined as events that may have negative impact on the well-being of households in the short run or in the long run. In the short run, shocks can influence well-being through impacting the current income (e.g., due to fall in labour supply) or consumption or selling of productive assets. On the other hand, to what extent shocks can affect well-being of the households in the long run depends on households' capacity to absorb the shocks and choices made to cope with the shocks. To obtain information on such adverse events, a shock profile is designed for the survey, which includes an exhaustive set of events typically encountered by the households in rural Bangladesh. Each household is asked whether it has faced any of the adverse events listed in the survey questionnaire or other similar events not specified in the survey.

The DIISP survey documents various types of shocks encountered by the households in the past 2 years of the survey, covering both idiosyncratic (e.g., health shock like acute illness) and covariate (e.g., climatic events) shocks. One key difference between health shocks and climatic shocks is that the former can be endogenously determined, and the latter types are generally caused by natural forces and therefore exogenously determined. In this article, we mainly analyse the impact of climatic shocks and other non-health economic shocks (e.g., unemployment or business loss) on household consumption. For the purpose of this article, the climatic shocks are broadly divided into the following categories: crop damage, loss of livestock, and fisheries and property damage caused by natural disasters. Loss in business and loss of employment are grouped into economic shocks, and rest of the shocks are categorised as other shocks. Property damage caused by fire is also included as a separate adverse event.

In addition to these, few more events are also included, which cannot be defined as shocks as such but involve lumpy expenditures that might have significant impact on household well-being. Incidents such as expenses for wedding and dowry or migration abroad are included in this category. The justification for including such events lies in the fact that households often fall into indebtedness by borrowing from moneylenders, financial institutions or friends and relatives, or encounter shortage of productive assets by selling or

mortgaging them out to handle such incidents. In both the cases, households' consumption may fall significantly, at least in the short run, depending on household-specific factors. Surveyed households are asked to provide information on the frequency of the events, total financial loss as a result of the shock, costs incurred and strategies adopted to cope with the shock.

Table 3 describes the incidence of shocks faced by the households, disaggregated by wealth quintiles, over the past 1 year of the survey. The households are categorised into the following wealth quintiles: lowest, second, middle, fourth and highest according to the wealth index, which is constructed using the Principal Component Analysis (PCA). Column 6 of Table 3 shows that overall, 23.3% of the households faced at least one shock (excluding lumpy expenses) over the past 1 year. With respect to the household wealth quintiles, no systematic pattern of shocks emerges for experience of any shock. The last row of Table 3 reports that the highest and lowest incidence of shocks are faced by households belonging to the highest (27.7%) and the middle (16.0%) wealth quintiles, respectively, with 22.1% of the poorest stating the same. Among the covariate shocks, crop damage appears to be the major one, affecting the highest percentage of households (16.6%). This is followed by livestock or fisheries loss, affecting 6.3% of the households and property damage due to natural disasters (3.5%). As observed in the case of experiencing at least one shock over the last survey year, no clear pattern is identified for each type of shocks against wealth status of the households.

Table 3. Incidence of Shocks by Wealth Quintiles.

	Wealth Quintiles					
	Lowest	Second	Middle	Fourth	Highest	Overall
	(1)	(2)	(3)	(4)	(5)	(6)
Crop damage	12.1	18.7	11.2	18.6	22.2	16.6
Livestock/fisheries loss	8.1	6.3	3.5	6.5	7.1	6.3
Property damage (natural disaster)	4.2	6.1	2.1	2.2	2.9	3.5
Employment/business loss	0.5	0.5	0.3	0.0	0.0	0.3
Lumpy expenses	2.4	1.3	1.1	1.9	1.1	1.5
Property damage (fire)	0.3	0.0	0.3	0.0	0.5	0.2
Others	1.8	2.3	2.1	1.1	1.1	1.7
Any shock (excluding lumpy exp.)	22.1	25.8	16.0	24.8	27.7	23.3

Source: Authors' calculation based on DIISP survey data.

Note: Columns (1–5) in the table represent the distribution of different shocks by wealth quintiles.

Table 4. Distribution of Coping Mechanisms by the Nature of Shocks.

	Crop Damage	Livestock/Fisheries Loss	Property Loss (natural disaster)	Employment/ Business Loss	Lumpy Expenses	Property Damage (fire)	Others	All Types of Shocks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unable to cope	94.0	88.5	38.5	61.1	5.3	16.7	57.4	77.7
Income	2.8	6	17.3	16.7	22.1	16.7	11.1	7.7
Savings	2.3	2.7	19.2	5.6	13.7	25	14.8	3.1
Borrowing								
Friends/relatives	0.3	0	5.8	5.6	11.5	8.3	3.7	2.2
MFI/NGO	0.8	2.7	9.6	11.1	17.6	16.7	9.3	4.7
Bank or FIs	0	0	1	0	0.8	0	0	0.1
Money lenders	0	0	1	0	6.1	8.3	1.9	0.9
Selling or mortgaging assets								
Permanent asset	0	0	0	0	4.6	0	0	0.6
Temporary asset	0	0	0	0	1.5	0	0	0.0
Livestock	0	0	4.8	0	12.2	0	0	2.0
Donation and relief	0	0	2.9	0	3.8	8.3	0	0.6
Others	0	0	0	0	0.8	0	1.9	0.2
Overall	100	100	100	100	100	100	100	100

Source: Authors' calculation based on DIISP survey data.

Note: Columns (1–7) in the table report distribution of coping mechanisms by the nature of shocks. Column 8 includes an overall distribution of coping mechanisms adopted by the households.

In the DIISP survey, respondents are asked to report two major coping strategies adopted by the households in response to each shock (Table 4).[3] Households may need to combine various coping strategies to deal with shocks, depending on the nature and burden of the shocks. The distribution of shock-coping mechanisms for different types of shocks is reported in Table 4. A significant portion of the households (77.7%) report that they are unable to cope with the shocks (column 8), which implies that they either fail to make use of any financing sources in response to shocks or are forced to use them inadequately. Such inability to cope with the shocks is very high for crop damage (94%) and loss of livestock or fisheries (88.5%). These two are generally the most direct income shocks with immediate impact for households who depend on agricultural activities for survival. As a result, when these shocks occur, most of the households fail to take any effective action in the short run to compensate the loss.

The distribution of shock-coping mechanisms for all types of shocks in column 8 of Table 4 shows that households utilise current income in 7.7% of the cases or savings in 3.1% of the cases in combination with other mechanisms. Household's utilisation of income and savings increases up to 17.3% and 19.2%, respectively, for recovering from property loss due to natural disasters. These measures are expected to be linked with short-term fluctuations in the level of household well-being. However, the data highlight the importance of the mechanisms that are likely to have long-run impoverishing effects like borrowing from different sources and selling or mortgaging assets. Table 4 shows that the affected households use borrowings from friends or relatives and MFIs to insulate themselves against various shocks. Households resort to borrowings from the MFIs in 4.7% of the cases to manage immediate need of funds caused by the adverse shocks.

Similarly, in case of property damage due to natural disasters, 9.6% of the households reported that they borrowed from MFIs. Though selling or mortgaging assets is not used to secure funds to cope with climatic shocks like crop damage and loss of livestock or fisheries, approximately 4.8% of the households sold their livestock to finance the property loss caused by natural disasters. The aforementioned analysis deserves careful consideration. In the survey, households are asked to report how they have managed funds to cope with the shocks. As such, coping strategies reflect financing options utilised by the households immediately after the shocks, the analysis does not reflect the impacts of shocks on different aspects of households' well-being like consumption and labour supply even in the short run. As observed in Table 4, most of the households reported that they were unable to cope with crop damage and livestock or fisheries loss, which might have far-reaching implications for household well-being like reduction in consumption expenses or borrowing at high interest rates to maintain their current level of consumption.

Estimation Method

Impact of climatic shocks on households' well-being is estimated by following household-level regression specification:

$$C_{hj} = \alpha + \beta_s \text{ Shock}_s + \delta X_h + \xi_{hj} \quad (1)$$

where the dependent variable, C_{hj} is a particular measure of well-being of a household h located in area j. In this article, we measure well-being of a household mainly with consumption expenditure per capita per day, where consumption is the combination of food and non-food items, excluding all types of medical expenditures. In regression analysis, we take natural log of consumption expenditure per capita per day as our main dependent variable. Since the impact of a shock on consumption may differ across various types of consumption within a household, we also test the impact of shocks separately on two main consumption categories—food and non-food. Shock_s is a dummy variable that takes the value of '1' if the household h has experienced a catastrophic event in the past 1 year of

the survey, and '0' if otherwise. In our baseline regressions, we consider the impact of three types of shocks: crop damage, livestock/fisheries loss and property loss, which are experienced by the households as a result of adverse climatic events like floods and cyclones.

The vector X_h represents a set of observable household characteristics, including household-specific factors like characteristics of the household head and wealth quintile dummies. ξ_{hj} is a mean-zero disturbance term that captures unobserved idiosyncratic and local-level shocks, contributing to differential level of well-being for households that are otherwise observationally equivalent.

The justification for using the aforementioned composition of consumption, excluding medical expenditure, is that there is a trade-off in consumption between the expenditure for healthcare and other items (food and non-food). Composition of the consumption expenditure variable is also importantly related with the significance of insurance mechanism. For example, Asfaw and von Braun (2004) cannot reject consumption insurance for the sample of rural Ethiopian households, when total food consumption expenditure is used as a dependent variable; though it is rejected for purchased food consumption.

Based on specification (1), we estimate the impact of climatic shocks on different types of consumption in logarithmic form, using the ordinary least square (OLS) approach. Our main variables of interest—climatic shocks—are exogenously determined and therefore are not subject to reverse causality bias (Dell et al., 2014). In order to check the influence of other household-specific characteristics on our main variables of interest, we show results both with and without household-level characteristics in alterative specifications. These factors control for other differences in household characteristics that are associated with the level of consumption expenditures. For instance, as consumption level is likely to increase with the wealth level of households, we include a set of wealth quintile dummies as control variables. We also control for sex, age and education of the household head, as these characteristics are generally associated with consumption expenditure. One such channel is through their influence on the resilience of the households as reported by Fuller and Lain (2019).

Results and Discussion

Impacts of various climatic shocks on consumption expenditure of households are reported in Table 5. Columns (1) and (2) report regression results for log of total consumption expenditure per capita per day, including both food and non-food components. Columns (3) and (4) present results for food and (5) and (6) present results for non-food consumption expenditures. Figures in parentheses show the robust standard errors for the estimated coefficients. Columns (1), (3) and (5) show the regression results for climatic shocks without controlling for the characteristics of households and columns (2), (4) and (6) report the results after controlling for these factors.

Table 5. Impact of Climatic Shocks on Consumption Expenditure.

	Total Consumption		Food Consumption		Non-food Consumption	
	(1)	(2)	(3)	(4)	(5)	(6)
Crop damage	−0.073**	−0.101***	−0.027	−0.048*	−0.242***	−0.284***
	(0.033)	(0.030)	(0.029)	(0.028)	(0.052)	(0.046)
Livestock/fisheries Loss	−0.079*	−0.061	−0.041	−0.028	−0.191***	−0.157**
	(0.042)	(0.038)	(0.039)	(0.037)	(0.072)	(0.063)
Property loss (natural disaster)	−0.053	0.028	0.014	0.070	−0.390***	−0.237***
	(0.067)	(0.060)	(0.062)	(0.058)	(0.108)	(0.091)
Education of household head (HH)						
Less than primary		0.071***		0.055**		0.113***
		(0.026)		(0.024)		(0.040)
Primary to less than secondary		0.183***		0.098***		0.411***
		(0.026)		(0.021)		(0.046)
Secondary and above		0.345***		0.217***		0.673***
		(0.045)		(0.035)		(0.078)
Age of HH head		−0.004		−0.002		−0.008
		(0.005)		(0.004)		(0.008)
Age of HHH square		0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)

(Table 5 Continued)

(Table 5 Continued)

	Total Consumption		Food Consumption		Non-food Consumption	
	(1)	(2)	(3)	(4)	(5)	(6)
Female-headed HH		−0.087***		−0.065***		−0.144***
		(0.028)		(0.024)		(0.054)
Wealth quintile						
Second		0.056**		0.051**		0.052
		(0.028)		(0.025)		(0.049)
Middle		0.157***		0.128***		0.296***
		(0.027)		(0.025)		(0.046)
Fourth		0.239***		0.195***		0.389***
		(0.030)		(0.027)		(0.052)
Highest		0.450***		0.318***		0.799***
		(0.032)		(0.027)		(0.056)
Constant	3.851***	3.631***	3.555***	3.391***	2.329***	1.979***
	(0.011)	(0.112)	(0.009)	(0.095)	(0.020)	(0.190)
R-squared	0.006	0.241	0.000	0.159	0.029	0.301
N	1,902	1,902	1,902	1,902	1,902	1,902

Source: Authors' calculation based on DIISP survey data.

Note: The table reports results from regressions of different types of consumption expenditures (total, food and non-food) in logarithmic form on a set of climatic risks and household characteristics. Robust standard errors of the coefficients are reported in parentheses.

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

The regression results are quite intriguing. First, the climatic shock coefficients appear with a negative sign in most of the specifications. Second, although damage to crops due to flood and other natural disasters has a statistically significant negative impact on log total consumption (per capita per day) of households, this is mainly driven by the reduction of non-food consumption rather than food consumption. Similar pattern is observed for loss of livestock or fisheries caused by natural disasters. Finally, although loss of property has no statistically significant impact on total consumption, it has significantly negative impact on non-food consumption (per capita per day).

In column (1) of Table 5, the coefficient of *crop damage* shock is −0.073 when we do not control for any household characteristics. After controlling for household characteristics in column (2), the estimated coefficient jumps to −0.101 and becomes statistically significant at the 1% level. Interpretation of the coefficient of crop damage is that total consumption expenditure (per capita per day) of the households that have experienced at least one event of crop damage in the past 1 year of the survey is approximately 10% lower than that of the households that have not faced any such event over the same period holding other factors constant. In columns (3–4), we observe that the coefficients of climatic shocks corresponding to crop damage and loss of livestock remain negative but those belonging to property loss shock become positive. However, none of the climatic shock coefficients is statistically significant for log food consumption per capita per day, except for crop damage in column (4), which is statistically significant only at the 10% level. The results are strikingly different for non-food consumption expenditure per capita per day. The size of the climatic shock coefficients increases significantly for non-food consumption compared to total consumption specifications, and results are statistically significant at the 1% level for both crop damage and property loss shocks in columns (5) and (6). For loss of livestock or fisheries, the coefficient is significant at the 1% level in column (5) and at the 5% level in column (6).

In specifications (2), (4) and (6) of Table 5, most of the estimated coefficients of household characteristics appear with economically meaningful signs and remain consistent across different specifications. First, coefficients on household head's educational qualification dummies appear with a positive sign and remain statistically significant at the 1% level in all regressions. The magnitude of the coefficients also increases with the education level of household head compared to the base category (i.e., no education).

The coefficient related to female-headed households is negative in columns (2), (4) and (6), suggesting that the households whose heads are females have lower level of per capita consumption compared to the male-headed households. Finally, the dummy variables representing wealth quintiles of the households are all positive and statistically significant in all regressions. In column (1), the coefficient 0.056, corresponding to the second wealth quintile, indicates that the per capita per day consumption expenditure of households belonging to the second wealth quintile is approximately 6% higher than that of the households that belong to the lowest wealth quintile (i.e., the base category). Such differences in consumption expenditure is largest between households in the lowest and in the highest quintiles.

Table 6. Impact of Climatic Shocks on Consumption Expenditure (wealth effect).

	Total	Food	Non-food	Non-food
	(1)	(2)	(3)	(4)
Climatic shock	−0.097**	−0.067*	−0.242***	−0.215***
	(0.045)	(0.038)	(0.093)	(0.061)
Education of household head (HH)				
Less than primary	0.058**	0.047*	0.091**	0.096**
	(0.026)	(0.024)	(0.039)	(0.039)
Primary to less than secondary	0.166***	0.087***	0.384***	0.388***
	(0.025)	(0.020)	(0.044)	(0.044)
Secondary and above	0.331***	0.210***	0.641***	0.653***
	(0.045)	(0.034)	(0.078)	(0.077)
Female-headed HH	−0.072***	−0.054**	−0.125**	−0.129**
	(0.028)	(0.024)	(0.054)	(0.054)
Wealth quintile (WQ)				
Second	0.037	0.033	0.035	
	(0.031)	(0.028)	(0.055)	
Middle	0.165***	0.125***	0.335***	
	(0.030)	(0.028)	(0.050)	
Fourth	0.248***	0.192***	0.444***	
	(0.033)	(0.029)	(0.058)	
Fifth	0.474***	0.320***	0.856***	
	(0.036)	(0.029)	(0.064)	
Second WQ × climatic shock	0.085	0.090	0.044	
	(0.069)	(0.063)	(0.124)	
Middle WQ × climatic shock	−0.040	0.019	−0.224*	
	(0.070)	(0.064)	(0.124)	
Fourth WQ × climatic shock	0.001	0.039	−0.168	
	(0.078)	(0.072)	(0.127)	
Highest WQ × climatic shock	−0.039	0.028	−0.149	
	(0.072)	(0.059)	(0.128)	
Wealth quintile (category)				
Middle (middle WQ and fourth WQ)				0.367***
				(0.038)
Highest (highest WQ)				0.834***
				(0.057)
Middle × climatic shock				−0.196**
				(0.086)

(Table 6 Continued)

(Table 6 Continued)

	Total	Food	Non-food	Non-food
	(1)	(2)	(3)	(4)
Highest × climatic shock				−0.174
				(0.107)
Constant	3.608***	3.385***	1.877***	1.893***
	(0.021)	(0.019)	(0.040)	(0.031)
R-squared	0.236	0.153	0.301	0.300
N	1,902	1,902	1,902	1,902

Source: Authors' calculation based on DIISP survey data.

Note: The table reports results from regressions of different types of consumption expenditures (total, food and non-food) in logarithmic form on a set of climatic risks and household characteristics. Robust standard errors of the coefficients are reported in parentheses.

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

In Table 5, we observe that in rural areas of Bangladesh, the average consumption level of wealthier households is relatively higher than the poorest group, and the difference in consumption increases as we move towards the highest wealth quintile. However, it is not clear to what extent the relatively wealthier households in these geographically challenged locations are insured against climatic shocks. To investigate this question, we interact the wealth quintile dummy variables with a climatic shock variable. For this regression, we construct a dummy variable and define it as *climatic shock* that takes the value '1' if a household has faced an incident of crop damage or livestock loss or fisheries loss or property damage due to natural disasters in the past 1 year of the survey, or '0' otherwise. We interact the *climatic shock* dummy with the set of wealth quintiles dummies to evaluate the impact of climatic shocks on consumption across wealth quintiles.

In Table 6, the estimated coefficient of *climatic shock* appears with a negative sign across all columns. In the first row of column (1), the estimated coefficient −0.097 indicates that within the lowest wealth quintile, total consumption (per capita per day) expenditure of the households that experienced at least one climatic shock is around 9% lower than that of the households that did not experience any shock in the past 1 year of the survey. The estimated coefficients corresponding to the wealth quintile dummies then show the differences in consumption levels between the lowest wealth group and the relatively higher wealth groups, given that the households did not experience any climatic shock. These estimated coefficients appear with a positive sign, indicating that the consumption level increases with wealth in the absence of shocks. The estimated coefficients are statistically significant at the 1% level in all cases, except for the second wealth quintile, where the coefficient is statistically insignificant in all specifications.

The estimated coefficients relating to the interaction terms are statistically insignificant in case of both total consumption and food consumption expenses but appear to be statistically significant for one out of four quintile dummies in case of non-food consumption. In column 3, the estimated coefficient of the interaction term for the middle quintile appears with a negative sign and is statistically significant at the 10% level. The coefficients on the interaction terms for the fourth and the fifth wealth quintiles are also negative but statistically insignificant.

In order to investigate the issue further, we re-categorise the households into three mutually exclusive wealth groups: low, middle and highest, based on the wealth quintiles. The low wealth category includes the lowest and the second quintile households, the middle wealth category includes the middle and the fourth quintile and the highest category includes only the highest quintile. In column (4), we show the regression results for non-food consumption using this wealth classification. The coefficient on the interaction term for the middle wealth group (i.e., middle and fourth quintile) appears with a negative sign and is statistically significant at the 5% level. The results suggest that climatic shocks negatively affect not only the non-food consumption of the poorest segment of the households but also the relatively wealthier ones in the geographically challenged areas of rural Bangladesh.

The relatively low impact of climatic shocks on food consumption expenditure of the households needs further clarification. In this article, the climatic shock variables are measured at the household level, based on self-reported experience of the households. The experience of shocks varies across households within locality, depending on the location of the agricultural land and property of the households, which are exogenously determined. In the descriptive analysis, we show that the incidence of shocks is not dependent on the wealth level of the households, which suggests the randomness of the climatic events. Since not all the households within a particular locality experience such shocks within a particular period, informal insurance mechanisms like borrowing from neighbours or MFIs can still play an important role in safeguarding consumption expenditure of the households. In a related study, Ahsan et al. (2014) show that in rural Bangladesh, 16.2% and 27.2% of the households cope with crop damage and property damage shocks, respectively, by borrowing from different sources (e.g., MFIs, formal and informal moneylenders).

Conclusion

Climatic shocks such as floods, cyclones, droughts and excessive rainfall adversely affect agricultural production and economic activities in rural areas. A large portion of the households living in rural areas are dependent on agricultural

production for their livelihood. As a result, their economic well-being critically depends on the occurrence and the extent of such adverse events. The risks of such climatic shocks are much higher in geographically challenged locations. In the absence of any formal insurance mechanism, households often rely on informal insurance or coping mechanisms. These shocks increase households' vulnerability to poverty and reduce their prospects of coming out of poverty. In order to design a formal social security system to protect the households from negative economic impact of such shocks, it is important to have a clear understanding of the impact of such shocks on the level of well-being.

In this study, we evaluate the impact of different climatic shocks on consumption-based measures of economic well-being in remote rural locations, which are prone to natural disasters. We find that food consumption of rural households is somewhat insured against climatic shocks, but that is not the case for non-food consumption. We observe that the households that have experienced a climatic shock in the past 1 year of the survey have spent less on non-food items compared to those that did not experience such shocks. We further document that climatic shocks adversely impact not only the non-food consumption of the poorest households but also that of the relatively wealthier households in remote locations of Bangladesh.

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Notes

1. A *haor* area is defined as a bowl-shaped concavity of a floodplain naturally surrounded by river levees, which can usually retain water for 7–8 months (IUCN, 2004).
2. A *char* area is defined as a non-permanent bar of sand with an area that is usually 100 meters across and with an average duration of 10 years, appearing in the Bengal Delta (Rogers et al., 2013).
3. Some households report that they were unable to cope with the shocks so could not adopt any coping mechanism or adopted one strategy inadequately. Again, some households report a single coping strategy in some cases.

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Article

Degradation of Soil Quality in Mandalay Region of Myanmar Due to Overuse of Pesticides in Agriculture

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Abstract

Landlords and cultivators of watermelon (*Citrullus lanatus*) and several other types of melons (*Cucumis melo var. Cantalupensis*, *Cucumis melo var. Reticulatus*, *Cucumis melo var. Cucumis melo Inodorusvar*, etc.) complained about soil degradation due to cultivation of melons without judicious use of pesticides. Conducting a field survey on the use of pesticides and the prevalence of pesticide residues in the soil of melon-cultivated areas, the study investigates the authenticity of such claims and figures out the actual reasons for such land degradation. The survey was carried out on 150 farmers from 30 villages in Kyaukse, Myitthar and Tada U Township in Mandalay division of Myanmar. The survey captures information on pesticide-related awareness, attitudes and practices and identifies possible health and environmental risks. The usage, storage and handling of pesticides by most of the respondents were found not safe, and knowledge on the adverse effects of pesticides on health, crops and the environment was found to be inadequate. The findings have indicated the potential risk of soil degradation. It appears that lack of cooperation among the government, non-governmental organisations (NGO), private sector stakeholders and farmers is the key weakness for improving agricultural practices adopted by farmers. Enhancing the awareness, changing the attitudes and improving the practices of the farmers regarding the use of pesticides may be the key step towards addressing this issue.

Keywords

Watermelons cultivation, pesticide use, degradation of soil quality, pesticide residues analysis

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Introduction

Myanmar relies mainly on agriculture, which is the backbone of its economy, accounting for 37.8% of its gross domestic product (GDP), 25%–30% of its total export earnings and 70% of its employment (Source FAO, 2014). Myanmar's trade with China is heavily dominated by cross-border trade through the Yunnan province, watermelons and melons being one of the main export items. In 2016, around USD 169.0 million worth of watermelons were exported to China from Myanmar through cross-border trade (Kubo & Sakata, 2018). The main cultivation areas of watermelons and melons are in Mandalay and Sagaing division, Central Dry Zone. According to the data published by Koji (2016), 18,907 acres were under watermelon, and 823 acres were under melon cultivation in the Mandalay area. One of the stylised facts of this melon farming is that many melon growers operating in these areas grow them on land received from local landowners by paying rentals.[1] Local landlords who rent out their land to tenant farmers of melon often complain that they (landlords) cannot grow any crops in their lands, where melons and watermelons are being cultivated for 3–5 consecutive years. There are complaints of indiscriminate or injudicious use of pesticides in melon cultivation, which is responsible for soil degradation.

Obviously, there is a potential conflict of interest between landlords and tenant farmers with respect to preserving the quality of soil. Often, we observe that excessive utilisation of pesticides and other chemicals increases production in the short term, but it brings an adverse consequence of such excessive utilisation in the long term. But the long-term consequence is borne by the landlords and therefore the complaints by the landlords deserve attention. Considering the repercussions relating to indiscriminate use of pesticides by farmers in melon cultivation, an urgent scientific study is deemed necessary to find out the authenticity of such claims and explain why these lands in this region have shown reduction in output for other crops typically grown in these areas.

This study aims to analyse pesticide residues, particularly in watermelon- and melon-growing area in the Kyaukse region to investigate the farmers' awareness, attitudes and practices towards pesticides and their use. A survey was carried out to collect information on commonly used agrochemicals, pesticide-related practices using questionnaires and examine pesticide residues in the fields where melons and watermelons are grown. The findings are applied for developing a suitable programme and action plan to prevent further deterioration of soil and environment in the focus area.

Literature Review

Soil degradation occurs due to the changes in the physical, chemical and biological properties of soil. Pollution of soil due to industrial or waste accumulation, excessive use of pesticides, acidification by airborne pollutants, excessive manuring, oil spills, etc., are some of the factors that cause soil degradation

(Oldeman, 1992). The cultivation of watermelons requires a more significant expenditure on farm labourers and input materials, including chemical fertilisers (Koji, 2016). Watermelons and melons are highly susceptible to environmental and biological factors such as pest and disease caused by fungi, bacteria, nematodes and viruses. Therefore, the use of pesticides is inevitable to get higher yields with good quality at harvest (Nguyen et al., 2008; Park et al., 2010). Further, Nguyen et al. (2008) recorded around 156 different pesticide residues in commercial watermelons in Korea. Moreover, Essumang et al. (2013) reported that organo-chlorine (OC) and organo-phosphorus (OP) pesticides persisted in other vegetable crops grown near watermelon fields in Ghana. These studies indicate that the use of pesticides in watermelon cultivation is unavoidable to get a reasonable yield, which, in turn, gives farmers a good economic return.

Deleterious effects of pesticides in the environment have been studied extensively, and abundant literature is available. Essumang et al. (2013) reported that if pesticides are used by directives, it will not harm environmental and human health. If the pesticides with long half-life are applied continuously to control insects, weeds or diseases, there will be a residual activity, and land degradation might occur after the continuous application of large quantities of pesticides (Joko et al., 2017). Indiscriminate use of pesticides can contaminate soil; destroy other non-target species; and damage soil biomass and microorganisms such as bacteria, fungi and earthworms (Azam et al., 2003). Furthermore, pesticides applied to soil can kill native microbial communities needed for soil fertility and pesticide degradation itself (Lo, 2010). Resistance to pesticides caused by improper use of pesticides is also a threat to the environment (Joko et al., 2017). The impact of pesticides on soil has been intensively studied in the laboratory and has proved to be correlated to the biological and physico-chemical properties of the soil. However, most of the studies have been carried out under laboratory conditions, and field studies are conspicuously lacking (Pal et al., 2010).

Lo (2010) reported that an integral part of the risk evaluation of pesticides is considering the impact of pesticides on soil microflora and their beneficial activities. In order to implement effective pest control programmes, understanding the current state of knowledge, attitude, practices adapted for pesticides and the perception that users have about pesticides is needed (Ajayia, 2000). It is also very crucial to study people's knowledge level regarding pesticide use and its effects on humans and the environment (Al-Zaidi et al., 2011).

Materials and Methods

Time and Study Area

A total of 30 villages from Kyaukse, Myitthar and Tada U Township, falling in the Kyaukse district, were selected for this study (Figure 1). Sampling and interviews were conducted from December 2016 (during the cultivation period) to April 2017 (after the cultivation period).

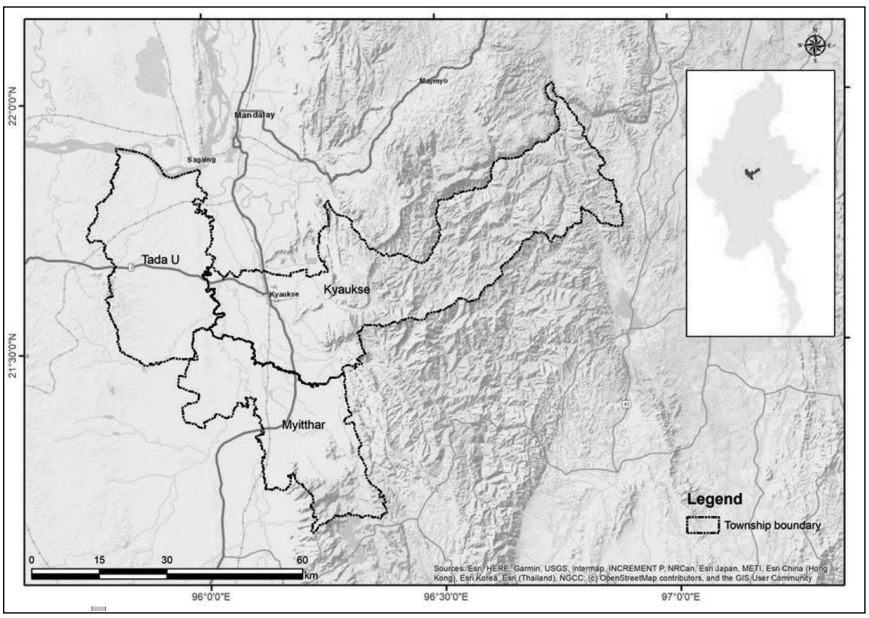

Figure 1. Map of the Study Area (Kyaukse, Tada U and Myitthar Township), Mandalay Division, Myanmar.

Source: Satellite data.

Questionnaire and Field Survey

A total of 150 farmers from study sites participated in the in-depth interview. The questionnaire was prepared in the Myanmar language to examine farmers' attitudes about agrochemicals handling, storage and disposal activities, information about adverse environmental and health effects, and the source of agrochemicals' information. A multiple-choice questionnaire was distributed among the participants to gather general information from the local farmers. There were 35 questions in the survey questionnaire, which took approximately 30–45 min to complete individually. Farmers who participated in interviews cultivated traditional (rice, beans, sesame seeds, etc.) and exported crops (watermelons and melons). Information on watermelon- and melon-planting patterns in the study fields, pesticide use, pesticide types, pesticide mixing, spraying and time of pesticide usage, depending on planting time, were also collected during the interview. While conducting the questionnaire survey, we educated the farmers about the potential risk of agrochemical overuse. Instruments used in the study are questionnaires, notes and recorders, and sampling bags for soil sample collection. For a detailed assessment, questionnaires' results were stored in the Microsoft Office Excel for descriptive analysis. Data are descriptively presented in tables and graphs based on the existing findings of observations and respondents' interviews.

Figure 2. Soil Sampling in Watermelon and Melon Fields.

Source: The authors.

During the questionnaire study, fields were searched to look for empty pesticide containers to check the pesticides that were used by farmers, as they did not share information on used pesticides. They did not want to reveal the information since they used unauthorised pesticides. The information collected in this way was classified by active ingredient, toxic level and type of pesticides.

Collection of Soil Samples

Soil samples were collected from 10 different fields, where watermelons and melons were cultivated for the first time, to study the pesticide residues (Figure 2). During December 2016 (during the cultivation period) and April 2017 (after the cultivation period) when farmers were being interviewed, soil samples were collected randomly across the field at a depth of 10–50 cm, using soil cover after removing the top soil. Approximately 1 kg of soil sample was collected from each sampling point. The soil samples were then placed in sampling plastic bags and labelled with sample codes, sampling dates and sample locations. Samples were immediately sent to the laboratory and stored at 4°C for analysis.

Preparation of Soil Samples and Extraction of Agrochemical Residues

All soil samples were dried in a hot air oven for 1 h at 60°C and then gently crushed and sieved with (< 2 mm) mesh. Then, 10 g of soil sample was dissolved in 10 ml of distilled water and centrifuged at about 4000 rpm for 10 min. After centrifugation, 10 ml of the upper layer was taken and mixed with 10 ml of

acetonitrile (90% purity grade), shaken in a separatory funnel and allowed to settle down to get a clear upper layer. After that, the upper layer was evaporated with a rotatory evaporator at 95°C and a small amount of residue concentrates was re-dissolved in 2 ml of acetonitrile and the vials were prepared to analyse the pesticides by GC-MS. Matrix extraction and purification were performed according to ISO 22892: 2006 (en).

For the determination of OC) and OP groups, GC-MS (SHIMADZU, GC-2010) with an electron capture detector (ECD) was used. The resulting chromatograms were analysed by using Mass Spectral Libraries and Databases (SHIMADZU). For the analysis of OC, the oven temperature programme was 70°C (2 min hold) to 160°C, 15°C/min to 270°C and 5°C/min (18 min hold). The temperature of the injection port was 250°C, and a 1 µL volume was injected in split-less mode. For the analysis of OP, the oven temperature programme was 150°C (1 min hold) to 225°C and 5°C/min (18 min hold). The temperature of the injection port was 220˚C, and a 1 µL volume was injected in split-less mode.

Results and Discussion

Data Analysis

Data were entered in Microsoft Excel and analysed with Stata (Intercooled Standard version 14.0). Descriptive analysis of various variables such as age, level of education, primary occupation, types of crops cultivated, household chemical use, pesticide use and storage, and knowledge about the effects of pesticides on crops, health and soil was also carried out. The analysis was carried out on the study population ($n = 150$). Data were analysed by descriptive statistics using frequency distribution, percentage, mean and standard deviation.

The Use of Pesticides in Studied Area

The results presented here are limited to the Kyaukse district only and do not represent the state or national scenario. Agrochemicals such as fertilisers and pesticides play an important role in increasing crop yields and productivity in modern agriculture. In this survey, from used pesticide packages, information on active substance(s) were recorded. Table 1 describes 27 different pesticides that were mostly used by farmers in the sites surveyed. In these study fields, various types of insecticides, herbicides, fungicides and bactericides were used. From the study area, there were 14 different kinds of insecticides that were recorded. Among them, imidacloprid was the most used insecticide followed by abamectin. It was also found that some products that were used in this area contained a mixture of active substances. All these insecticides listed belong to WHO Hazard Class and Health Effects of IB, II and III and was rated as moderately hazardous. Fungicides, bactericide and herbicide have also been widely used, especially during the rainy season. The reason behind this is that increased rainfall triggers

weed growth, leading to crop diseases (Joko et al., 2017). From field surveys, eight types of fungicides, two types of bactericides and two types of herbicide packages of different brands were collected. Glyphosate and quizalofop-p-ethyl were the recorded herbicides in this survey. Glyphosate was the most widely used active ingredient in the herbicide category and Carbendazim was found to be an extensively used fungicide.

Table 1. List of Used Pesticides Collected in Studied Locations, Classified Using the WHO Hazard Class and Health Effects, 2009.

Type of Pesticides	Active Ingredients	Concentration (%)	WHO Class	Distributer
Insecticide	Imidacloprid	70	II	WiSaYa, Aventine Ltd, Awba, Golden Key Co. Ltd, J. japan, Powder Agro, No poison Crop Science Co., Ltd., Taung paw thar YiShin
	Abamectin	1.8	II	Awba, Golden Key Co. Ltd
	Carbofuran	3	IB	WiSaYa
	Lambda cyhalothrin	10	II	Min Ma Har, Powder Agro
	cypermethrin	10, 5	II	Arysta Life Science, Powder Agro, Awba, Armo
	Dinotefuran	20	-	Armo
	Thiamethoxam	25	III	JDS Company
	Thiocyclam oxalate	50	-	Arystal Life Science
	Acephate	75	III	Powder Agro
	Emamectin Benzoate	15, 5	II	Min Ma Har, Powder Agro
	Acetamiprid	20	II	Powder Agro, Farm Link
	Chlorpyrifos	50	III	Powder Agro, Awba, Armo
	Carbamic acid	50	-	Golden Key Co. Ltd
	Endosulfan	35	II	Golden Key Co. Ltd
	Profenofos	50	II	Awba

(Table 1 Continued)

(Table 1 Continued)

Type of Pesticides	Active Ingredients	Concentration (%)	WHO Class	Distributer
Fungicide	Zineb	14.5	III	Anawyahta
	copper oxychloride	37, 45	III	Anawyahta, Powder Agro
	Hexaconazole	5	No Hazard	Awba
	carbendazim	50	U	Awba
	Cymoxanil	-	III	WiSaYa
	Copper hydroxide	77	III	Product of Thailand
	Mancozeb	80	No Hazard	Awba
	Propiconazole	250g/L	II	Awba
Herbicide	Glyphosate (isopropylamine salt of glyphosate)	41.2	2A	WiSaYa
	Quizalofop-p-ethyl	10	II	WiSaYa
Bactericide	kasugamycin	2	No Hazard	Powder Agro
	Oxalic acid	20	Acute Tox. 4	EVOGRO Co. Ltd

Source: The authors.

From this field survey, it was found that kasugamycin and oxalic acid were the only two bactericides used by the farmers. Registered dealers with many representative sellers in every village have sold these pesticides found in this field survey. Pesticides when exposed to environment start to break down into simple, usually less toxic compounds, through photolysis, hydrolysis, volatilisation and microbiological degradation. Some pesticides stimulate growth of microorganisms, whereas some other pesticides, when administered at normal rates, have depressive effects or have no impact on microorganisms (Lo, 2010). The exact half-life of each pesticide depends on the active ingredient, the formulation and the condition of the environment (Kerle et al., 1994). All the pesticides reported are moderately hazardous to humans and the environment according to the WHO hazard classification (Terms Safety & IPCS, 2005). If farmers follow the directions on the label properly, pesticides will be less harmful to humans and the environment.

Table 2. Pesticide Residues in Soil Collected from Watermelons and Melon Fields During the Cultivation Period.

No.	Sampling Sites	Residues Name	Molecular Weight (kb)	Formula	Kind of Residues
1	1 (U Min)	2-(o-Methoxyphenyl)-4,5-diphenylimidazole	326.4	$C_{22}H_{18}N_2O$	Insecticide
2	2 (Chaung bat)	Naphtho(2,1-b) thiophene	184.26	$C_{12}H_8S$	Insecticide
3		Benzamide,4-fluoro-N-(2-(2-furanyl) ethyl)			Herbicide
4		7-chlorp-2,3-dihydro-5-phenyl-3-trienyl-2) methylene)-1H-1,4-Ben-benzodiazepin-2-one	364	$C_{20}H_{130}N_2O_{18}$	Insecticide
5		2,5-dioxo-2,5-dihydropyrol-1-yl) acetic acid	155	$C_6H_5O_4N$	Herbicides
6	3 (Pal Lay Sal)	Ethanol 2-(2,4-dichlorophenoxy)	20	$C_8H_8O_2Cl_2$	Herbicide
7	4 (Ton lon)	9-chloro-1-fluro-12H(1,3) benzothiazole(2,3-B) quinazdin-12-one	304	$C_{14}H_{80}N_2OF_8$	Insecticide
8		1-alpha-acetoxy-3-alpha,4-alpha-dimethyl-4-beta-(1,3-dioxolan-2-4)	490	$C_{27}H_{38}O_{68}$	Insecticide

Source: The authors.

Pesticide Residues in Soil

The collected soil samples were analysed to determine the presence of pesticide residue that are accumulated in the soil due to overuse of pesticides during the cultivation period and stoppage of pesticide spraying after the cultivation period. The presence of pesticide residue was confirmed by the GC-MS analysis of soil samples, as shown in Tables 2 and 3. The findings revealed that there was some accumulation of residue of pesticides in soils where watermelons and melons were cultivated.

Table 3. Pesticide Residues in Soil Collected from Watermelon and Melon Fields After the Cultivation Period.

No.	Sampling Sites	Residues Name	Molecular Weight (kb)	Formula	Kind of Residues
1	1 (U Min)	Pyrrole,2-(2-naphthyl)-3,5-diphenyl			Insecticide
2		Acridine-9yl-naphalen	320	$C_{23}H_{16}N_2$	Dye
3	5	2,5-Dihydrothiophene	88	C_4H_{66}	Insecticide
4	(Thaman Gone)	Benzothiozole,2-(4-amino-3-methylphenyl	240	$C_{14}H_{12}N_{28}$	Anti-bacterial
		Ethane 1,2-dione,1-(2-methyl-1H,indo-3-yl)2-(4-phenylpiperazin-1)	347	$C_{21}H_{21}O_2N_3$	Antivirus
5	6 (Nwar Ku Lay)	Anthracene,9,10-dihydro-9-91-Methylpropyl	236	$C_{18}H_{20}$	Pesticide
6		Methane,Bis (fluoranthen-3-yl)	416	$C_{33}H_{20}$	Polycyclic aromatic hydrocarbon
7		5,5-BIS 92-94-Aminophenyl-1H-1,3-benzimidazole	416	$C_{26}H_{20}N_6$	Herbicides
8	7 (Kyan Taw)	Benzenamine,4-nitro-N-(triphenylphosphoranylidene)	398	$C_{24}H_{19}N_2O_2P$	Organo-inorganic compounds
9		propanedinitrile(5-dimethylamino)2,3 dihydro-1H-inden-1-ylidene	223	$C_{14}H_{13}N_3$	Insecticide
10		quinoline,3,6-dimethyl-2,4-diphenyl	309	$C_{23}H_{19}N$	Fungicide
11	8(Kone Gyi)	methylthio-2-cyano-3-(2-cyano(carboxy)methyl-1-cyclopent	334	$C_{16}H_{1804}N_{26}$	Herbicide
12		P-toluic acid,3,5-dimethyl phenyl ester	240	$C_{16}H_{16}O_2$	(free aromatic acid) biodegradable and insecticide
13	9 (Nal Toe)	2-(p-bromohenyl)-8-methyl-8Hthieno(2,3-B)Indole	341	$C_{17}H_{12}NBr_8$	Antivirus
14		thiophene-2-methylamine,N-(2-fluorophenyl)	207	$C_{11}H_{10}NF_8$	Insecticide
15		(2-methyl phenyl) (methyl,N-pentyl ether)	192	$C_{13}H_{20}O$	Solvent
16	10 (Yin Gone)	1,4,dioxane,2-(2 furanyl)	154	$C_8H_{10}O_3$	Chlorinated solvent

Source: The authors.

During the cultivation period, herbicide and insecticide residues from four different fields were detected (Table 2). Owing to the presence of imidazole, 2-(o-Methoxyphenyl)-4,5-diphenylimidazole found in sampling site 1 can be the residues of imidacloprid. Oi (1999) and Liu et al. (2006) reported that imidacloprid compounds absorbed into the soil decreased biodegradation and were highly persistent in soils. Zhang et al. (2014) indicated that imidacloprid has a potentially harmful effect on the population of earthworms and reduces soil fertility. In sampling site 2, benzamide, naphtha (2,1-b) thiophene, benzodiazepine and 2-maleimido acetic acid were detected as a residue. Benzamide is a residue from benzamide containing herbicides, and it is a major degradation product of dichlobenil (Beynon & Wright, 1972). Carbendazim is a prominent fungicide used in these fields under study, and hence the derivatives may have come from this fungicide. Furthermore, naphtho (2,1-b) thiophene is another residue found in soils that would have been derived from insecticides. Jacob et al. (1991) also reported that naphtho (2,1-b) thiophene is a primary insecticide used explicitly for the management of mites.

Ethanol 2-(2,4-dichlorophenoxy) detected from sampling site 3 has been reported as an herbicide residue of 2,4-dichlorophenoxyacetic acid (Zahm et al., 1990). It has been well established in the literature that 2,4-dichlorophenoxyacetic acid is a commonly used compound among chlorophenoxy herbicides that is an analogue of auxin and thus also aids as a plant growth hormone (Marziano et al., 2017; Song, 2014). The herbicide 2,4-dichlorophenoxyacetic acid along with its derivatives have been detected in surface and groundwater, threatening the environment and health (Gaultier et al., 2008; Kearns et al., 2014; Shareef & Shaw, 2008).

At sampling site 4, two insecticide residues were found, viz. 9-chloro-1-fluro-12H (1,3) benzothiazole(2,3-B) quinazdin-12-one and 1-alpha-acetoxy-3alpha,4-alpha-dimethyl-4-beta-(1,3-dioxolan-2-4). The former is reported to be from a benzothiazole-containing insecticide (Dong et al., 2017), whereas the latter is reported to be a derivative of dioxolan-containing insecticide (Pape et al., 1970).

In total, 3 different herbicide residues and 5 different insecticide residues were found from 4 out of 10 sampling sites during the cultivation period. Higher numbers of insecticide residue in the soil can cause various types of deterioration in soil quality. Further, generally, it is difficult to assess the relevant role of organic matter and clay in the binding process once pesticides reach the soil. It is also quite challenging to quantify realistic field situations (Calderbank, 1989). Therefore, it is extremely difficult to predict the fate of pesticide derivatives in the soil. On the other hand, residues reported from the soil are often found not to be from widely used materials such as organic manure, urea, phosphorus fertilisers and NPK fertilisers. After contact with the soil, they undergo several transformations that include a complex metabolite pattern (Andreu & Picó, 2004). Hence, the chances are very remote that the identified residues have come from the inorganic fertilisers applied to the fields.

After the cultivation period, there were several kinds of residues detected from 7 different fields out of 10 sampling sites, as shown in Table 3. From the sampling site 1, two residues were found, viz. Pyrrole,2-(2-naphthyl) -3,5-diphenyl and Acridine-9yl-naphalen, a mixture of acridine and naphthalene dye was discovered

as a dye residue. The former residue is reported to be a residual derivative of pyrrole-based insecticides like chlorpyrifos (N'guessan et al., 2007).

There were three residues, namely 2,5-Dihydrothiophene (insecticide residue), Benzothiozole,2- (4-amino-3-methylphenyl (anti-bacterial residue) and Ethane 1,2-dione,1-(2-methyl-1H,indo-3-yl)2-(4-phenylpiperazin-1) (antivirus residue) at sampling site 5. The results show that the farmers use even antivirus chemicals in their fields, which was not reported previously. Many authors in the past have reported the presence of these residues in pesticide-treated soil (El-Feky et al., 2010; Mcconnell & Shearer, 1959; Seenaiah et al., 2014).

Similarly, Anthracene,9,10-dihydro-9-(1-Methylpropyl) and 5,5-BIS 92-94-Aminophenyl-1H-1,3-benzimidazole were detected in sampling site 6. Many studies have earlier reported that these residues are from OC pesticides (Sawaya et al., 1999; Villeneuve et al., 1999; Zhou et al., 1996). The OC pesticides such as Endosulfan are still widely used in melon fields without realising their repercussions. OC pesticides have a long half-life, ranging from months to years and, in some cases, decades, and resist degradation by chemical, physical or biological means.

While analysing the soil from sampling site 7, organo-inorganic compounds, fungicide and insecticide residues were detected. Benzenamine,4-nitro-N-(triphenylphosphoranylidene), which is reported to be a benzenamine-based herbicide residue (Shasha et al., 1981), a malonitrile derivative, Propanedinitrile(5-dimethylamino)2,3 dihydro-1H-inden-1-ylidene, reported to be used as insecticide (Otaka et al., 2006), and quinoline,3,6-dimethyl-2,4-diphenyl, a quinolone-containing residue reported to be from fungicide (Liu et al., 2017) were detected.

Furthermore, in the sampling site 8, two residues (herbicide and insecticide) were detected. These residues are Methylthio-2-cyano-3-(2-cyano(carboxy) methyl-1-cyclopent and P-toluic acid,3,5-dimethyl phenyl ester. Earlier studies reported that Methylthio-2-cyano-3-(2-cyano(carboxy)methyl-1-cyclopent can be the residue of methylthio-2-cyano-containing herbicide (Wang et al., 2004), while P-toluic acid,3,5-dimethyl phenyl ester is the combination of ester-containing insecticide and biodegradable free aromatic acid (Fischer et al., 2002; Schwartz & Bar 1995).

Apart from this, a potentially hazardous residue was also detected from sampling site 9, viz. 2-(p-bromohenyl)-8-methyl-8H-thieno(2,3-B) Indole. Earlier studies have reported that this is a hazardous and recalcitrant residue derived from an antivirus substance containing thieno (2,3-B) indole (Boeini, 2009). Moreover, thiophene-2-methylamine, N-(2-fluorophenyl) was also detected. Many studies have previously reported about the presence of this insecticide residue in soils treated with the combination of three different active ingredients (thiophene, methylamine, 2-fluorophenyl) (Arnason et al., 1989; Jain, 2015; Shi et al., 2000). Authors have also reported that Methyl and N-pentyl ether that are used as insecticides are hazardous solvents that act as general anaesthetic when inhaled above the lethal concentration (Voss et al., 2005).

Similarly, at sampling site 10, presence of 2-(2-Furyl)-1,4-dioxane was detected. Zenker et al. (2003) has reported the oncogenic impact of 1,4-dioxane

complex residue on humans, thus making it hazardous in nature. Thus, it could be inferred that residues that are more hazardous were detected from soil collected after the cultivation period. This fact is in concordance with earlier literature in which many authors have monitored the pesticide residues in soils and examined their potential health risks and found that the stable nature of the pesticides and their derivatives make them extremely recalcitrant, and, thus, they remain in the soil or water for many years in cultivable lands (Atreya et al., 2011; Ritz & Yu, 2000; Samsel & Seneff, 2013; Shelton, 2014). It has also been observed that as the trend of pesticide usage is growing alarmingly worldwide, many researchers have also reported that these pesticides have the tendency to cause cancerous and non-cancerous diseases in humans as well as other animals when they enter into the food chain through the environment (Bhandari et al., 2018; Shelton et al., 2014).

There were many residues from different pesticides that were found in this study. Interestingly, many pesticide residues that were detected from this study were not from the pesticides reported to be used in these fields. This may be because farmers use cost-effective, dangerous and unauthorised pesticides that can rapidly control pests without considering their implications, which have a higher deleterious effect on soil fertility and environment than the registered pesticides. The presence of antivirus residue in the soil after the cultivation period is also supportive of the fact that many cheap, unauthorised pesticides are used without even knowing its name or actual use. The literature also reports that due to the ever-increasing demand for food and other agricultural commodities due to rapid increase in world population, the framers tend to use increasing number of pesticides to meet the growing demand. If farmers across the world desist from using pesticides, there will be a 78%, 54% and 32% increase in the crop losses due to pests in fruits, veggies and grains, respectively (Cai, 2008). Even though pesticide use is inevitable, the pesticide residues in soil can cause unpredictable harmful effect on life forms and non-living things. This is supported by findings of Kookana et al. (1998), who reported that trace levels of pesticide residues present in the soil, water, air and sometimes food might result in harmful effects on human and environmental health, especially inducing potential hazard of land degradation. On the other hand, transformation products after contacting with soil provides complex metabolites, which may be more toxic or less toxic than the parent compound itself (Andreu & Picó 2004).

From an environmental sustainability perspective, the present study reveals the need for good agricultural practices (GAP) particularly in export-oriented agriculture sector. To establish these practices, the growers must understand the potential risk of agrochemical overuse. Joko et al. (2017) pointed out that land degradation, particularly the decline in soil quality, can occur after the continuous application of large quantities of pesticides. Our study also confirms the claim that the soil is degraded even in the fields where watermelon and melons were cultivated for the first time. Such residues can accumulate increasingly through several consecutive years of watermelon and melon cultivation and become the main reason for causing severe soil degradation.

The Basic Information on Respondents

The average age of respondents in this survey was 47.38 (range 17–80 years). A total of 76.39% of respondents were males, and 23.61% were females. The respondents in the research have 23.35 years (range 2–60 years) of farming experience. For the use of pesticides in their farming practices, an average of 15.67 years (1–45) has been recorded. According to the survey responses, 46.53% of respondents had primary education (standard I to standard IV), 25% of respondents had secondary level of (standard V to standard VIII) education, 8.33% of respondents had higher education (standard IX to standard X), only 1.39% of respondents had graduated from university and the remaining 18.75% had no education. Accordingly, 81.25% of farmers in the sample had at least primary education. The overall percentages are presented in Figure 3. Education plays a vital role in a better understanding of the details provided in the label. The pesticide label is an important source of information for the safe and proper use and mitigation of environmental and health risks (Waichman et al., 2007). Therefore, a higher percentage of educated farmers in this area should be able to read and understand pesticide labels. Nguyen et al. (2018) pointed out that if farmers read the pesticide label and directions before use, they should be able to use the appropriate dosage, stick to the correct time of spraying, take necessary safety measures while handling pesticides, understand the potential toxicity of pesticides and adhere to instruction on preharvest intervals. However, Lekei et al. (2014) found that the level of education could not influence knowledge regarding pesticide management and practices. Therefore, creating awareness for local farmers on the safe use of pesticides by local authorities is highly advocated.

About the size of the farm, the average farm size is 6.75 acres. It was recorded that 71.8% of the respondents owned agricultural land, 7.38% worked on hired land and 20.8% did not declare ownership of their land (Figure 4). During soil tillage, 11.1% of respondents used NPK fertiliser, 15.28% used urea, 0.69% used phosphorus fertiliser and 72.2% of respondents did not specify the fertiliser applied.

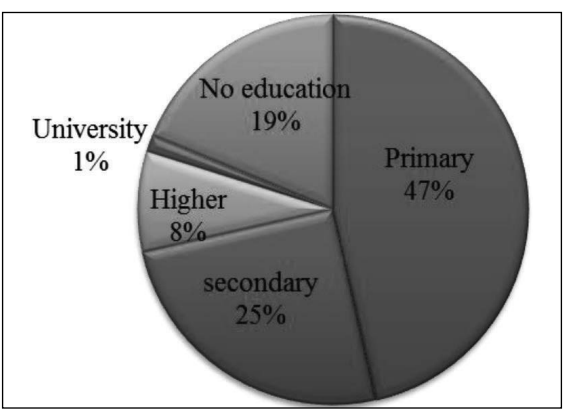

Figure 3. Education Status of Respondents.

Source: The authors.

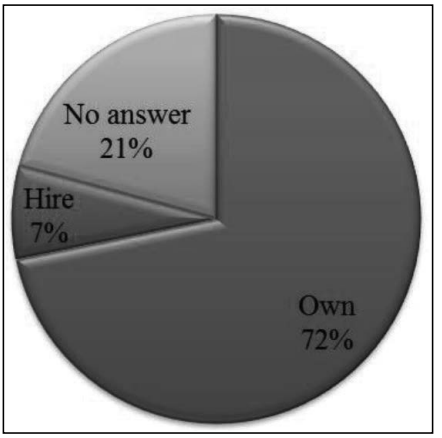

Figure 4. Land Possession by Farmers.

Source: The authors.

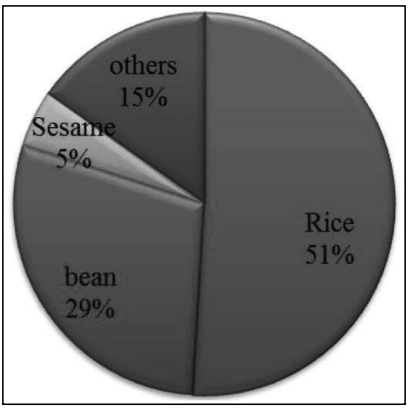

Figure 5. Crops Grown in Study Area (others include watermelon, melons and sunflower).

Source: The authors.

Figure 5 shows the crops cultivated in this area. More than 50% of households cultivated more than one crop. The crops commonly grown were paddy (51%), beans (29%), sesame (4.86%) and other crops (15.14%). Also, some households cultivated watermelons, melons and sunflowers. However, farmers were inclined to cultivate crops that were more profitable.

In Table 4, statistical data on the use, handling, storage and disposal of pesticides are presented. Approximately 49.33% of farmers did not use protective clothing because they were unaware of the potential health risk, not easily accessible and expensive. Raksanam et al. (2012) also reported that such unsafe practices might have adverse health consequences. However, 50.67% of respondents used at least one of the protective wears like a mask, glove, coat, eye

cover, long boots, long sleeve shirts and long pants, whereas 72.36% of spraying personnel used face masks as protective cover. Respondents were ignorant about the health hazard at the individual and even at the community level. Safety measures adopted by these farmers were ineffective and inadequate. A total of 30.49% of the respondents admitted that they prepared pesticide solutions for spraying and wash sprayers closer to water well, canal, stream or river, which provide water for households and other day-to-day activities. However, 69.51% of the respondents declined to answer this question.

Table 4. The Results of Responses on Pesticide Handling Practices.

Characteristics	Percentages of Response (n = 150)
Equipment washed	
• At well at home	8.54
• Outside the yard	1.22
• Nearby River/lake	20.37
• Not specify	69.51
Storage	
In the storage room	28.46
In the house	7.32
Outside the house	24.39
Not specify	39.82
Waste disposal sites	
• In yard	11.22
• In canalisation	2.04
• In solid waste disposal	9.18
Not specify	77.56
Wearing protective clothing when applying pesticides	50.67
• Yes	49.33
• No	
If No, please pick one:	
• Lack of knowledge	89.18
• not available	1.35
• uncomfortable	9.45
If Yes, check one or more of the following:	
• Gloves	38.15*
• Coat	43.42*
• Eyeglasses	5.26*
• Face mask	72.36*
• Boots/shoes	19.73*
• Long-sleeved shirt/long pants	43.42*
Reuse the pesticide containers	
• Yes	5.69
• No	94.31

(Table 4 Continued)

(Table 4 Continued)

Characteristics	Percentages of Response (*n* = 150)
Amount of pesticide usage	
• Normal	58.67
• Increase	22.67
• Decrease	18.67
Non-repetitive use of same pesticide	
• Always	63.43
• Never	14.18
• Sometimes	22.39

Source: The authors.

Note: *Each respondent uses more than one kind of item.

Regarding disposal of used pesticide packages, 75.51% of the respondents denied providing any information, but 9.18% disposed used pesticides at the garbage disposal site, 11.22% disposed of used pesticides outside the compound and 2.04% disposed of used pesticides in the drainage system. These data show that there is high potential of polluting surface water, natural water bodies and soil, and the environment. This kind of pesticide waste disposal can lead to the accumulation of toxic substances in the environment, depending on their water solubility, soil-sorption constant (Koc), the octanol/water partition coefficient (Kow) and half-life in soil (Swann et al., 1983). They can also be moved from the soil by run-off water with time and leaching, thereby creating a problem in the supply of drinking water to the population (Andreu & Picó, 2004). According to Székács et al. (2015), most of the pesticides released into the environment are considered toxic substances, and new toxicological interactions have been reported. However, the behaviour of farmers in terms of waste disposal in the surveyed areas also contribute considerably to the degradation of soil through accumulation of pesticides in soil.

However, the pesticide storage activities carried out by these farmers are encouraging. Only 7.32% of respondents stored pesticides within the house, 28.46% stored in a separate storage room, 24.39% stored outside the house and 39.02% did not reveal the area where pesticides were stored. According to the interviewer's experience, most of them stored pesticides either in the living quarters or in the agricultural field. These results highlighted the farmers' ignorance on the safe use of pesticide and the need for precautions to be taken while preparing and spraying. They also did not cooperate when asked about the practices adopted while handling pesticides. These findings showed that there is a strong need to create awareness on pesticide hazards, safety practices and safe storage among farmers. However, achieving these goals is severely hampered due to the lack of skilled and well-trained agricultural extension staff in the existing agricultural extension services in Myanmar, as reported by Cho and Boland (2004). Thus, it is strongly advocated that appropriately designed education and training programmes on pesticide handling, application methods and health effects must be implemented in this region.

Table 5. Source of Knowledge on Usage and Storage of Pesticides.

Question	Percentages of Response (n = 150)
Agricultural consultation services in your district	
• Yes	65.89
• No	24.11
Consultations about the right use and storage of pesticides	
• From distributor	66.66
• From consultancy services (government)	3.78
• From neighbours	19.69
• From consultancy services (NGO)	3.78
• Others	6.06
The decision on the usage of the pesticides	
Seller	62.26
Self	30.19
Others	7.55
Receive information about pesticides usage guidelines	
• Yes	77.52
• No	22.48

Source: The authors.

Source of Knowledge on Usage and Storage and Risk of Pesticides

Knowledge on effects of pesticides on the environment and health of farmers revealed that approximately 30.08% of respondents are aware of pesticide hazard, 47.15% of respondents believe that it has some hazard but not serious and 22.76% of respondents believe that it does not cause any risk to humans or the environment. With respect to taking decisions on the selection of pesticide for the management of pests, most respondents (62.26%) received information from persons selling pesticides, 30.19% of farmers determined by themselves and 7.55% followed the advice of their neighbours. Questions were also asked about the source of knowledge on current farming practices, pest control and safe use of agrochemicals. Overall, 66.66% of respondents received advice from distributors, and 19.69% shared knowledge from their neighbours, and only 3.78% of respondents received knowledge from agricultural staff and non-governmental organisations (NGOs). According to our survey (Table 5), a considerable number of farmworkers gained information from individuals selling pesticides and experienced neighbouring farmers.

Based on these two questionnaire results, it was found that local farmers have very little knowledge on pests that infest crops and their management, and lack of proper handling of pesticides and safety measures. Therefore, it is also important to educate the village pesticide retailers and farmer leaders as they can strongly influence the farmers to adopt appropriate pest control measures and GAP. As stated earlier, cooperation and participation of farmers in trainings and extension programmes are also major issues. It is, therefore, necessary to involve the private

sector, particularly distributors and local government authorities, in training and extension programmes to disseminate and share the right information and promote innovative agricultural practices in the agricultural sector in Myanmar.

Farmers' Perception on the Use of Pesticides

Most farmers are aware that chemical pesticides are not safe for them and the environment. However, from an economic and productivity point of view, they cannot avoid using pesticide for effective control of pests. Overall, 82.47% of respondents used pesticides to protect their crops and getting a good yield. While these chemicals play a major role in increasing production the yield improvement is often associated with the risk and persistence of pesticide residues in food, soil and water due to intensive and indiscriminate pesticide use. Another concern associated with maximising crop yields is that farmers intentionally and continuously release these pesticides into the environment at levels, which might severely affect human health. Essumang et al. (2013) also emphasised the importance of training farmers to ensure proper application of pesticides to minimise its impact on the health of consumers. A total of 88.66% of respondents admitted that they would like to shift to viable alternatives to pesticides (Table 6).

Felix and Sharp (2016) also reported that poor pesticide management practices and violation of safety rules lead to undesirable consequences such as untreatable diseases affecting growers, non-farmers, manufacturers, customers, negative impact on the climate and the ecosystem even though pesticides contribute to increased food production and reduce agricultural production loss.

Table 6. Farmers' Perception on the Use of Pesticides

Farmers' Perception	Percentages of Response (n = 150)
Perception on pesticides usage and potential risk	
• Not harmful	22.76
• Moderately harmful	47.15
• Very harmful	30.08
Pesticide requirement is essential for crop yield	
• Yes	90.82
• No	9.18
Why not stop the use of harmful pesticides	
• Cheap	1.03
• Not require labour force	6.19
• Concern about yield	82.47
• Do not know about risk	4.12
• Not specify	6.19
Want to use alternative pesticides	
• Yes	88.66
• No	11.34

Source: The authors.

Farmers' Experiences Regarding Pesticide Poisoning and Environmental Risk

Approximately 41.67% of farmers reported having experienced physical discomfort with pesticides such as nausea, eye and skin irritation, blurry vision, dizziness, headache, etc. It was recorded that 40.33% of respondents witnessed accidental contamination of pesticides with water and air, dying of fish and birds, and declining population of beneficial insects. As reported by Gupta (2004), long-term exposure to low doses of pesticides in humans has been found to cause immune repression, hormonal disruption, reduced intelligence and reproductive malfunction through a human endocrine disorder phenomenon. The use of pesticides in agriculture may have negative consequences not only for humans but also for the natural environment due to dispersion of pesticides into the environment, sorption and binding by organic and mineral soil components; volatilisation, run-off and leaching (van der Werf, 1996). Microflora and fauna of soil, which play a critical role in soil fertility maintenance, are also adversely affected by pesticides.

The long-term consequences of such structural changes in soil microflora are difficult to predict, as they can lead to changes in the occurrence of soil-borne pathogens (Elmholt et al., 1993). Concerning soil fertility, 42.86% of respondents reported it being degraded over time, and 57.14% of respondents reported not having encountered this issue. According to Bhattacharyya et al. (2015), the reason for land degradation is improper agricultural practices such as excessive and unbalanced use of inorganic fertilisers, pesticide overuse and insufficient crop residue and/or organic carbon inputs. Myanmar faces severe land degradation, particularly soil erosion in upland agricultural areas and dry zones. Degraded agricultural areas were estimated at 33% in 2008 as a percentage of total cultivated area. The total degraded land has continuously increased in Myanmar according to the results of this study. Environmental impact assessment is still weak in the use of agrochemicals and soil degradation according to the findings from Table 7.

Table 7. Farmers' Experiences Regarding Pesticide Poisoning and Environmental Risk.

Experiences on Health and Environmental Risk	Percentages of Response (n = 150)
Using pesticides or being exposed to them have you experienced	
• Yes	41.67
• Dizziness	40
• Headache	14.28
• Nausea/vomiting	8.57
• Blurred vision	8.57
• Skin rashes	25.71
• Excessive sweating	14.28
• excessive salivation	5.71

(Table 7 Continued)

(Table 7 Continued)

Experiences on Health and Environmental Risk	Percentages of Response (*n* = 150)
• Irregular heartbeat	2.85
• Difficulty breathing	5.71
• Others discomfort	8.57
• No	58.33
Experiences on accident with pesticides	
• Yes	40.33
• Water pollution	25.67
• Air pollution	21.62
• Fish, bird etc. dying	31.08
• Reduction on beneficial insect population	21.62
• No	50.66
Changes in soil fertility due to pesticide usage	
• Yes	42.86
• No	57.14

Source: The authors.

Conclusion

The study showed that farmers use various types of authorised and unauthorised pesticides and other chemical inputs in their lands. Residues of different pesticides, which were reported to be used and not used in this area, were detected during and after cultivation from the soils. Therefore, it can be inferred that pesticide-induced gradual soil degradation has been occurring in this area. Further, farmers are ignorant about the judicious use of pesticides and their management. Waste management of used pesticide containers in this region is also in a poor state. Indiscriminate and injudicious use of pesticides can lead to several health hazards and environmental problems.

Therefore, it is recommended to promote awareness on the safe use of pesticides, impose strict regulations about sales and handling of pesticides, introduce and promote biotechnology in agriculture and promote the use of bio-pesticides. It is also recommended to promote the use of botanical and bio-pesticides to reduce hazards caused by inorganic pesticides to humans and environment.

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TTW designed the research, analysed the data and wrote the article; other participants worked on planned research; and AAK supervised the research work.

Declaration of Conflicting Interest

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Note

1. Three different types of growers are found to cultivate melons in these areas; (a) resident farmers who own land, (b) resident farmers who hire the land and (c) international migrants who hire land. The complaints were reported by the landlords who rented out their land for melon cultivation by tenant farmers.

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Article

Assessment of Urban Sprawl and Its Impacts on Rural Landmasses of Colombo District: A Study Based on Remote Sensing and GIS Techniques

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Abstract

Urban sprawl is one of the significant issues faced by cities in Sri Lanka today. Urban sprawl is unplanned and uneven pattern of growth, driven by a multitude of processes and leading to inefficient resource utilisation. This study evaluates urban sprawl and its impact on rural land masses of Colombo district, Sri Lanka in 1997, 2009 and 2018 using Shannon's entropy values. Maximum likelihood supervised classification was applied for Landsat 8 OLI/TIRS (Operational Land Imager/Thermal Infrared Sensor 2018) and Landsat 5 TM (Thematic Mapper 1997, 2009) satellite images to get the build- up areas and then the Shannon's entropy values using GIS were assessed. Calculated built-up areas were 98.97 (14.6 %), 178.76 (26.38%), 276.80 (40.85%) km^2 and Shannon's entropy values were 0.928, 1.009 and 1.059 for the years 1997, 2009 and 2018, respectively. Since Shannon's entropy is an efficient indicator to measure urban sprawl, it is observed that Colombo district continues to sprawl from 1997 to 2018. The analysis of the results further showed that rapid increase of built-up area resulted in decrease in vegetation and agricultural areas. Calculated relative entropy values were 0.83, 0.91 and 0.95 for consecutive years, which has an increasing trend and exceeded the threshold value of 0.5 indicating a higher level of urban sprawl in Colombo district. Developed maps show that since 1997, the city has experienced pronounced urban sprawl along the main roads of Colombo district consuming rural lands at a faster pace as population shifts from urban areas.

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Prioritised policies in Government's public investment programme 2017–2020 for sustainable urban development may help concentrate growth within targeted areas and restrain sprawling development in rural settings of Colombo district. Further, similar studies are encouraged to check the effectiveness of applying policies.

Keywords

Urban sprawl, Shannon's entropy, Landsat, GIS, supervised classification, rural mass, Colombo district

Introduction

Urban sprawl is defined as unplanned and uneven pattern of growth, driven by multitude of processes and leading to inefficient resource utilisation (Bhatta, 2010). The direct impact of sprawl is change in land use and land cover (LULC) of the region as sprawl accelerate the spreading of built-up and impervious area (Sudhira & Ramachandra, 2007) and there has been a growing concern that the mainstay of rural masses, that is forest, agriculture and allied sectors will face adverse ecological threats by urban encroachment. In Sri Lanka, Urban growth of the past 20 years has resulted significantly crowded slums and sprawling settlements in the urban fringe as cities are rapidly consuming lands to accommodate new developments. Some regions show much faster urban growth than the urban population, producing less dense, disorganised and inefficient land-use patterns.

Urban sprawl is one of the key challenges facing Sri Lanka's cities today and a good evidence of sprawl development can be seen in the immensely urbanised Western Province, which is believed to be a prime urban hub of South Asia (Western region Megapolis planning project, 2017). Further, in the Government's Public Investment Programme 2017–2020, urban sprawl is identified as a priority issue facing urban planners. Addressing this issue is also emphasised by the World Bank and UN-Habitat and is a key feature of international agreements, including the Sustainable Development Goal 11 as sustainable cities and communities.

Sprawled urban growth poses huge threats to principal ecological habitats in the rural lands (Satkunarajah, 1996). Thus, increasing the destruction of these natural habitats including irreversible loss of forests, productive agricultural lands, surface water bodies and groundwater prospects (Torrens & Alberti, 2000). Also, Rapid land-use modification from rural to urban also adversely affects climate change tolerance to sprawled space, particularly through increasing flood vulnerability. Especially the conversion of wet lands and other water retention areas to urban land use have been significantly reduced drainage capacity in sprawled areas and caused frequent flooding incidents.

The main objective of this study was to apply a simple and accurate method to assess LULC information in Divisional Secretaries Divisions (DSDs) for assessing urban sprawl and its encroachment in rural environment of Colombo district, Sri

Lanka for 1997, 2009 and 2018 by using Shannon's entropy values. LULC information will get into 04 classes, namely built-up areas, agriculture, vegetation and water body. For that freely available Landsat 05 images were used for 1997 and 2009, and Landsat 08 images were used for 2018 according to the availability.

Methodology

This section explains the procedures followed to achieve the objectives of the study. It gives a brief description of the study area which is depicted in Figure 1. The analytical tools mainly comprised of experimental design, data collection and data analysis. LULC analysis and urban sprawl assessment are the main intentions of data analysis. The detailed analysis of them are provided below under different subtitles.

Study Area and Data

Colombo district in Western Province of Sri Lanka is being urbanised rapidly and thus to make the study meaningful this district has been selected for the study area (which is shown in Figure 1). Choosing one place with moderate level of urban growth may not capture the adverse impact of urban sprawl adequately. Table 1 shows the demographic data of this district.

Digital maps and shape files, that is, administrative boundary shape file of Colombo district was obtained from the Survey Department, Colombo.

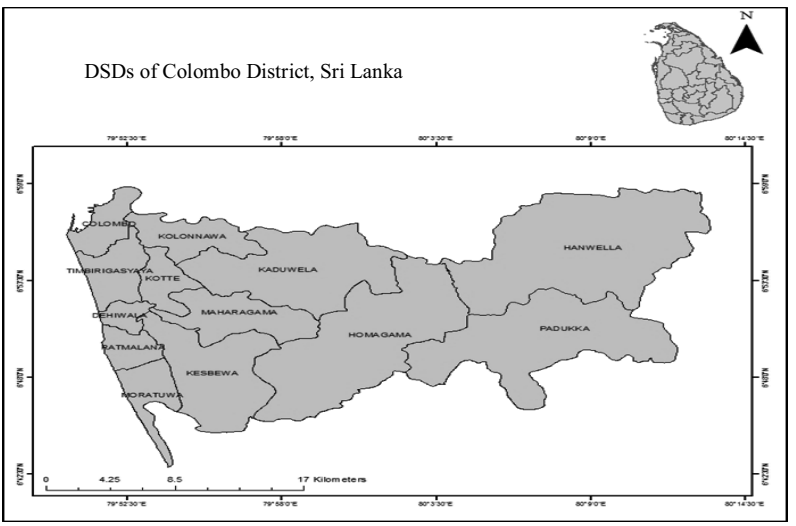

Figure 1. DSDs of Colombo District, Sri Lanka

Source: Survey Department of Sri Lanka (2012).

Table 1. Demographic Details of the Study Area

Study Area	Colombo District
Divisional Secretary's Division (DSDs) in Colombo district	13
Latitude	6.8602° N
Longitude	80.0535° E
Total area	699 km^2
Total population (2015)	2,375,000
Urban area population (2015)	2,219,782

Source: Department of census and statistics, Sri Lanka (2015).

Table 2. Details of Acquired Satellite Scenes

Image No.	Landsat Product Identifier	Acquisition Date	Satellite Series	Sensor	Bands Used	Path	Row	Scene Cloud Cover
1	LT05_L1TP_141055_19970207_20170102_01_T1	1997/02/07	Landsat (5)	TM	1-5,7	141	055	8
2	LT05_L1TP_141055_20090208_20161028_01_T1	2009/02/08	Landsat (5)	TM	1-5,7	141	055	12
3	LC08_L1TP_141055_20180201_20180220_01_T1	2018/02/01	Landsat (8)	OLI/TIRS	1-7	141	055	35.06

Source: USGS Earth Explore.

Satellite images, that is, Highest quality level 1 Landsat satellite scenes for the years of 1997, 2009 and 2018 were ordered and downloaded from USGS Earth Explore website (http://earthexplorer.usgs.gov/) Table 2 details the acquired satellite scenes obtained.

Analytical Method

There are many indicators used to assess urban sprawl in many studies in the world. Ramachandra et al. (2012) used vegetation cover analysis, land-use analysis, density gradient analysis, Shannon's entropy, alpha and beta population density and landscape metrics. Shahraki et al. (2011) considered the indicators of population growth, built-up area expansion, per capita land consumption and

land-use transformation. In 2011 there was another study by Arribas-Bel et al. which used connectivity, decentralisation of population, population density, scattering, availability of open spaces and land-use mix. Bekele in 2005 used population, population density, and land-use land cover information as urban sprawl indicators in the study. Huang and Sellers (2007) did a global study on urban sprawl using built-up areas. The report of 'State of Sri Lanka cities 2018' which is a collaborative effort by the Sri Lanka Institute of Local Governance in partnership with the United Nations Human Settlements programme (UN Habitat), used Normalized Difference Built Index (NDBI) using Landsat 8 image. They classified image into 04 classes, namely urban, semi-urban, non-built-up and water.

Land-Use Land Cover

The methodology is based on classification of satellite images using the principal component analysis (PCA), normalised difference vegetation index (NDVI) followed by supervised classification methods. PCA is used to convert raw remote sensing data of multispectral imageries into a new principal component image. In this study PCA derived image was used to select differentiated training samples of vegetation and forest cover. NDVI technique is used to reduce the multiple bands of data down to a single band that accesses the vegetative ground cover similar to the study of Zheng et al. (2015). Hence, to attain high separability and contingencies between classes, PCA and NDVI are used to extract specific training sites. 160 training samples were created across the study area to represent each four of the major classes, namely build-up areas, waterbodies, vegetation and agriculture. Those classes should be separated in the multidimensional attribute space.

To check the separability and distribution of the selected training samples, histogram technique was used, which allows to compare the distribution of multiple training samples. The minimum overlapping of training samples represent different classes were confirmed using histograms. Maximum likelihood supervised classification technique is used to produce satellite-derived LULC maps. Accuracy assessment was done only for the years 2009 and 2018 due to unavailability of reliable cadastral data for the year 1997. As ground truth data, reference maps from Google Earth historical imagery was used to validate the classified images. Reference data set of 40 randomly selected pixels were used to develop error base matrices to get the classification accuracy for the two images using Kappa coefficient. Landsat satellite data of 1997, 2009 and 2018 years were analysed using ArcGIS version 10.2.2.

Urban Sprawl Assessment

Urban sprawl assessment was done for the area of DSD in Colombo district. There are 13 DSDs in Colombo district. Previously produced LULC maps of 1997, 2009 and 2018 were used to evaluate urban sprawl. Extend of urban sprawl in 1997, 2009 and 2018 in Colombo district was assessed using the Shannon's entropy values. The major steps taken to classify the satellite images of 1997, 2009 and 2018 and urban sprawl assessment are shown in Figure 2.

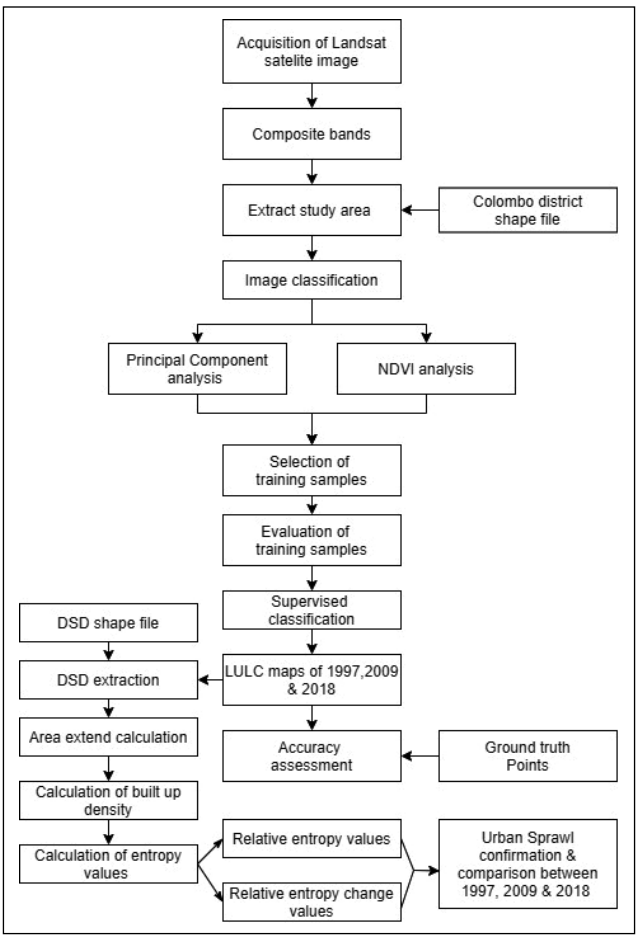

Figure 2. Flow Chart of LULC and Urban Sprawl Assessment in Colombo District for 1997, 2009 and 2018

Source: Derived by the author.

DSD boundary shape files were used to extract 13 DSDs from the classified satellite images of 1997, 2009 and 2018. Pixels of each land-use classes for each DSD were derived from the attribute table. Using the pixels, area extend of each land-use classes belongs to particular DSD were calculated. Built-up area calculation procedure is shown in following equation (Equation 1) where 900 is area of single raster cell in m^2.

$$\text{built-up area km}^2 = \frac{\text{No. of pixels} \times 900}{10^6} \quad (1)$$

Built-up density of each DSD was calculated by dividing the built-up area of concerned DSD by net developable area which is excluding public places and roads. Calculated values were used to get the Shannon's entropy values.

Calculation of Shannon's Entropy Values

Entropy value

Entropy is a widely accepted spatial measurement concept used to analyse urban sprawl. Shannon's entropy (E) can be used to compute the level of spatial concentration or dispersion of a geographic variable among n zones. Here entropy value was calculated for Colombo district using entropy of individual DSDs. The value of entropy ranges from 0 to $\log_e(n)$, where a value of 0 represents minimal dispersion (concentrated) of the variable, and a value of $\log_e(n)$ indicates high dispersion (spread out) of the variable which can be calculated using Equation (2) (Chong, 2017).

$$E = \sum_i^n P\ \mathrm{DEN}i \log\left(\frac{1}{P\ \mathrm{DEN}i}\right) \tag{2}$$

where $P\ \mathrm{DEN}i = \left(\frac{\mathrm{DEN}i}{\sum \mathrm{DEN}i}\right)$

P DENi describes the density of the variable, DENi describes built-up density in ith DSD and n describes the numbers of DSDs (13).

Relative Entropy Value

Relative entropy can be used to scale the entropy value into a value that ranges from 0 to 1 and can be calculated using the following equation. In this instance 0.5 is considered as the threshold for the urban sprawl. Relative entropy was calculated using Equation (3) (Chong, 2017).

$$\text{Relative entropy}\left(\mathrm{Et}\right) = \frac{\text{Entropy of a particular year}}{\mathrm{Log}\left(n\right)} \tag{3}$$

Relative Entropy Change Value

The difference of relative entropy among two different time periods of time can be used to indicate the changes in extend of urban sprawl. By using Equations (4) and (5), relative entropy change value was calculated for the time periods of 1997–2009 and 2009–2018.

$$\Delta\ \mathrm{Et}_1 = \mathrm{Et}\ (2018) - \mathrm{Et}\ (2009) \tag{4}$$

$$\Delta\ \mathrm{Et}_2 = \mathrm{Et}\ (2009) - \mathrm{Et}\ (1997) \tag{5}$$

where, Δ Et is the difference of the relative entropy values between two time periods, Et (2018) is the relative entropy value in 2018, Et (2009) is the relative entropy value in 2009 and Et (1997) is the relative entropy value in 1997.

Results and Discussion

The LULC classes of built-up areas, water bodies, vegetation and agriculture have been shown in Figure 3, whereas Figure 4 shows the area extend of LULC classes.

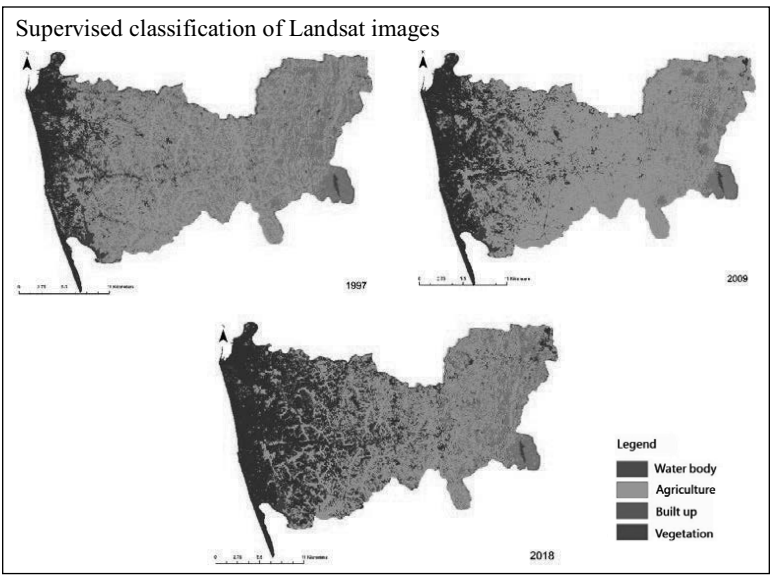

Figure 3. Supervised Classification of Landsat Images

Source: Derived by the author.

Note: Grey: built-up, blue: water body, green: vegetation and dark green: agriculture.

Accuracy of the classification was given for 2009 Landsat image as 80 per cent and Kappa coefficient was 0.74 and Landsat image in 2018 was given as 90 per cent and Kappa coefficient was 0.87. In year 1997, agriculture and vegetation occupied more land area in Colombo district. In 2009, Vegetation has been reduced drastically and considerable growth of built-up areas can be seen.

When considering 2018, built-up area become the major LULC class in Colombo district. Agricultural area has been reduced and vegetation has been moderately increased. It can be due to filling up lands for constructions and start of urban reforestation programmes in Colombo district (Ministry of Mahaweli Development & Environment, 2016).

These classified images clearly show that during the period 1997–2018 there is an increase in built-up areas which means vegetation cover and agriculture areas in Colombo district were affected with the rapid growth of built-up area. Agriculture and vegetation area changes of DSDs in Colombo district during 1997–2018 is shown in Figures 5 and 6.

What they show is that there is a slight increase in agricultural area in 2009 but a decrease in 2018 in all DSDs except in Colombo, Thimbirigasyaya, Dehiwela, Ratmalana and Moratuwa which have very negligible agricultural area. Similar trend was recorded for vegetation as well. Agriculture and vegetation in Colombo, Thimbirigasyaya, Dehiwala, Ratmalana and Moratuwa westward DSDs show very less area contribution when compared with other eastward DSDs in Colombo district. When considering built-up area distribution, those DSDs show higher area contribution for all three years of the study (Figure 7).

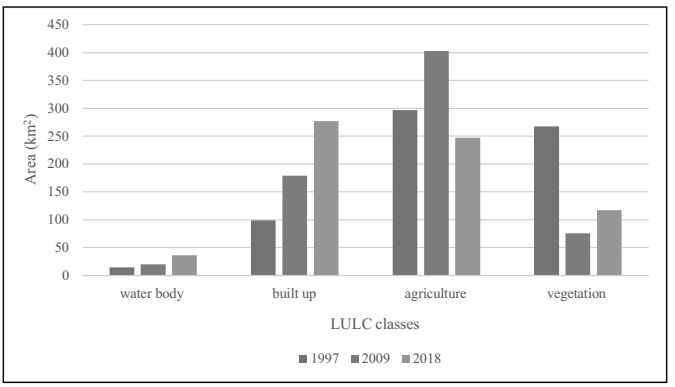

Figure 4. Area Extend of LULC Classes in 1997, 2009 and 2018

Source: Derived by the author.

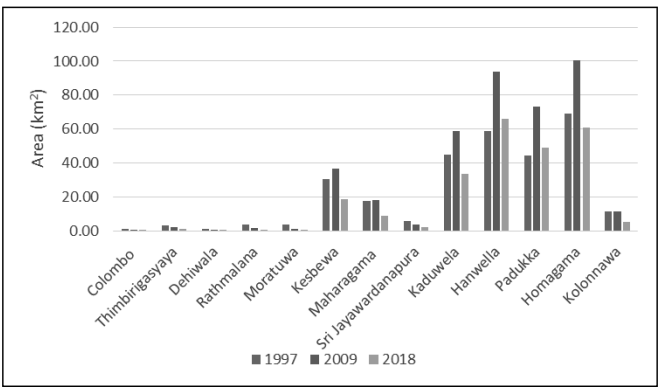

Figure 5. Agricultural Area Changes in DSDs in Colombo District

Source: Derived by the author.

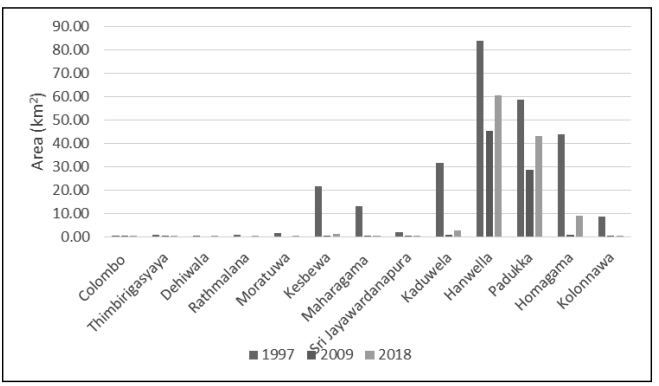

Figure 6. Vegetative Area Changes in DSDs in Colombo District

Source: Derived by the author.

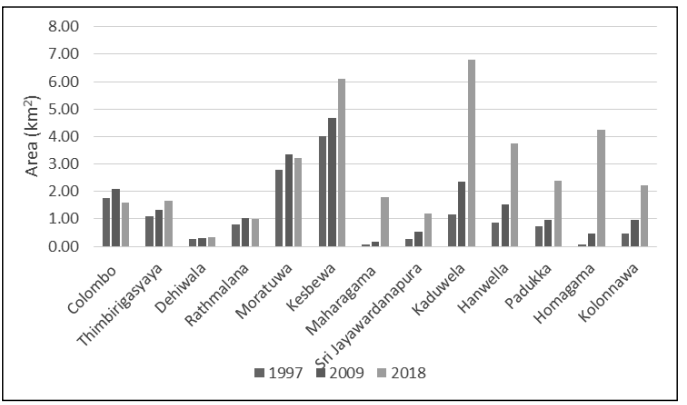

Figure 7. Built-up Area Changes in DSDs in Colombo District for the Years 1997, 2009 and 2018

Source: Derived by the author.

Built-up Areas in DSDs in Colombo District

Figure 7 shows that the increment of built-up area in different DSDs in Colombo district. All DSDs are having increasing trend of built-up areas. Homagama, Kaduwela and Kesbewa DSDs show the higher increment of built-up areas in year 2018. The observations show clearly that the built-up areas expand from the westward to eastward direction in Colombo district throughout the study period. Rural urban fringe can be observed in eastward in Colombo district.

Urban Sprawl in 1997, 2009 and 2018

In the Tables 3–5, total area is referred to as developable area (without the area extend of water bodies). Built-up areas and built-up densities are calculated from the data of classified Landsat images. Following that Equation (2) is used to calculate the entropy values of each year. Table 3 shows that total area in different DSDs ranges between 7.75 km^2 in Dehiwela and 145.27 km^2 in Hangwela, whereas built area is only 0.94 km^2 in Padukka and the highest of 18.14 km^2 in Thimbrigasyaya. But built-up density ranges between 0.01 in Padukka and 0.91 in Colombo. However, the summation of build-up density is 5.01 and Shanon's entropy for the Colombo district is 0.93.

Table 4 shows the entropy calculation for the year 2009. The minimum total area of 7.72 km^2 was recorded in the Dehiwela DSD while maximum total area of 144.62 km^2 was recorded in Hangwela. Very low built-up area of 2.17 km^2 was recorded in Padukka, whereas maximum of 23.35 km^2 of built-up area was recorded in Kaduwela. When compared to 1997 figures for Kaduwela there is a very rapid increase in built-up area in this DSD. Built-up density was also low in Padukka (0.02) and the highest was 0.96 in Colombo. Summation of built-up density for Colombo district is 7.19 and Shanon's entropy is 1.01.

Table 3..Entropy Calculation for the Year 1997 (Total Area = Developable Area)

1997-DSD	Total Area km^2	Built-Up Area km^2	Built-Up Density	*P* DEN*i*	1/*P* DEN*i*	Log 1/*P* DEN*i*	*P* DEN*i* × log1/*P* DEN*i*
Colombo	15.66	14.29	0.91	0.18	5.49	0.74	0.13
Thimbirigasyaya	21.90	18.14	0.83	0.17	6.05	0.78	0.13
Dehiwala	7.75	6	0.77	0.15	6.48	0.81	0.13
Rathmalana	12.28	8.01	0.65	0.13	7.68	0.89	0.12
Moratuwa	16.58	11.11	0.67	0.13	7.48	0.87	0.12
Kesbewa	58.15	5.69	0.10	0.02	51.23	1.71	0.03
Maharagama	37.02	6.24	0.17	0.03	29.74	1.47	0.05
Kotte	16.24	8.59	0.53	0.11	9.48	0.98	0.10
Kaduwela	84.01	7.28	0.09	0.02	57.85	1.76	0.03
Hanwella	145.27	2.25	0.02	0.00	323.66	2.51	0.01
Padukka	104.42	0.94	0.01	0.00	556.85	2.75	0.00
Homagama	117.26	4.24	0.04	0.01	138.64	2.14	0.02
Kolonnawa	26.61	6.2	0.23	0.05	21.51	1.33	0.06
		∑built-up density	5.01			∑*P* DEN*i* × log1/*P* DEN*i*	**0.93**

Source: Derived by the author.

Note: Significance for bold value: This is the final summation of entropy value of years which are used to compare the sprawl level between years.

Table 4. Entropy Calculation for the Year 2009 (Total Area = Developable Area)

2009-DSD	Total Area km^2	Built-Up Area km^2	Built-Up Density	*P* DEN*i*	1/*P* DEN*i*	log 1/*P* DEN*i*	*P* DEN*i* × log1/*P* DEN*i*
Colombo	15.33	14.68	0.96	0.13	7.51	0.88	0.12
Thimbirigasyaya	21.67	19.28	0.89	0.12	8.08	0.91	0.11
Dehiwala	7.72	7.13	0.92	0.13	7.79	0.89	0.11
Rathmalana	12.07	10.10	0.84	0.12	8.59	0.93	0.11
Moratuwa	16.01	14.69	0.92	0.13	7.84	0.89	0.11
Kesbewa	57.50	20.75	0.36	0.05	19.93	1.30	0.07
Maharagama	36.95	18.48	0.50	0.07	14.38	1.16	0.08
Kotte	15.96	12.19	0.76	0.11	9.41	0.97	0.10
Kaduwela	82.84	23.35	0.28	0.04	25.51	1.41	0.06
Hanwella	144.62	5.44	0.04	0.01	191.15	2.28	0.01
Padukka	104.18	2.17	0.02	0.00	345.22	2.54	0.01

(Table 4 Continued)

(Table 4 Continued)

2009-DSD	Total Area km²	Built-Up Area km²	Built-Up Density	*P* DENi	1/*P* DENi	log 1/*P* DENi	*P* DENi × log1/*P* DENi
Homagama	116.89	15.73	0.13	0.02	53.43	1.73	0.03
Kolonnawa	26.11	14.77	0.57	0.08	12.71	1.10	0.09
		∑built-up density	7.190			∑*P* DEN*i* × log1/*P* DEN*i*	**1.01**

Source: Derived by the author.

Note: Significance for bold value:This is the final summation of entropy value of years which are used to compare the sprawl level between years.

When we consider year 2018, Table 5 shows that there is a small change in total areas of DSDs in Colombo district. Dehiwela recorded the minimum total area of 7.68 km² and showing a marginal increase in the area and the maximum of 142.36 km² was recorded in Hangwella. The built area was minimum in Padukka (10.42 km²) and maximum (42.06 km²) in Kauwela. These changes in area could be due to recent re-demarcation of boundaries of DSDs. Built-up density was minimum in Padukka (0.10) and maximum (0.98) in Colombo DSD. The overall built-up density for this year is 8.97 and the Shanon's entropy is 1.06.

Table 5. Entropy Calculation for the Year 2018 (Total Area = Developable Area)

2018-DSD	Total Area km²	Built-Up Area km²	Built-Up Density	*P* DENi	1/*P* DENi	Log 1/*P* DENi	*P* DENi × log1/*P* DENi
Colombo	15.80	15.51	0.98	0.11	9.13	0.96	0.11
Thimbirigasyaya	21.34	20.17	0.95	0.11	9.48	0.98	0.10
Dehiwala	7.68	7.48	0.97	0.11	9.21	0.96	0.10
Rathmalana	12.09	11.29	0.93	0.10	9.60	0.98	0.10
Moratuwa	16.15	15.65	0.97	0.11	9.25	0.97	0.10
Kesbewa	56.07	36.34	0.65	0.07	13.83	1.14	0.08
Maharagama	35.31	26.17	0.74	0.08	12.10	1.08	0.09
Kotte	15.29	13.20	0.86	0.10	10.39	1.02	0.10
Kaduwela	78.40	42.06	0.54	0.06	16.71	1.22	0.07
Hanwella	142.36	15.85	0.11	0.01	80.53	1.91	0.02
Padukka	102.78	10.42	0.10	0.01	88.43	1.95	0.02
Homagama	113.10	43.35	0.38	0.04	23.39	1.37	0.06
Kolonnawa	24.85	19.32	0.78	0.09	11.53	1.06	0.09
		∑built-up density	8.97			∑*P* DEN*i* × log1/*P* DEN*i*	**1.06**

Source: Derived by the author.

Note: Significance for bold value:This is the final summation of entropy value of years which are used to compare the sprawl level between years.

It is evident that the entropy values are increasing from 1997 which explains the gradual expansion of urban sprawl and the subsequent intensifying impact on the rural environment When considering the results of built-up density (Tables 3–5) for DSDs, all 13 DSDs show increasing trend of built-up density in years of 1997, 2009 and 2018. Shannon's entropy of the Colombo district has been increased from 0.93 in year 1997, to 1.01 in year 2009 and to 1.06 in year 2018. Log (*n*) for 13 DSDs, is 1.11. Therefore, in Colombo district, Shannon's entropy can be changed from 0 (minimum dispersion) to 1.11 (maximum dispersion). Hence, considered years of 1997, 2009 and 2018 show closer to maximum dispersion levels of urban sprawl in Colombo district. It further shows increasing trend of urban sprawl in Colombo district.

Relative entropy values for the consecutive years of 1997, 2009 and 2018 are 0.83, 0.91 and 0.93. These values also closer to one and exceeding the threshold value of 0.5 which means there was an urban sprawl in Colombo district in 1997, 2009 and 2018. According to the results, the entropy value for 1997 is lower than that of 2009 and the entropy value of 2009 is lower than that of 2018 so there is an increasing trend of sprawl can be observed indicating that Colombo district continued to sprawl from 1997 to 2018 as well as the relative entropy values of these three years exceeded the thresh hold value of 0.5, indicating a higher magnitude of urban sprawl in Colombo district. But the relative entropy change (Equation 4) is higher in 1997–2009 than that of 2009–2018 (Equation 3) indicating that from 2009 to 2018 sprawling in Colombo district has been reduced.

In developed countries, the migration of the middleclass population from the high-density urban space with congestion and pollution to the low-density suburban areas with better environmental conditions was the main reason of suburban expansion (Deal & Schunk, 2004). But in developing countries like Sri Lanka, individual choices are one of the important factors that contribute sprawl development (Amarawickrama et al., 2015). Also, the influence of economic issues forces the low-income population to buy cheap lands and construct more affordable housings with minimum construction regulation, maximum tax incentives and low transportation costs at the urban fringe.

It is obvious that when moving out from the compactly developed areas to eastward of the district those areas shows a prominently high magnitude of sprawl. The reason could be the pressure of urbanisation affects its contiguous areas and, therefore, the DSDs which are located in the subsequent outer ring of the core area, is experiencing a low density, dispersed urban expansion, resulting in urban sprawl, that is, low built-up densities when moving out from core area (Tables 3–5).

The relative entropy change is higher in 1997–2009 than that of 2009–2018 indicating that 2009–2018 sprawling of Colombo district has been controlled. This can be validated by several incidents such as clearing slums in the urbanised areas and construction of major housing complex in the suburb of capital Colombo, targeted for middle-income employees who work in Colombo but cannot afford to reside in the capital city (Jagoda, 2010). Further, the governments have taken significant measures to control this issue by building high-rise housing under Sahaspura Housing Scheme in 2001 and under the Beira Development Project the

Government cleared away all nearby slum dwellings and housing complexes were constructed under the Urban Renewal Programme in 2016. These developments indicate that Colombo district is directed to more sustainable development (Colombo Page, 2018; Urban Development Authority, 2018).

However, despite the national and regional urban development trends by various authorities, the traditional obsession for owning a house with land in Sri Lankan societies (Amarawickrama et al. 2015) promote inefficient land use. Since it is obviously not affordable to buy land and build a house in the highly urbanised areas such as in Colombo, Dehiwala DSDs, residents move to the urban edges in order to achieve the house with land ownership causes rapid increase in the impervious areas in Homagama, Kesbewa, Kaduwela provide the evidence of sprawling residential development.

According to the Department of Census and Statistics (2001, 2015) the population growth of core areas are in a declining rate (i.e., population growth rate in Dehiwala is –0.11), on the other hand population growth rate of suburban areas show an increasing rate (Homagama 0.31); therefore, it is obvious that people are moving to the periphery of the district and the rapid increase of built-up area can be observed. In middle-income countries like Sri Lanka, there is little effective control over land-use conversions from agriculture to non-agricultural uses. In the absence of effective control measures, it led to the rapid land-use changes in rural land masses which supports livelihood of thousands of villages amidst paddy fields, home gardens, coconut groves and plantations.

Agricultural land conversion into impervious areas may cause multiple issues, among them degradation of fertile soil and lifelong threat to agricultural lands are major concerns (Ding, 2009). In several studies it has been documented that people had sold their agricultural lands due to social, financial and agricultural related reasons including the following factors; expand business of existing markets and shops, higher land prices as earnings and better other investment options, family problems, better job option in service sectors, ability to purchase land in other areas where the agricultural land prices are low, low production profit from agriculture, high expenditure in agricultural activities, etc. (r9Asif & Rahman, 2013; r2Peerzado et al., 2019). Resulting rapid recession of labour force employed in the agriculture sector and the high cost of labor have led to high cost of production. Which eventually leads to disruption of traditional livelihoods, that is, traditional gastronomy, rituals and Food insecurity.

Conclusions and Recommendations

Rate of sprawling in Colombo district from 1997 to 2009 was higher than that of 2009 to 2018. This is mainly by applying sustainable development strategies. Further, built-up area has been increasing in 1997, 2009 and 2018 years and consequently occupying land areas also increased to 98.97, 178.76 and 276.80 km^2 and all DSDs in Colombo district show increasing trend of built-up areas from 1997 to 2018. This has mostly affected Agriculture and vegetation in Colombo

district during last 21 years. Colombo district shows sprawl with the entropy of 1.06 and relative entropy of 0.95 which is exceeding its' threshold of 0.5 in year 2018. In year 1997 entropy was 0.928 and relative entropy was 0.83 and in year 2009 entropy was 1.01 and relative entropy was 0.91. Both years shows sprawl in Colombo district.

Since this study considered only the entropy value of Colombo district using built-up areas, it is recommended to consider other urban sprawl indicators such as population growth, population density, poverty, as well as impervious area or built-up area. If relative entropy can be kept below the threshold level, effect of urban sprawl on Agriculture and vegetation can be minimised and sustain the agriculture and environment of the district and protect the livelihood of the rural folk those who depends on agriculture and environment.

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Article

The Impact of Internet Information and Communication Literacy and Overload, as Well as Social Influence, on ICT Adoption by Rural Communities

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Abstract

The adoption of information and communications technology (ICT) for rural development remains a critical issue in developing countries like Indonesia. Broadband projects, both infrastructure- and literacy-related, have been launched to increase ICT access and usage in rural areas. However, the extent of ICT usage for community development in rural areas remains unclear, and therefore this deserves critical assessment. This article argues that the higher the ICT adoption (ICTA) in a rural community, the greater its benefits in terms of development. By exploring Internet information literacy (IIL), Internet communication literacy (ICL) and social influence (SI), this study aims to get a better understanding of the relative influence of these factors on ICTA in rural areas. Also, this study considers Internet information overload (IO) and communication overload (CO) as moderators between independent and dependent variables. This study has been conducted in Gubugklakah village, Malang, Indonesia, with a pre-existing telecentre in the community. Using the partial least squares (PLS) method, the study finds that the ICL and SI variables are considerably higher in terms of construct validity compared with other variables. Both IIL and ICL significantly determine ICTA behaviour. IO and CO may even weaken the relationship between information and communication literacy and ICTA.

Keywords

ICT, Internet information, communication literacy, overloads, social influence, rural development

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Introduction

The Indonesian government, through the Ministry of Communication and Informatics (MCI), endeavours to provide evenly distributed information and communications technology (ICT) infrastructure within the archipelago, including rural areas. The *Palapa Ring*, a broadband backbone project, was accomplished in 2019, with fibre optics covering 12,000 km, connecting the western, central, and eastern parts of Indonesia (BAKTI, 2018). At present, there are at least 514 cities/regencies (*Kabupaten*) that have an Internet connection, which previously was limited. In 2015, MCI launched *Desa Broadband Terpadu*, an integrated broadband programme that aimed to accelerate ICT development and usage in 50 villages included in the list of priority regions for development (Kementerian Kominfo, 2015). Besides providing Internet infrastructure access, particularly to targeted communities (i.e., farmers, fishermen and remote villages), this programme also encouraged the development of applications that could be used by these communities. However, the continuity of this programme is unclear. The official website of Desa Broadband Terpadu, which is supposed to be the source of information about this programme, no longer exists.

The prominent issue regarding the sustainability of the ICT for rural development programmes in Indonesia is in what way that internet is used for community development in rural areas. Desa Broadband Terpadu is not the only one that is stagnant. *Telecenter,* initiated in 2005 funded and by the United Nations Development Programme (UNDP), ran only for 2 years. Eight telecentres had been built in three provinces during that period (World Bank, 2005). But the permanence of telecenter remains unclear when the fund was stopped either by the UNDP or central and local governments. Two key issues emerged regarding Telecenter's sustainability: (a) the lack of an 'infomobilisator', a person who manages, as well as assists, the local community in their search for relevant information in telecentres and (b) the lack of financial support for telecentres' operational costs (Masiero, 2011; Santoso, 2011).

Empirical evidence confirms that ICT has huge potential for rural development in many sectors. It enables improving digital literacy, community economy and online community activities (Ko et al., 2019). The presence of the Internet would increase the social capital of youth in rural areas through their building social networks with economic leaders and volunteer-based organisations, which at the end could contribute to community development (Whitten et al., 2009). Wallace et al. (2017) found that ICT was able to build social cohesion and enhance social integration among community members in two rural areas in Scotland. Although ICT infrastructure existed in the rural areas, the great potential of ICT in rural development would never have been achieved if the communities had been reluctant to adopt it in their daily activities.

Scholars have been suggesting ICT as a path to rural development. It can be seen in the growing number of conferences that specifically discuss this topic, sponsored by universities and governments, over the last 5 years. One of the conferences was the 2018 International Conference on ICT for Rural Development (IC-ICTRuDev), hosted by MCI, in which the earlier version of this article was

presented. The article investigated the impact of Internet information and communication literacy and overloads on ICT adoption (ICTA) for rural communities. Two prominent findings were presented: (a) there is no evidence that information overload (IO) may influence ICTA; and (b) Internet information literacy (IIL) has a higher impact on ICTA than Internet communication literacy (ICL) (Rumata, 2018).

This article investigates three ICTA behaviour determinants: IIL, ICL and social influence (SI). Also, it examines the extent of both IO and communication overload (CO) in moderating these determinants' influence on such behaviour. ICT that is covered in this study includes any technology that facilitates communication and information-seeking functions, which includes the Internet. Without an Internet connection, it is impossible to use ICT for either function.

This study is conducted in Gubugklakah village, Malang, East Java, Indonesia. A telecentre, namely *Desa Wisata Gubugklakah* (DWG) Sakti telecentre, was built in this village in 2005 and was funded by the local government. At present, the telecentre is managed and independently sponsored by the local community to promote tourism and apple products. This village is located at the foot of Mount Bromo, one of the well-known volcanic mountains in Indonesia. This indicates that the local community adopted the Internet properly for economic purposes. It would be interesting to study the community's ICTA behaviour. Therefore, the specific objectives of the study are:

1. To identify the determining factors of ICTA behaviour in rural communities with a pre-existing telecentre;
2. To identify which mediating factors may hinder ICTA behaviour in rural communities with a pre-existing telecentre; and
3. To present empirical evidence of construct variables of ICTA behaviour in rural communities with a pre-existing telecentre.

Literature Review

Information and Communications Technology Adoption in Rural Communities

There are two broad categories of ICT for rural development studies, both theoretically and practically, which are access and application (Xia, 2010). In terms of application, ICT opens new opportunities for rural people to access a wide range of services, such as healthcare, government services, market and security, as well as accelerating the exchange of information, especially knowledge (Migiro & Kwake, 2007). These applications, which can be accessed through mobile phones, can have tremendous impacts on rural communities in many sectors, including the health sector (Chib et al., 2015), agriculture sector (Nabhani et al., 2016), public sector and digital sector (Nurchim & Nofikasari, 2018).

In terms of access, a study finds that Internet connectivity infrastructure would increase the economic activities in rural areas (Ariansyah, 2018). Nevertheless,

the prominent issue of telecommunication access in rural areas pertains not to a coverage gap but to a usage gap. Coverage gap refers to the absence of a mobile broadband network. By the end of 2018, 76.74% of rural areas had been covered by 4G network, which supports mobile Internet connection (Afidah & Doom, 2018). Usage gap refers to the absence of mobile Internet usage even when a mobile broadband network is present in a concerned area. In 2018, the usage gap in rural areas was 38.4%, while in urban areas it was 25.9% (APJII, 2019).

ICTA plays a critical role in closing the usage gap in rural areas. We argue that the success of ICT integration in rural areas does not solely involve the deployment of ICT physical infrastructures. Instead, we should consider non-technical aspects that may drive the sustainability of ICT in rural development programmes. Studies found a wide range of factors that may determine ICTA behaviour in rural communities. Conceptually, there are several heavily used models to explain ICTA behaviour, such as Technology Acceptance Model (TAM) (Davis, 1989), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) and Rural Technology of Acceptance Model (RuTAM) (Islam, 2011). These models are based on the assumption that perceived ease of use and usefulness of technology form technology adoption behaviour. The application of these models to understand ICTA in Indonesian rural communities is common (Heimerl et al., 2015; Nabhani et al., 2016; Sambodo & Nuthall, 2010).

There are also studies that explain ICTA behaviour from a non-technical perspective. A study found that the economy is not a barrier for ICTA. A community in Olilit Raya, a village in Tanimbar island, Maluku, in the eastern part of Indonesia, prefers to use commercial mobile broadband rather than zero-cost Internet provided by the government through the Integrated Broadband Village Program (Dhahir, 2018). SI, such as that of peer group and family, appears to be a significant factor that influences ICTA and sustainability in rural communities (Khalil Moghaddam & Khatoon-Abadi, 2013; Sambodo & Nuthall, 2010).

Yu et al. (2017) propose a conceptual framework that consists of psychological factors that influence ICTA behaviour. There are five key constructs in this framework: (a) task characteristics; (b) media richness; (c) media experience; (d) social interaction; and (e) ICTA behaviour. The prominent finding of Yu et al.'s framework is that ICT media richness (as information source and communication channel) would lead to better media experience and social interaction, which would in turn accelerate the adoption process. On the other hand, task characteristics have no direct impact on ICTA behaviour.

This study adopts Yu et al.' framework in exploring ICT media richness as an information source and communication channel to understand ICTA behaviour in rural communities in Indonesia, which has never been done before. Besides exploring information and communication literacy, this study also investigates the role of SI in the formation of ICTA behaviour. Apart from these determinants, this study also elaborates on IO and CO as mediators. To measure the ICTA behaviour, we assess the perceived usefulness and perceived ease of use of existing ICT; there are five items of the 'ICTA' indicator, which includes 'ICT helps me to communicate with others borderless and timeless' and 'ICT helps me to keep productive to look for the new economic opportunity' (Table 1).

Table 1. Information and Communications Technology Adoption Items.

Code	Questionnaire Items
ICTA1	ICT technology (i.e., the Internet) is useful in supporting my daily tasks.
ICTA2	ICT technology (i.e., the Internet) makes communication with others easier, with no spatial and time boundaries.
ICTA3	ICT technology (i.e., the Internet) helps me be productive and find other jobs or business opportunities.
ICTA4	ICT technology (i.e., the Internet) is easy to learn and use.
ICTA5	I am sure that I can learn to use ICT technology (i.e., the Internet) in a short time.

Source: Adapted from Islam (2011, p. 13).

Internet Information Literacy and Overload

The main reason why ICTA is so important for rural communities is that ICT facilitates the production, distribution and consumption of information tremendously and ubiquitously. Information needs and seeking behaviour are the primary driving factors for households in Southern Ethiopia to adopt mobile phone usage (Kacharo, et al., 2018). This should be preceded by pre-existing information literacy. This means that the more rural inhabitants realise their information needs, the more likely they are to adopt ICT to meet their needs.

Information literacy, by definition, is the ability to search for and evaluate information that is most relevant to specific needs (Welsh & Wright, 2010). The American Library Association concludes five dimensions of information literacy outcomes which are not just to recognise the needs and/or locate and evaluate the information, but also to use the information for certain purposes and to build awareness economically, socially, and legally (Abdullah, 2013). In the more connected world of today, information is a valuable resource. One being an ICT literate means that the person would be able to participate in the wider society and pursue knowledge, particularly for personal purposes. Hence, if a rural person has a certain level of information literacy, it is possible for her/him to be independent and empowered. Turkalj et al. (2015) reported that an adequate level of information literacy was needed to integrate Croatian farmers into a modern agricultural market successfully. This adequate level of information literacy cannot be accomplished without the Internet. This article adapts the IIL variable of van Deursen et al. (2014), as seen in Table 2.

Table 2. Internet Information Literacy Items.

Code	Questionnaire Items
IIL1	I always find the information that I need on the Internet.
IIL2	I do not know how to evaluate the information I find on the Internet.

(Table 2 Continued)

(Table 2 Continued)

Code	Questionnaire Items
IIL3	I am aware that I should not trust all the information on the Internet, and hence I am looking for other references.
IIL4	I understand the technical language of the Internet (i.e., browser, download/upload).
IIL5	I know the etiquette to follow when I create content on the Internet.

Source: Adapted from van Deursen, Curtosis & van Dijk (2014) and Karr-Wisnlewski & Lu (2010).

Table 3. Information Overload Items.

Code	Questionnaire Items
IO1	I am disturbed by the abundant information on the Internet.
IO2	I am overwhelmed on processing the information on the Internet.
IO3	There is so much information on the Internet, and I hardly understand all of it.
IO4	I am confused whenever I have to type exact keywords in a search engine to find the information that I want.

Source: Adapted from Cho et al. (2011) and Karr-Wisniewski & Lu (2010).

The diverse and abundant information that is available on the Internet may cause someone to feel overwhelmed, making it difficult to recognise relevant information. There are several terms to describe this condition, such as 'information overload', 'information anxiety' or 'infobesity', but Bawden and Robinson (2009) call it 'pathologies of information'. These information pathologies may comprise IO and information environment changes, among which the latter refers to the diversity in the types of information. Many scholars have defined IO, but the first person who coined the term was Alvin Toffler (Davis, 2011). Davis (2011) argues that IO is a consequence of the failure to contain the amount of information and to filter out information. This article adapts the IO variable of Karr-Wisniewski and Lu (2010), as seen in Table 3.

Communication Literacy and Overload

Besides information exchange, ICT can serve as a facilitator to support two-way communication and immediate responses and feedback. ICT facilitates a user to connect with more than one online social network. Face-to-face communication between two persons is completely different from communication mediated by a computer or a gadget. van Deursen et al. (2014) add communication skills as part of the Internet skills framework that was developed by van Deursen and van Dijk in their previous works in 2009 and 2010. The dimension of communication skills encompasses: (a) the ability to search, select and reach contacts online; (b) having vast tacit knowledge on the nature of computer-mediated communication, which is different from face-to-face communication; (c) the ability to attract someone to

read your message on the Internet; (d) having the skill to create a distinctive online personal profile; and (e) the ability to respond to others online (van Deursen et al., 2014). Based on these, we adopted six items to measure Internet communication skills, including 'asking people for advice' and 'receiving feedback on posted messages' (Table 4).

The average time spent on social media worldwide is 2 hours and 16 minutes per day, whereas time spent by Indonesians is 3 hours 26 minutes per day (Hootsuite & We Are Social, 2019). Hence, the occurrence of the so-called CO is possible. Like IO, CO is also considered as a cognitive overload, whereby someone feels overwhelmed by the abundant messages, interactions and symbols that he/she receives through various and synchronous communication channels (Cho et al., 2011). There are few studies about CO in the context of rural communities. Studies on CO are conducted mostly in an organisational or professional setting (Cho et al., 2011; Karr-Wisniewski & Lu, 2010). Nevertheless, we adopted Cho et al., as well as Karr-Wisniewski and Lu's, CO indicators, which we modified so that they could be understood by the respondents in the rural community. For instance, one of Karr-Wisniewski and Lu's CO indicators is 'I often find myself overwhelmed because technology has allowed too many other people to access my time'. In our questionnaire, we modified it to 'I feel too exhausted to reply to messages on social media and instant messaging'. All the CO items are presented in Table 5.

Table 4. Internet Communication Literacy Items.

Code	Questionnaire Items
ICL1	I ask people for advice on the Internet (i.e., social media, instant messaging).
ICL2	I receive positive responses or comments through the Internet (i.e., social media, instant messaging).
ICL3	I add new friends and contacts through the Internet (i.e., social media, instant messaging).
ICL4	I get involved in online discussions with my friends on the Internet (i.e., social media, instant messaging).
ICL5	I easily get social support from friends through the Internet (i.e., social media, instant messaging).
ICL6	I feel the harmony between residents is maintained despite the presence of ICT developments (i.e., the Internet).

Source: Adapted from van Deursen, Curtosis & van Dijk (2014).

Table 5. Communication Overload Items.

Code	Questionnaire Items
CO1	I feel that I generally get too many messages or comments, either from friends I know or just acquaintances, through social media and instant messaging.

(Table 5 Continued)

(Table 5 Continued)

Code	Questionnaire Items
CO2	I feel too exhausted to reply to messages on social media and instant messaging.
CO3	I receive too many notifications on my social media accounts and through instant messaging.
CO4	I feel overwhelmed by the many messages I receive on social media, email and instant messaging.
CO5	I spend less time with my family since I use ICT technology (i.e., the Internet, social media and instant messaging)
CO6	The availability of ICT technology (i.e., the Internet) has created more interruptions than it has improved communication.

Source: Adapted from Cho et al. (2011) and Karr-Wisniewski & Lu (2010).

Social Influence

There is scientific and empirical evidence to support the idea that social setting may influence ICTA. SI may form the perception that ICT would improve the rural community's performance, as well as the perception on ICT's ease of use (Tambotoh et al., 2015). Yu et al. (2017) argue that SI in a particular group is a great social factor that motivates people to adopt ICT.

Strong social capital may still exist in the rural community. Scientific evidence supports the idea that social capital could influence the development of a village. Social capital could be in various forms within a village, as both human and non-human resources, for a community to pursue its development goals (Nugrahani et al., 2019). With the development of ICT, social capital is needed to build 'a bridge' to other communities outside the village. However, studies confirm that ICT would be able not only to enlarge but also to reduce social capital (Ei Chew et al., 2011; Hobe, 2016). A study in a rural area located at the Indonesia–Timor Leste border found that the contribution of social capital's influence on youth's perception that ICT has role in rural development is slightly significant (less than 37%) (Rumata et al., 2019).

SI is a strong indicator of social capital. There is scientific and empirical evidence to support the idea that SI may influence ICTA. SI may form the perception that ICT would improve a rural community's performance, as well as the perception of ICT's ease of use (Tambotoh et al., 2015). In the UTAUT model, SI refers to someone's perception that he/she should use a particular technology that people in his/her social circle may suggest (Brown et al., 2010). This study adapts Brown et al.' (2010) SI indicators, but we modified them for the rural context, to include the SI items such as 'My peers in the village think I should use instant messaging and social media to communicate and expand my network outside the village' and 'The chief of the village suggests that ICT (i.e., the Internet) is useful for increasing social interaction with other villagers' (Table 6).

Table 6. Social Influence Items.

Code	Questionnaire Items
SI1	My peers in the village urge me to use ICT (i.e., the Internet) for communication and daily-task completion.
SI2	My peers in the village think I should use instant messaging and social media to communicate and expand my network outside the village.
SI3	The chief of the village uses ICT to communicate with other villagers.
SI4	The chief of the village suggests that ICT (i.e. internet) is useful for increasing social interaction with other villagers.

Source: Adapted from Brown et al. (2010).

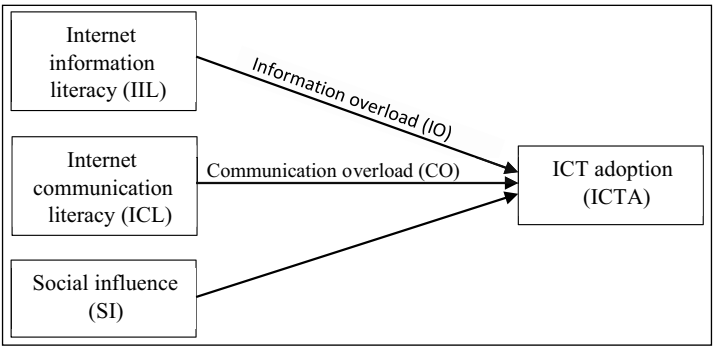

Figure 1. Research Framework.

Source: Authors' calculations.

Methodology

This is a quantitative study in which the primary data were gathered through a questionnaire, which was determined based on the existing measurement frameworks. A closed-type questionnaire based on a 5-point Likert scale was used to measure the respondents' opinions. The survey was conducted in Gubugklakah village, Malang, East Java, Indonesia, between 6 September 2017 and 9 September 2017. Non-probability-based accidental sampling (Notoatmodjo, 2010) was used to select respondents who were available particularly in the office of the head village and Desa Wisata Gubugklakah telecentre.

There are five variables in this study: ICTA (Y variable); IIL (X_1); ICL (X_2); SI (X_3); IO (moderator); and CO (moderator) (Figure 1). Each variable has different numbers of indicators, adding up to 30 items. Interpretative statistics have been used to determine the influencing extent of the parameters. The partial least squares (PLS), or soft-modelling, path model was used to analyse the data. PLS is a powerful data analysis method that can be applied with no requirement of specific data size, and further, it does not need a large sample (Jaya & Sumertajaya, 2008). PLS path models can detect and estimate not only direct or indirect causal

relationships but also bidirectional causal relationships or spurious and non-analysed relationships (Henseler & Fassott, 2010). Simultaneously, PLS can be used to test both sub-models in structural equation modelling (SEM), which are: (a) the inner model (the relationships between the independent and dependent latent variables) and (b) the outer model (the relationships between the variables and the indicators) (Wong, 2013). The inner model (known as the structural model) also determines the hypothesis test, whereas the outer model (known as the measurement model) test indicates the validity and reliability results (Abdillah & Jogiyanto, 2009).

Outer Model Evaluation

There are two measures to evaluate the outer model: convergent validity and discriminant validity. Convergent validity measures the extent to which the indicators can form a latent variable. To check it, the following parameters should be tested: (a) reliability (the validity of each indicator); (b) composite reliability (CR); and (a) average variance extracted (AVE) (Yamin & Kurniawan, 2011). A standardised factor loading value determines the correlative value of indicators to the latent variable. If the factor loading value is more than 0.7, then the indicator is considered valid. In some cases, a standardised factor loading value of more than 0.5 is also considered valid (Bagozzi & Yi, 1988 in Wong, 2013). In contrast, if the standardised factor loading value is below 0.5, then the indicator should be eliminated from the model (Chin, 2000). The Cronbach's alpha technique is used to determine the CR. If Cronbach's alpha is more than 0.7, it suggests that the variable is reliable (Jaya & Sumertajaya, 2008). The last test of convergent validity is AVE, which measures the amount of variance in the indicators due to measurement error. It is acknowledged that if the AVE value is more than 0.5, it means that convergent validity is established (Wong, 2013), meaning that the latent variable could explain more than half the variance that is captured by a construct.

The other measure used to evaluate the outer model is discriminant validity, which determines whether the constructs in the model are highly correlated or not. A reflective measurement model type in SEM is considered 'if the indicators are highly correlated and interchangeable' (Wong, 2013). The cross-loading factor is determined by comparing the square root of AVE of a particular construct with the correlation between that construct and other constructs. The value of the square root of AVE should be higher than the correlations among the latent variables (Fornell & Larcker, 1981 in Wong, 2013).

Inner Model Evaluation

Bootstrapping is a procedure to test both the inner and outer models through *T*-statistics (Wong, 2013). These *T*-statistics determine the significance of the *path coefficient*, the relationship between the independent and dependent variables. To

validate the model in general, a measure of goodness of fit (R^2 value), introduced by Tenenhaus et al. is used (Yamin & Kurniawan, 2011).

Results and Discussion

The details of the respondent profile are described in Rumata (2018). In summary, the composition of respondents was 48.5% males and 51.5% female (99 respondents). Smartphones (69.7%) and 2G mobile phones (41.4%) are the mobile gadgets most owned by the respondents. Regarding their age groups, the respondents are mostly post-millennials (26–35 years old) and Generation Z members (15–25 years old), constituting 24.2% and 39.4%, respectively. (Rumata, 2018).

Each variable is scaled and determined based on three categories: low (1–2.33); moderate (2.34–3.66); and high (3.67–5). Based on the recorded data, ICL and SI are categorised as 'high', while the remaining variables, IIL, CO, IO and ICTA, are categorised as 'moderate' (Table 7).

Outer Model Evaluation

The outer model evaluation involves two steps: (a) testing convergent validity (loading factors) and reliability (AVE and CR) and (b) testing discriminant validity. The convergent validity is used to measure the degree of both internet information and communication literacies (as independent variables) would form the construction of ICT adoption (as the dependent variable). The factor loading value indicates the significant contribution of the indicators in each variable. A factor loading value between 0.5 and 0.6 is considered sufficient, as long as there are few indicators for each variable construct (Jaya & Sumertajaya, 2008). As shown in Figure 2, all latent variables have a factor loading value greater than 0.55 and therefore are valid (the threshold is 0.5), which means that ICL and IIL, as well as SI, form ICTA behaviour among rural communities with a pre-existing telecentre.

Table 7. Variables' Construct Validity.

Variables	Mean	Std. Deviation	Category
Internet communication literacy (ICL)	3.74	0.98	High
Internet information literacy (a)	3.20	1.08	Moderate
Communication overload (CO)	3.12	1.04	Moderate
Information overload (IO)	3.50	1.06	Moderate
Social influence (SI)	3.90	0.95	High
ICT adoption (ICTA)	3.58	1.02	Moderate

Source: Authors' calculations.

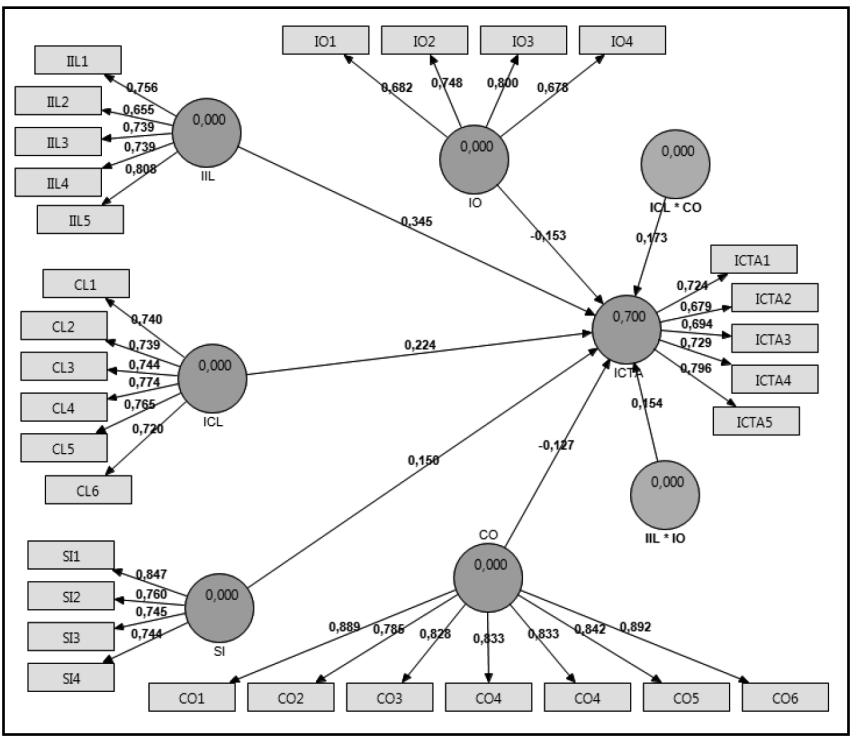

Figure 2. Inner and Outer Models

Source: Authors' calculations.

Figure 2 also shows the factor loading value of each indicator in every variable. For the IIL variable, the highest contribution is IIL5 ('I know the etiquette to follow when I create content on the Internet'), with a factor loading value of 0.808. This is imperative, since Internet etiquette is something that rural communities may not be familiar with. It is worth noting that not all the respondents in this study are Internet users, since some residents do not own a mobile phone and/or a smartphone. This finding needs to be explored in further studies. Nevertheless, this study shows that the rural community may perceive that the Internet is a beneficial medium for fulfilling their daily information needs. The second biggest contributor is IIL1 ('I always find the information that I need on the Internet'), with a factor loading value of 0.765. This finding contradicts that of the previous study of Ting (2014), who suggests that rural people prefer not to use the Internet since they do not know the Internet's information and transaction benefits for them.

The highest factor loading value for the ICL variable is found for ICL1, or the statement, 'I ask people for advice on the Internet (i.e., social media, instant messaging)'; this finding shows that social support could be the strongest reason for rural people to adopt ICT. This finding contradicts the Internet's paradox, found particularly in Gregg et al. (2007), who found that the increase of online social support may indicate that social bonding with the offline community is lower (Gregg et al., 2007). Social support is conceptually similar to bonding

social capital, where ICT is used to increase social relationships with other community members online. A study carried out on rural youths' online social capital suggests that bonding social capital and self-efficacy are conceptually moderators of the relationship between the use of online social networking and community participation (Ei Chew et al., 2011). A rural youth who believes that online social networking would be beneficial for him/her would be able to expand and have meaningful interactions with his/her online social network. Nevertheless, this study also suggests that rural people tend to contact and interact with the existing offline community members, particularly with prominent figures, through social networking platforms. Table 8 shows that the AVE value of each variable is greater than 0.5, which means that the latent variable could explain, on average, more than half the variance of the indicators. Further, the value of CR is above 0.7 for all the variables, which means that the variables are reliable as measurement scales of ICTA (Jaya & Sumertajaya, 2008).

Discriminant Validity

The discriminant validity test compares the square root of AVE of each indicator with the correlation among the construct variables (Jaya & Sumertajaya, 2008). If the AVE values are larger than the corresponding values of correlation with all the construct variables, then discriminant validity is confirmed. Table 9 shows the discriminant validity value of each indicators of the variables. It confirms that each indicators would construct the latent variable.

Table 8. Variables' Reliability.

Variables	AVE	CR
Internet communication literacy (ICL)	0.56	0.88
Internet information literacy (IIL)	0.55	0.86
Communication overload (CO)	0.71	0.95
Information overload (IO)	0.53	0.82
Social influence (SI)	0.60	0.86
ICT adoption (ICTA)	0.53	0.85

Source: Authors' calculations.

Table 9. Discriminant Validity Test.

Indicators	CO	ICL	ICTA	IIL	IO	SI
ICL1		0.74				
ICL2		0.74				
ICL3		0.74				
ICL4		0.77				

(Table 9 Continued)

(Table 9 Continued)

Indicators	CO	ICL	ICTA	IIL	IO	SI
ICL5		0.77				
ICL6		0.72				
CO1	0.89					
CO2	0.78					
CO3	0.83					
CO4	0.83					
CO5	0.84					
CO6	0.89					
ICTA1			0.72			
ICTA2			0.68			
ICTA3			0.69			
ICTA4			0.73			
ICTA5			0.80			
IIL1				0.76		
IIL2				0.65		
IIL3				0.74		
IIL4				0.74		
IIL5				0.81		
IO1					0.68	
IO2					0.75	
IO3					0.80	
IO4					0.68	
SI1						0.85
SI2						0.76
SI3						0.75
SI4						0.74

Source: Authors' calculations.

Inner Model Evaluation

The goodness of fit of the model is measured by the *R*-squared test considering the dependent variable. The *R*-squared value of ICTA is 0.640 (Table 10), which means that the structural model is moderately good to explain that both communication and information literacy have a direct relation with ICTA, with 64%, while 36% may be influenced by other variables outside the structural model.

Table 10. Variables' Reliability.

	R-squared
ICTA	0.640

Source: Authors' calculations.

Table 11. Hypothesis Test.

Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	*T*-statistics (|O/STERR|)
IIL → ICTA	0.34	0.35	0.09	0.09	3.99
ICL → ICTA	0.22	0.18	0.09	0.09	2.40
SI → ICTA	0.15	0.16	0.07	0.07	2.23

Source: Authors' calculations.

Structural Model Test

Table 11 shows that the three independent variables, IIL, ICL and SI, have a positive and significant influence on ICTA behaviour (*T*-statistics > 1.645).

The usage of ICT for information fulfilment becomes a prerequisite for ICTA. A farmers community in Kirinyaga County, Kenya, for instance, would be able to adopt ICT easily, as long as ICT is used as source of information by the farmers for gathering information on the things such as paddy seeds' price and availability (Migiro & Kwake, 2007). A qualitative study conducted in 10 remote villages in Chile that received Internet infrastructure facilities in 2010–2011 found that community occupation and individuals' start-up businesses in the community may have high ICT engagement (Correa & Pavez, 2016). Furthermore, a study conducted in Gharn Abad's ICT centre, Iran, showed that there is a correlation between the usage of ICT for information and communication purposes by families and the development of pre-existing ICT centres in that area (Khalil Moghaddam & Khatoon-Abadi, 2013). People in rural communities may be aware that ICT could be a source of information that could help them, mostly for economic purposes. The community in Gubugklakah village predominantly comprises apple farmers who coexist with tourism service providers. Henceforth, the ICT inevitably support the community to do daily tasks particularly in providing valuable information. An apple farmer needs information on how to cultivate apples and transform them into profitable commodities, the price of apple seeds, etc. For tourism service providers, the Internet helps the community to spread information about the available off-road vehicles for tourists to explore Bromo Mountain.

ICT may broaden an individual's social network by expanding his/her communication without time and spatial limitations. It is not always easy for a

new ICT user in a rural area to communicate in the absence of another person. Nevertheless, some studies have found that ICT may increase social capital and/or social cohesion—social relationship—among individuals within a community as well as among members of other communities outside rural areas (Rumata et al., 2019; Wallace et al., 2017).

In the context of a rural community, SI may affect the approval and usage of new technology (Tambotoh et al., 2015). An individual may use new technology because people in his/her community use that new technology too. In addition, when individuals use technology for interaction and communication, they also think that technology could be used as a socialisation tool (Yu et al., 2017). In this study, SI indicates not to what extent technology would facilitate social interaction and influence but to what extent a social community may influence ICTA.

Moderating Information Overload and Communication Overload

In this research, a moderating test was applied to determine whether both IO and CO mediate the relationship between IIL and ICL with ICTA. According to the factor loading values seen in Table 12, IO may reduce the strength of the relationship between IIL and ICTA (0.345). Similarly, it has also been found that CO may reduce the mediating relationship between ICL and ICTA (0.150). This also means that both IO and CO may reduce ICTA, although there is existing Internet information and communication literacy.

The existence of IO and CO, based on existing studies, may be because of the overuse of technology (Lee et al., 2016). In this study, we do not use the frequency of daily ICT use as a factor that causes IO and CO. However, this study shows that IO and CO may hinder rural people from adopting ICT even when they perceive that ICT may fulfil their needs of information and communication. In the context of website usage in the rural tourism area, the intention to search and find useful information may increase the perceived use of websites' functionality. Even so, Herrero and San Martín (2012) suggest that IO may hinder website usage and that there should be some sort of 'threshold' that indicates the level of 'overload'. The level of IO is not determined by the existing amount of irrelevant information. However, Lee et al. (2016) found that relevant information does create the feeling of overload if it goes beyond the threshold.

Table 12. Moderating Test Information and Communication Overload.

	Original Sample (O)	Loading with Information Overload Moderation	Loading with Communication Overload Moderation
IIL → ICTA	0.359	0.345	
ICL → ICTA	0.154		0.150

Source: Authors' calculations.

Conclusion

This study analyses the determining factors of ICTA behaviour in rural communities with a pre-existing telecentre. It was conducted in Gubugklakah village in East Java, Indonesia, which was one of the beneficiaries of the local government–funded Telecenter project. The basic argument of this study is that ICTA in rural communities plays a critical role in their harnessing the benefits of ICT for rural development.

The study finds that IIL and ICL significantly determine ICTA behaviour among rural people with a pre-existing telecentre in their village. The ICL and SI variables are considerably high in terms of construct validity compared to the other variables, indicating that rural people may perceive that ICT would facilitate information and communication in a better way. Nevertheless, ICTA may be hindered by the existing perceptions of IO and CO.

This study recommends to the Indonesian government to promote the awareness of rural people regarding the potential impact of IO and CO on ICTA or ICT usage in every ICT literacy programme.

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Article

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Abstract

Agriculture is the mainstay of Bangladesh's economy, accounting for 15.89% of its GDP and 45.1% of its labour employment. Efficiency of economic activities in agriculture crucially depends on the flow of information relating to farming decisions, as well as on demand for such information by farmers. This study examines the information needs and information-seeking behaviour of small-scale farmers in rural Bangladesh. Opinions and feedback of farmers were collected through mini–focus group discussions (MFGD) and in-depth interviews (IDI) in seven districts across Bangladesh. The study finds that many farmers lack awareness of where and how to obtain agro-information. The priority areas on which farmers typically seek information include seeds, fertilisers, agriculture credit, irrigation, disease and pest management. The information-seeking behaviour of the farmers depends on two variables: the nature of the crisis and the reliability of the information available. Farmers rely on personal experience and informal networks when the nature of crisis is familiar or non-critical; they rely on multiple external sources when the nature of crisis is critical and personal knowledge proves inadequate. The use of information and communications technology (ICT) (such as Union Digital Centers and Agricultural Helplines) in this regard is minimal, and the potential of utilisation of the office of agriculture extension remains untapped. The major constraints faced by the farmers in

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seeking information using modern ICT include farmers' prevailing norms and perceptions (e.g., resistance to change and adoption of new technology), relatively high costs of and low awareness regarding agro-information, poor infrastructure to be able to support ICT services, spatial inconvenience, in terms of location and availability of ICT facilities, and low literacy among the farmers.

Keywords

Small-scale farmers, information-seeking behaviour, Bangladesh agriculture, agricultural extension services, agricultural development

Introduction

Bangladesh is an agriculture-intensive country with more than 14 million farming households extensively depending on agriculture for their livelihood. Agriculture is the third largest contributor to the gross domestic product (GDP) of Bangladesh (including fisheries and forestry) and employs 45.1% of the total labour force of the country. It is a major source of income for 14 million farm holdings (BBS, 2013). In financial year (FY) 2014–2015, Bangladesh earned US$1,154.08 million by exporting agricultural products, which account for 3.6% of the total export earnings of the country (Bangladesh Bank, 2015).Therefore, knowledge about agriculture—a key sector of the country's economy and employment—is vital for farmers to ensure their yields and ensure the food security of the country (Taylor & Jakku, 2020). It is now unequivocally established that timely availability of information and its proper use by farmers result in increased production and economic prosperity. Farmers require information on availability and use of various agriculture inputs, such as seeds, fertilisers, insecticides, agricultural equipment and subsidy. They also need information concerning farming activities, such as market information, bank credit, transport facilities, crop insurance, irrigation, animal husbandry and so on. Access to and use of current information is critical for increasing firm production, as well as for supporting sustainable agricultural systems (Babu et al., 2012).

Farmers need authentic agricultural information in order to make the optimum use of their farmland. Over the years, agriculture in Bangladesh has been mechanised, and technology and modern agricultural machinery and tools are being used. Farmers have limited opportunity to articulate and inform about their needs to service providers. There is a growing need to appreciate the spectrum of information needs and information-seeking behaviour of farmers by intermediary (service providing) agencies.

This study intends to contribute to the existing body of knowledge on farmers' information-seeking behaviour in developing countries, in general, and in Bangladesh, in particular. The findings of the research will be of practical use for the policymakers at the Ministry of Agriculture, as well as for field-level extension agents, private organisations and non-governmental organizations (NGOs), while planning for efficient and effective information delivery. This study is conceived

and materialised against the above backdrop and context. It aims to examine the information needs and information-seeking behaviour of small-scale farmers in rural Bangladesh.

The specific objectives of the study are to:

1. Determine farmers' information needs at various stages of agricultural production;
2. Assess the information-seeking behavioural patterns (channels and sources of information search and its use) of small-scale farmers; and
3. Identify constraints that limit farmers from seeking information using modern information and communications technology (ICT) in agriculture services.

Literature Review

Since 2008, the current Awami League–led Bangladesh government has attached special emphasis to information sharing and ICT through a campaign popularly coined 'Digital Bangladesh'. In following this spirit, the Right to Information Act was enacted in 2009, and an Information Commission was also constituted with the stated goal of facilitating citizens' access to information, and thereby establishing good governance. The government has established 4,547 Union Digital Centers (UDCs) across all Union Parishads (UPs; lowest tier of local government) across the country. UDCs are one-stop service outlets, and using ICT, these centres provide various categories of information related to the government, livelihood (including agriculture) and private services to the doorstep of citizens in rural areas (Rahman & Bhuiyan, 2016, p. 6).

The existing sources of information for farmers may be categorised into 'traditional' and 'modern'. Traditional sources of information include peer farmers, lead farmers, input retailers/dealers and government extension officers. Modern sources comprise ICT services that provide agricultural information to farmers, including newspapers, relevant websites, helplines, telecentres and agriculture programmes on television and radio channels.

The significance and topicality of understanding farmers' information-seeking behaviour are also well established (Momodu, 2002; Babu et al., 2012). As Dutta (2009) argues, there has been a relatively insignificant number of studies on the information-seeking behaviour of the citizens of developing countries. There has been strikingly limited research on the subject, especially in the context of marginal farmers in Bangladesh. A study conducted by Ahmed et al. (1997) noted that most rural dwellers who work in the agricultural sector (farmers and labourers) need information regarding increased agricultural productivity and related facilities available locally. Such facilities would include grants, subsidies, provision of credit and supply of fertilisers and agricultural implements. However, the study did not analyse the information-seeking behaviour of the farmers in rural areas. This study attempts to contribute to this relative lacuna in the concerned literature.

Data and Methodology

Data

The primary data used in this study partially draw on the work of an exploratory market development project that aims to contribute to increasing the income of poor men and women in rural areas by facilitating changes in services, inputs and product markets, which in turn increases the competitiveness of farmers and small enterprises (Swisscontact-Katalyst, 2014). One of the authors has worked in the project and was directly involved in the empirical data collection process. Appropriate permission has been secured for use of the information.

This study has adopted a qualitative approach. Such an approach is considered particularly useful in studying the behavioural dynamics of participants in their natural setting (Creswell, 2014). The research sites and study respondents were purposely selected based on the following rationale: ensuring representation of the regions that are highly agriculture-intensive, or where a significant farming population exists, with the presence of both traditional and modern sources of agriculture information accessible to the farmers. Accordingly, 7 out of a total of 64 districts in Bangladesh were selected, namely Cumilla, Jessore, Bogra, Mymensingh, Dinajpur, Tangail and Nilphamari.

The principal fieldwork tools included mini–focus group discussions (MFGDs) and personal (one-on-one) interviews. Each MFGD typically comprised five participants and lasted approximately 1.5 hours. This tool allowed the researchers to extract varying information from a homogenous group. In-depth discussions helped elicit views and perceptions of the target participants, which helped them develop a holistic understanding of the information-seeking behaviour of farmers. An interview lasted for approximately 1 hour. Qualitative data were analysed through categorisation of themes contained in the data, followed by the linking of themes and ideas and exploration of new ideas (Pickard, 2007, p. 280). Table 1 summarises the tools used in the study.

Table 1. Research Tools Used.

Locations	Mini-focus Group Discussions (MFGD)	Personal Interviews (PIs)	Total
Comilla	12	11	23
Jessore	9	10	19
Bogra	11	13	24
Mymensingh	5	9	14
Tangail	11	2	13
Dinajpur	5	9	14
Nilphamari	10	1	11
Total	**63** (63 ´ 5 = 315)	**55**	**(MFGDs + PIs) = 118** Number of respondents = (315 + 55) =370

Source: Excerpted from Swisscontact-Katalyst (2014).

The study respondents comprised 370 small-scale farmers (60% male, 40% female). The monthly income of the respondents ranged from Bangladesh Taka (BDT) 6,000 to BDT 10,000, and they owned less than 1 acre of land. The mean age of the respondents was 52. There were 315 (63 X 5) farmers in the MFGDs—189 were male and the rest were female. The majority of the female farmers in the MFGDs were homestead farmers. A total of 55 in-depth interviews (IDIs), targeting 33 men and 22 women, were conducted. Among the female respondents, 10 were involved in post-harvest activities, while the rest were engaged in homestead farming.

Analytical Framework

Information-seeking behaviour is defined as a complete range of human behaviours, as it relates to the search for information in a purposeful way to meet an information gap (Wilson, 2000). The conceptual framework depicted in Figure 1 was developed drawing on a number of the major studies on information needs and the information-behaviour models developed by Wilson (1981, 1999), Krikelas (1983), Leckie et al. (1996), Johnson (1997) and Babu et al. (2012) for grasping the information needs and information-seeking behaviour of farmers. A composite framework based on the above-mentioned models enables us to sense how characteristics of information search from an individual perspective translate into final outcomes, such as farm productivity and income, through the various contexts of information search, information barriers, information content and sources, and how information is converted into specific action through its adoption by farmers (Babu et al., 2012).

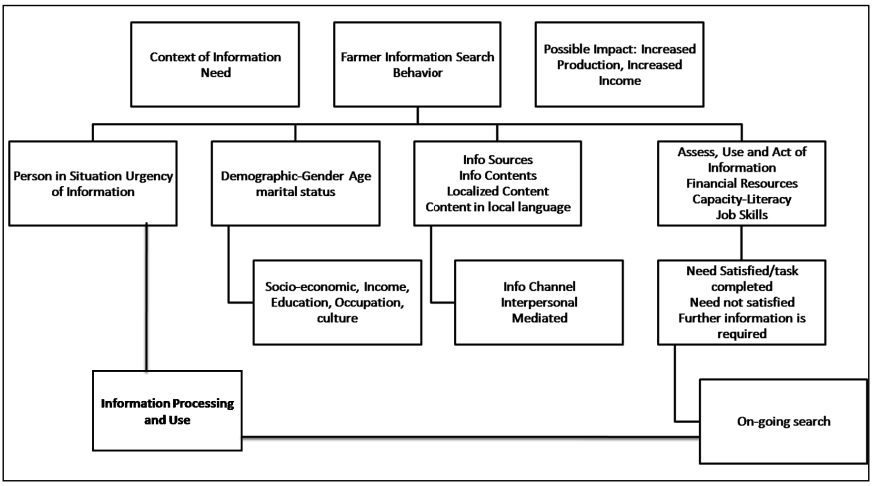

Figure 1. Exploring Farmers' Information-Seeking Behavior: An Analytical Framework.

Source: Developed by the authors based on Wilson (1981, 1999), Krikelasv (1983), Leckie et al. (1996) and Johnson (1997).

Information Needs in Context

All information-seeking behaviour takes places within a context and must be understood as influenced by context. An information need is described as a recognition that personal knowledge is inadequate to satisfy a goal that needs to be achieved (Case, 2007, p. 5). Information needs can be recognised by the information seeker or by the information intermediary on behalf of the information seeker. As part of the search for the satisfaction of these needs, an individual may engage in information-seeking behaviour (Wilson, 1981), which is purposive in nature and is an outcome of a need to satisfy some objectives. In the course of seeking, the individual may interact with people, face to face or electronically (Wilson, 2000). Thus, the individual recognises an inadequacy in his/her knowledge that needs to be resolved in order to deal with a problem, which then results in information-seeking behaviour (Lwoga el al., 2010).

Krikelas (1983, pp. 6–7) underscores the importance of uncertainty as a motivating factor and of the potential for an information seeker to retrieve an answer from his/her own memory or from that of nearby persons. A person becomes aware of a state of uncertainty about a problem (question, issue) and attempts to reduce that state of uncertainty to an acceptable level. The cause of that uncertainty may be a specific event or simply an ongoing process associated with work or ordinary life, or both. Naturally, for many issues, much of the information required would already exist in the individual's memory; only a small part of a person's ongoing needs would produce an outward behaviour that we might identify as information seeking.

Furthermore, the level of 'urgency' and the perceived importance of a problem would influence the pattern of information seeking. This can produce both immediate and deferred information needs. This is supported by Julien and Michels (2004, p. 552), who argue that the temporal constituents manifest themselves in that an individual may differentiate between information needed today, information needed within a few weeks and information needed with no set deadline. For instance, triggers during the cropping or production season, such as pest incidence, shortage of rainfall or falling prices in the community, need immediate attention and intervention (Babu et al., 2012).

Visalhi and Srivastava (2002) categorised the information needs of farmers into the following six categories:

1. Field acquisition: Farmers are required to know the different types of schemes and subsidies for purchase of agricultural land.
2. Agricultural inputs: Farmers need information about improved varieties of seeds, pesticides, agricultural equipment, weather conditions and harvest and post-harvest technology.
3. Agricultural technology: Farmers should be provided with information about innovative technology in farming.
4. Agricultural credit: Farmers need information about credit facilities, terms of loans, etc.
5. Agricultural marketing: Information on day-to-day market trends in the prices of different varieties of crops is necessary for farmers.
6. Food technology: Information on post-harvest food technology is needed by farmers for them to derive optimum benefits out of their crops.

Barriers to Obtaining Information

Certain factors may interfere positively or negatively in the process of information seeking and thus create barriers to obtaining useful information. Various scholars have illustrated these issues. Wilson (1999) termed these as intervening variables. These variables are of six types: psychological predispositions (e.g., tending to be curious or averse to risk); demographic background (e.g., age or education); factors related to one's social role (e.g., whether one is acting as a manager or a mother); environmental variables (e.g., the resources available); characteristics of the sources (e.g., accessibility and credibility); and resource-based factors, namely availability of information, awareness of availability and acquaintance with and ease of use of information resources (Kaniki, 2001; Wilson, 1999).

Factors that influence farmers' use of information include personal characteristics, such as age (Carter & Batte, 1993), education (Waller et al., 1998) and experience in farming (Schnitkey et al., 1992), and business characteristics, such as market orientation of farming (Ngathou et al., 2006). Social and cultural factors also affect people's way of preferring and using information sources (Savolainen, 2005, p. 143). For Momodu (2002), informal networks are considered by users to be the best source for reliable and authentic information, and illiteracy is the primary barrier to fulfilling information needs.

Information Sources, Contents and Channels

Information needs create an awareness of information sources and/or content and thus motivate a person to examine those. The worth of agricultural information lies in its application. Effective communication of information to the ultimate end user is just as important as the information itself. In providing information to users, the information intermediaries must come up with client-centred information services that can meet the needs of users in terms of both the content of the information and the channel(s) through which it is communicated (Ekoja, 2002).

Previous studies on the knowledge and information sources used by most information seekers in the rural areas of developing countries find that local people prefer to obtain information from informal to formal sources (Lwoga et al., 2010, p. 85). In Zambia, in addition to obtaining information from NGOs, most farmers relied on personal experience and informal social networks (family, friends, neighbours and colleagues) to meet their information needs (Kaniki, 2001). Dutta's (2009) study reinforces this argument. Other studies indicate (Meitei & Devi, 2009; Momodu, 2002) that farmers predominantly rely on informal networks and, to a lesser extent, mass media, such as radio, television and newspapers, to meet their information needs.

The level of information search in terms of global, national and local information sources will depend on the aspirations of the searcher. Further, farmer's ability to search for information depends on the sources that are accessible to them. For example, local information needs could be met by a well-organised extension system that uses traditional and modern methods of communication, such as television, radio and mobile phones, while the need for global information has to be met through Internet connections or through contact with private firms.

The roles of NGOs and farmer-based organisations (FBOs) are increasingly being recognised as key for information sharing on specific crops and cropping systems.

Lack of locally relevant content, as well as lack of content in local languages, excludes users from accruing the benefits provided by public access to ICT (Gomez et al., 2009; Islam and Hasan, 2009). If the problem of scarcity of local content (in local language) for farmers in a developing country is not addressed, the objective of increasing agricultural productivity and sustainable agriculture through providing information will falter (Bailur, 2007; Madon et al., 2009). In the information-seeking context, there is a strong preference for information that comes directly from other people. Salience is a key motivator in deciding to look for information. The concept of *salience* implies that information is not only perceived to be relevant to a need but is also applicable (Johnson, 1997, p. 72).

Beliefs are important in information seeking, because they constrain the individual's thinking and level of motivation regarding information seeking. If we do not believe that knowing more about a topic will allow us to affect a change, then we are not likely to seek information. Conversely, feeling that we can solve a problem will motive us to find the means to do so—which includes gathering information (Case, 2007).

Johnson (1997), citing studies, suggests, however, that ease of accessibility often wins over authoritativeness (the latter implying, apparently, better utility); the public still receives much of their health information in a watered-down form through mass media, despite the availability of health professionals to answer their questions and despite the general preference (noted earlier) for interpersonal channels. Here, the most important variables are thought to be the familiarity and prior success with the source (or the search strategy employed), along with the trustworthiness, packaging, timeliness, cost, quality and accessibility of the sources (Leckie et al., 1996).

Rural farmers need information for their day-to-day farming work for the enhancement of their productivity, and this information needs to be well packaged, in a way that will make a great impact on them. In packaging the information, the language of communication needs to be properly addressed, bearing in mind that most rural farmers are not educated. The researcher observed that most of the villagers embrace educative programmes that are broadcast in their local language more than those in the English language, because they understand the message better in their own language than in a foreign language (Emmanuel, 2012).

One of the agencies or services put in place to diffuse agricultural information is that of agricultural extension. Agricultural extension is a service meant to educate farmers and encourage them to adopt new technologies. The work of extension service revolves around information diffusion, because information communication is the process through which innovation, agricultural knowledge and so on is passed on from researchers and policymakers to the frontline people or farmers (Ekoja, 2002). The common meaning made out of extension is that it involves the conscious use of communication of information. This information can be disseminated to the rural farmers through the following media: farm broadcasts, extension publication, training, extension advisory services,

demonstrations and exhibitions, including those mounted at agricultural shows, farmers' field days and so on (Emmanuel, 2012).

A number of channels exist for communicating information to rural farmers. Abraham (2009) identified several channels and sources used to bring information to the audience, such as the media, the Internet, institutions, social functions, town criers and so on. Zaniki (1991) found that the source of agricultural information most often used by farmers is personal experience (74.7%). The second and third most often used sources of agricultural information are friends/relatives/neighbours (34.9%) and the radio (20.9%), respectively. In his study on rural farmers in Pakistan, Naved (2013) found the role of mass media and printed materials as sources of information to be very small.

It is very clear from the sources and channels of information used by rural women that their information-seeking behaviour is mainly informal. They align more to information received from friends, relatives, husbands, sons and daughters and market women. This, according to Momodu (2002), is because 'those sources to them are more reliable and authentic'. It can also be seen to conform with Zipf's (1949) 'Principle of Least Effort' with regard to human behaviour.

Information Processing and Use

By the phrase 'information processing and use', Wilson (1999) implies that information is evaluated on its effect on need and forms part of a feedback loop that may start the process of seeking all over again if the need is not satisfied. The end results of information seeking, labelled 'outcomes', affect most other aspects of the model through feedback loops to need in context, intervening variables, sources and content and act of information (information is sought) (Leckie et al., 1996). According to Johnson (1997), 'information seeking is clearly a dynamic and cyclical process, with an individual's level of knowledge changing as it goes on', along with the perception of the gap.

The information seeking model can be structured as a feedback loop. It begins with the task as perceived by the user, personal factors (e.g., education, experience, attitude, motivation and mood) and situational factors (e.g., time available for performing the task) affecting the user. These factors affect how the user determines what information is needed and then what actions (such as selection of a source) he/she takes to satisfy the need. To access, assess and apply the content, users must have economic resources, including money, skills and technology, and social resources, such as motivation, trust, confidence and knowledge (Heeks, 2005). Individuals must be able not only to access that content, assess its relevance and apply it to a specific decision, but ultimately also to act upon the information. This requires further resources at the user level, including action resources and capacity. For example, content may be available to a community, but it may not be accessed, because of, for instance, low levels of literacy, or it may be accessed but not acted upon, because of poor financial capacity to buy the necessary inputs (Babu et al., 2012). Some studies have shown that farmers who have access to information technology are more likely to participate in agricultural and rural development programmes and other political, social and cultural practices.

However, unless the whole information chain operates successfully at the user level, information provided by ICT cannot contribute to development (Heeks 2005). As Coudel and Tonneau (2010, p. 63) note, 'Information may seem appropriate, usable, relevant, but it can only be useful if the actors have the capacity to use it and if their environment offers them the opportunity to use it'. When ICT has been included as part of an integrated service, for example, mobile information provided to rural women in Tamil Nadu to support goat rearing as part of a microfinance loan, the results have been more positive (Balasubramanian et al., 2010). The nature and extension of the benefits farmers gain by using information in specific operations will determine not only productivity and welfare outcomes but also how information is sought in the next round of information search.

Once a course of action has been chosen and implemented, the results are evaluated for sufficiency and pertinence; the evaluation tends to fall into one of three rough categories: 'the search is done', 'the search is impossible' or 'I need to continue searching'. This evaluation feeds back into the determination of needs, yet is mediated by the user's personal style of seeking, which also affects the user's choice of actions to implement before results are obtained and evaluated.

Agricultural Extension System in Bangladesh

The Department of Agriculture Extension (DAE) is responsible for carrying out extension activities at the local level under the supervision of the Ministry of Agriculture. Traditionally, DAE concentrates on providing crop advice to small/medium farmers (who operate 60% of the land but only represent 22% of the farmers). Separate public agencies deal with advice on livestock (Department of Livestock Services), fisheries (Department of Fisheries) or tree crops (Forest Department) (Local Consultative Group Bangladesh, 2003). The DAE field position nearest to the community is called Sub-Assistant Agricultural Officer (SAAO), and the territorial unit is 'block'. There are some 13,224 SAAOs working all around Bangladesh, covering 12,640 blocks. In most of the UP complexes, SAAOs have a place to sit and do their job. DAE has, on average, three SAAOs per union. The working area of an SAAO is known as a 'block'. There are many complaints against thousands of SAAOs who never visit farmlands. On the other hand, it is impossible for one SAAO to provide service to 1,700 farming families (Siraj, 2014).

There is a lack of union- and block-level fishery and livestock extension workers; there are 60,000–70,000 farm households in an *upazila*, yet there are only two or three livestock or fishery extension workers at the *upazila* level. Given that there are no livestock or fisheries extension workers at the union and block levels, most farmers have little or no access to these current technologies and management practices. Therefore, it is critical that the current SAAOs be trained and/or have access to technical and management information about producing both livestock and fisheries products. Field extension staff face serious resource constraints (i.e., no transport, communications, office or programme

funds), especially at the union and block levels. This lack of resources severely limits the capacity and performance of these field extension workers. Depending on the *upazila*, about 15% have motorcycles, but most have to walk or use public transportation (USAID Bangladesh, 2011).

Agricultural Information Service (AIS) is making good progress in making technical and market information available online for all crops, livestock and fisheries. However, villagers, especially farmers, cannot access this web-based information, because the majority of them lack logistics and financial capability and ICT literacy to do so. Moreover, very often, farmers and field extension staff cannot access the website due to network downtime and frequent electricity outages. Also, the current online information covers all crops, livestock and fisheries management practices, but this information, especially for crops, needs to be made more location-specific, based on local agro-ecological growing conditions. Location-specific content development is a major constraint in this regard. However, if the AIS could be upgraded, using new ICT capabilities, then more location-specific technical information could easily be made available across different agro-ecological zones of Bangladesh (USAID Bangladesh, 2011).

Most small and medium 'progressive' farmers routinely use mobile phones to speak with input-supply dealers and wholesale markets. Some of the larger commercial farmers are now using 'smartphones' and can access the AIS website. The SAAOs have their own personal mobile phones, but most are conventional mobile phones that are limited to voice and SMS-texting capabilities. The SAAOs seldom use their mobile phones for work, except to respond to incoming farmer questions (since incoming calls are free). If the SAAOs had the appropriate type of 'smartphones', along with funding for appropriate online charges, then they could quickly access and download rapidly expanding sources of both technical and market information. In addition, they could easily share this needed information directly with small-scale, marginal male and female farmers. With appropriate ICT resources, they could bypass the 'top-down' DAE management structure and begin serving small and marginal farmers across their block with up-to-date technical and market information (Rashid & Qujie, 2016; USAID Bangladesh, 2011).

Private-sector organisations, which are a more recent addition to the extension system, largely comprise seed, irrigation and fertiliser dealers (which expanded as a result of de-regulation in the 1990s) but also include private hatcheries, vets, fish/fry traders and village doctors. Information is usually provided to farmers at the point of sale (Local Consultative Group Bangladesh, 2003). Call centres are being created by research and most extension departments (DAE, DLS and DOF), as well as through the AIS at the national level. Since medium- and larger-scale farmers are using mobile phones on a daily basis to get more location-specific input-supply and market information (primarily from private-sector firms), these call centres probably need to be decentralised to the major agro-ecological zones within Bangladesh (e.g., to subject matter specialists [SMSs] at the district level and/or to the Bangladesh Agricultural Research Institute [BARI] stations in each of the 22 major agro-ecological regions), so that this technical advisory information can be communicated directly to SAAOs and/or farmers and made more specific to local needs (USAID Bangladesh, 2011).

Table 2. Farmers' Agriculture Information Needs Based on Their Priorities.

	Information Needs (on the basis of priority)	Agricultural Production Phases
1.	Seeds	Cultivation and seed management
2.	Fertilisers	Cultivation
3.	Agriculture credit	Cultivation and irrigation
4.	Irrigation	Management of Irrigation
5.	Diseases and pest management	Crop care and crisis management
6.	Weeding and thinning	Crop care
7.	Post-harvest techniques	Harvesting
8.	Storage of crops	Harvesting
9.	Market information	Selling
10.	Weather information	Crop care and cultivation

Source: The authors' fieldwork and Rahman and Bhuiyan (2016).

Table 3. Classification of Key Challenges According to Key Practice Phases.

Key Practices	Key Controllable Challenges
Soil management	Low quality of fertilisers
	Lack of opportunity to explore new kinds of productive seeds.
Management and utilisation of seeds	Low quality of seeds
	Inappropriate usage of seeds
	Poor maintenance while sowing
Cultivation	None
Maintenance of irrigation	Inappropriate water usage
Management of fertilisers	Poor quality of fertilisers
	Inappropriate usage of fertilisers
Crop care	Improper growth of crops
	Attack from grazing animals
Crisis management	Understanding symptoms of new kind of diseases
	Attack from insects, viruses, seasonal diseases, cattle, etc.
	Poor quality and inappropriate usage of pesticides and medicines
	Health hazards of application
Harvesting	None
Selling	None

Source: The authors' fieldwork and Swisscontact-Katalyst (2014).

Results and Discussion

This section presents the study findings according to the following themes: farmers' information needs and priorities, exploration of information needs at various stages of production, information-seeking patterns of small-scale farmers, constraints that limit farmers from seeking information and proper use of the same.

Farmers' Information Needs and Priorities

Farmers have a variety of information needs on marketing, weather conditions, agricultural loans/credit, new seeds, storage methods, disease and pest control and pesticide availability and its application. Farmers' information needs may be grouped into two categories based on their priority. Priority areas of agricultural information sought by the famers include seeds, fertilisers, agricultural credit, irrigation and disease and pest management. The areas such as weeding and thinning, post-harvest techniques, storage of crops, market and weather are lower-priority areas on which farmers seek information. Table 2 shows the farmers' information needs based on their priorities at different phases of agricultural production.

Despite rural women's active involvement in farming, they do not have access to scientific and technological knowledge. They meet most of their information needs from NGO field workers. Their areas of information needs include poultry, gardening and animal husbandry, small cottage industry, market and so on. The nature of information sought by farmers also varies, depending on their geographic location and seasonal specifics.

Information Needs at Various Stages of Farming

The study found that farmers have tapped various information sources at different levels of the issues at hand, depending upon the gravity of the situation and reliability of the source of information.

There are a number of problems and challenges in farming (see Table 3). Farmers know that risks associated with some of these problems can be mitigated with the help of their personal experience and different knowledge sources. However, risks associated with uncontrollable challenges are perceived as a part of their 'misfortune' and cannot be altered and lessened, as deemed by the respondent farmers.

The need for information at farmers' end varies based on the severity of the problem they are faced with. Farmers are comfortable with cultivating and harvesting methods, as they are seasoned or have migrated from traditional farming (a primitive style of farming that involves the intensive use of indigenous knowledge, traditional tools, such as plough, yoke and cattle, natural resources, organic fertilisers and cultural beliefs of the farmers**)**. Their level of susceptibility

is high as regards problems concerning seeds, fertilisers, pesticides and insecticides. In sum, as shown in Figure 2, while farmers are relatively less susceptible to problems at the cultivating and harvesting phases, their level of vulnerability increases during such tasks as soil management, crop care and maintenance of irrigation. Farmers' susceptibility is at the highest during phases related to crisis management, fertiliser management, selling and management and utilisation of seeds.

Information-seeking Patterns of Small-scale Farmers

As noted earlier, information can be categorised into two groups: traditional and modern. In all interactions with farmers, as reported by the respondents, they do not seek information from all the sources every time a situation occurs. Seeking of information from sources depends to a large extent on the nature of the problem and its perceived impact on the ultimate return (profit). Farmers usually seek agricultural information from peer groups, veteran farmers, government extension officers and government-endorsed agriculture workers, input retailers, input company representatives, NGO field workers, television and radio programmes and UDC/telecentre informediaries. The channels of information they use include face-to-face conversation, telephone, television, radio, newspaper and the Internet.

Farmers set their personal experience and other farmers in the vicinity as their primary sources of information for solving issues that arise in the process of farming. They also consult with SAAOs and agriculture officers at the *upazila* level when the situation is severe in nature. Farmers are aware of some of the modern sources (input dealers, electronic and print media, call centres, the Internet, extension workers, NGOs and so on) of agricultural information but are not comfortable obtaining information from them, due to the perceived irrelevance and low interaction-ability.

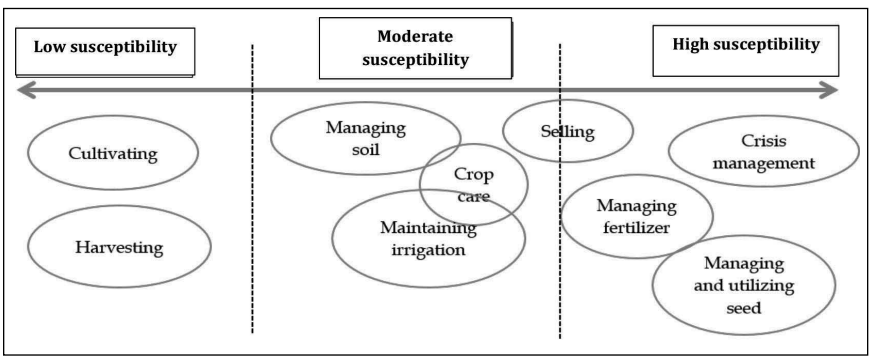

Figure 2. Differential Levels of Susceptibility in Relation to Challenges at Practice Phases.

Source: The authors' fieldwork and Swisscontact-Katalyst (2014).

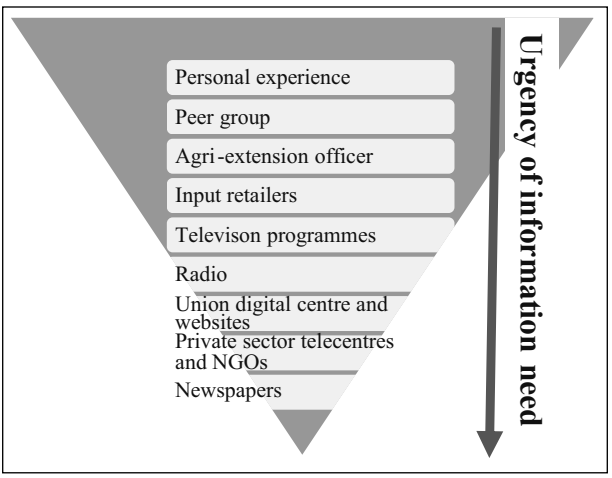

Figure 3. Farmers' Preferences of the Sources of Agricultural Information According to the Urgency and Importance of the Information Needed.

Source: The authors' fieldwork.

The sources of agricultural information mentioned by the famers can be ranked based on their preference, as illustrated in Figure 3. At times when farmers are in critical need of agricultural information, their preferences lie with personal experiences with the problem in the past, peer groups and agriculture extension officials. Farmers comply with a community culture where trust and reliability are given utmost importance. Farming is part of this culture where most small- and medium-scale farmers rely heavily on their reference groups for acquiring different kinds of information. When the gravity of a problem is medium to low, farmers are comfortable with consulting local input company representatives. Agriculture programmes on television channels and telecentres are preferred sources of information when the need for information is low.

Upon collecting information, farmers take necessary actions to mitigate their issues at hand. The outcome from the actions taken creates a strong imprint and determines the reliability and effectiveness of the sources. If the consequences of the actions are positive, farmers usually refer back to these sources in the future. If the outcome of the actions is negative or neutral, farmers perceive the information source to be unreliable and keep looking for new, more reliable information sources. When the information does not result in the desired impact, the farmers are compelled to surrender to fate.

Constraints that Limit Farmers' Access to Information

The following factors limit the farmers from seeking information from the ICT services such as helplines, telecentres, agriculture programmes on television channels, the radio, newspapers and the Internet:

1. **Prevailing norms and perceptions:** Farmers have a strong culture of learning from others and using their own judgements. They are reluctant to change and averse to adopting new ideas. The adoption of ICT among rural farmers of Bangladesh is currently at a nascent stage, and it will take a long time for ICT to be an accepted method of accessing agricultural information among farmers.
2. **Cost and lack of awareness:** Farmers face two key barriers to access to agro-information: high costs and low awareness. Most ICT services require farmers to pay a price for agricultural information. Farmers lack the willingness and ability to spend money for buying information and technology for a higher production of crops. Their ability to acquire information and use of the same are low. They perceive receiving agro-information from the government through its relevant officials free of cost as a social right. Findings indicate that farmers are more likely to adopt ICT-based services if they are made available free of cost. Most farmers are illiterate, and many of them believe in superstitions. They are fatalistic and are used to applying traditional methods of cultivation and farming. One of the reasons for the low usage of ICT-based agriculture information services is farmers' low level of awareness. They are not aware of the benefits of using modern technology and its salutary impact on farm production and income. Awareness generation campaigns are hard to conduct and time-consuming. The study findings indicate that the majority of farmers are unaware of existing agriculture helplines and agriculture programmes on television and radio channels.
3. **Low level of literacy:** The study finds that female farmers are affected more adversely than their male counterparts while seeking agricultural information from ICT-based sources, because their general and ICT literacy rates are lower than those of male farmers. They are unable to use mobile-based services on their own and often rely on the male members of their families to guide them through the process. The final decision of using ICT lies at the discretion of the male members of a family.
4. **Poor infrastructure and spatial problems**: Farmers who are aware of the existence of the ICT services such as helplines and telecentres have opined that poor network coverage and slow Internet speed greatly hinder the service quality of the mentioned services and also deter their willingness to use these important sources of information. The location and distance of the UDCs and opportunity costs (time, distance and conveyance) of the farmers also matter. Most of these UDCs are a few kilometres away from the farmers' place of residence, which discourages them to turn to telecentres/UDCs for help.
5. **Conclusions and clues for improvement**: In this concluding section, the major observations and findings of the study are recapitulated and summarised according to the stated objectives. As regards objective 1 (information needs at various stages of production), it is found that the priority areas of agricultural information sought by famers include seeds, fertilisers, agriculture credit, irrigation and disease and pest management. While farmers are relatively less susceptible to problems at the cultivating and harvesting phases, their level of vulnerability increases during such

tasks as soil management, crop care and maintenance of irrigation. Farmers' susceptibility is at the highest during phases related to crisis management, fertiliser management, selling and management and utilisation of seeds.

Regarding objective 2 (information-seeking behavioural patterns), it has been observed that seeking of information from sources depends vastly on the nature of a problem and its perceived impact on the ultimate return (profit). Farmers predominantly rely on personal experiences and informal networks (relatives, friends and neighbours) when the nature of crisis facing their crops is familiar or non-critical. Farmers rely on multiple external information sources when the nature of crisis is critical and personal knowledge falls short in mitigating them. They usually seek agricultural information from peer groups, veteran farmers, government extension officers and government-endorsed agriculture workers, input retailers, input company representatives, NGO field workers, television and radio programmes and UDC/telecentre informediaries. The channels of information they use include face-to-face conversation, telephone, television, radio, newspaper and the Internet.

The major constraints faced by the farmers in seeking information using modern ICT (objective 3) include farmers' prevailing norms and perceptions (e.g., resistance to change and adoption of new technology), the relatively high costs of and low awareness regarding agro-information, poor infrastructure to be able to support ICT services, spatial inconvenience, in terms of location and availability of ICT facilities, and low literacy among the farmers.

Policy Recommendations

Based on the findings of the study, the following recommendations are furnished towards improving the information-seeking experience of farmers:

- It is imperative to provide specialised training on agriculture to the common sources of information (notably, government extension officials and input retailers) used by farmers. These sources may be capacitated and linked to adjacent knowledge centres, such as the local agriculture colleges, universities, research institutes and libraries. This will help develop a better information delivery system in terms of relevance and accuracy.
- ICT services require better design and formulation in terms of pricing, user-friendliness, accessibility and promotional campaign, which may lead to better adoption of these services by farmers. Besides, modern facilities, such as telecentres and agriculture helplines, can be positioned as convenient and timely sources of information.
- Targeted training of UDC entrepreneurs on the 'basics of agriculture' is imperative to enable them to deliver agricultural information more effectively to farmers.
- As farmers seldom find agriculture extension officers in their locality, in the context of this reality, the alternative could be the use of mobile phones and other ICT-based communication media to access the officers. ICT can be a useful instrument in connecting farmers to SAAOs.

The Government of Bangladesh is already in the process of equipping SAAOs with computer tablets and smartphones. These tools may be used to develop services that can be used by farmers to reach SAAOs. It is possible to take advantage of the high-speed mobile network penetration in the country to develop services whereby farmers can dial to a service centre from their mobile phone, which can connect them to their nearest SAAO. SAAOs would, however, require orientation training to get them familiarised with the use of various ICT tools (such as computer tablets and smartphones) to disseminate information among farmers.

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Practitioner Paper

Skilling the Rural Youth of the Northeast of India Through Rural Technologies

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Abstract

The proportion of rural youth population in India is about 67–68 per cent of the country's total population. The North Eastern region of India has its share of over 1.07 per cent of the youth population of the country and also a relatively higher proportion of youth unemployment (57.37 per 1,000), indicating that the challenge is paramount. The eight North Eastern states have their unique requirements in skill-based training, depending on the natural resources, industry and native trades. The governments of these states have embarked on skill development missions to meet the aspirations of youth through training, to enhance employability and employment. However, it is observed that the need-based simple skills required by the rural youth of the North Eastern region which will enable them to take up self-employment were not provided by the multiple agencies—both government and non-government. There is a strong need to bring simple rural technologies to the skill development agenda in the North Eastern region of India while creating a way forward plan. There are success stories of young entrepreneurs who have started on a small scale, overcome the difficulties and have grown to make a name for themselves in the region, providing the necessary fillip to the rural economy of the North Eastern region of India.

Keywords

Rural youth, skill training, rural technologies, self-employment, demographic cohort

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Introduction

India has a high proportion of youth in its population, especially that of rural youth. The proportion of rural youth population in India is about 67–68 per cent of the country's total population. Harnessing their potential to contribute to the country's growth would require rural-centric policies that combine the development of appropriate technologies and innovations, skilling of youth and the creation of an ecosystem for the establishment of own enterprises. Many education and training systems do not provide young people with the basic skills needed to escape poverty and unemployment, even when they continue to receive formal education. Non-formal education programmes and training seek to fill this gap by providing learning and skills development opportunities that are relevant to the context in which young people live and seek their livelihoods.

India's big and small economic patterns and trends are all highly impacted by its largest demographic cohort—the youth. The pitiable figures on India's formally trained workforce—which stand at merely 2.3 per cent in comparison with economies like South Korea which are at a mammoth share of 96 per cent—indicate that the former will have to rethink, redefine and repaint the entire talent map of the country to stand a fair chance of participating in global jobs market and hence play a resourceful role in the growing economy. It is vital for India to reimagine its talent landscape by studying the global job market trends and pursue novel approaches to fulfil the skill gaps in the industry and reset the talent demand−supply equilibrium in the country (India Skills Report, 2020).

Youth and Skill Development

The youth population (aged 15–29 years as India's National Youth Policy 2014; Ministry of Youth Affairs and Sports, 2014) in India, which is about 333 million (around 27.5% of the total population) as per Census 2011, suffers from a low level of education and skill base. Only 3.8 per cent of the youth population had either received or was receiving formal vocational training in 2011–2012. This percentage is very low as compared with developed countries such as the United Kingdom (68%), Germany (75%), Japan (80%) and South Korea (96%) and developing countries such as Mauritius (36%) and Colombia (28%). Similarly, the level of education which is treated as the foundation for acquiring a specific type of skill reflects dismal performance. Around 20 per cent youth were illiterate or below primary education in 2011–2012. Besides this, there exist huge disparities in education and skill attainment across gender, social groups, income groups, rural–urban and formal–informal sector workers, type of work, etc.

In such a scenario, education and skill development of youth is a particular imperative due to two reasons. First, the demand for a skilled workforce has gone up due to changing work organisation. It is estimated that there will be an additional net incremental requirement of around 110 million skilled manpower

by 2022 in 24 key sectors in India. Second, changing demographic profiles of India with bulging youth population suggests that the youth population will increase from about 333 million in 2011 to about 370 million by 2030. These young people are likely to join the labour market. They need to be provided quality education and training to make them employable workforce in the future. This will not only expand the production possibility frontier of India but will also help meet the expected shortfall of the young skilled workforce in the ageing developed world (Ministry of Skill Development and Entrepreneurship, 2015).

As the educational participation of youth increases, there arises a strong case for strengthening quality education and building the skill component in education became stronger, along with schemes for skill training of youth who are not in education.

The projection of increase in youth labour force at state level made by National Commission for Enterprises in the Unorganised Sector (2009) reveals that between 2006–2007 and 2016–2017 around 81 per cent of the increase in youth labour force will be in the eastern and central states (Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar, Uttar Pradesh, West Bengal, Odisha, Assam and the North Eastern states) while the southern and western states will contribute negatively. This trend is of serious concern as the formal training capacity in a former group of states is only 28.1 per cent as compared with 57.1 per cent in the latter group of states. As a result, the skill-training programmes must address skilling needs of lagging states to have their significant impact on youth (Rajiv Gandhi National Institute of Youth Development, 2017).

Youth in the North Eastern Region of India

The North Eastern states of India comprise Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, covering an area of 2,62,179 km^2 and constituting 7.9 per cent of the country's total geographical area and 46 million people or about 4 per cent of the total population of the country (Census 2011). Most North Eastern states have remained one of the underdeveloped and untapped regions of the country.

It is in this context that the North Eastern Council (NEC) and the Ministry of Development of North Eastern Region (DoNER) have prepared Vision 2020 for the North Eastern region. This requires substantial investment and implementation of Action Agenda outlined in the Vision and Strategic Plan, and also imparting of skills at all levels. The North Eastern states, clubbed together, have some common attributes. But they also have significant variations related to culture, language, values, work preferences and ethics and overall environment related to government, infrastructure, terrain, proximity to or availability of markets and services. Hence, the skilling interventions may vary across states and districts despite similarities of activities (National Skill Development Corporation, 2012).

Skilling of Rural Youth of the North Eastern States of India

The North Eastern region of India has its share of over 1.07 per cent of the youth population of the country and also a relatively higher proportion of youth unemployment (57.37 per 1,000), indicating that the challenge is paramount. Therefore, the North Eastern states of India have their unique requirements in skill-based training depending on the natural resources, industry and native trades. The governments of these states have embarked on skill development missions to meet the aspirations of youth through training and enhance employability and employment. Several training partners, academic institutions and vocational training centres are actively involved in a range of programmes that enable livelihoods and increase productivity and income levels of people in the states. Most initiatives are a part of national schemes like Pradhan Mantri Kaushal Vikas Yojana (PMKVY) (*transl*. Prime Minister's Skill Development Programme) and Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY) (a villagers' skill development programme) apart from regional schemes from the states.

In Arunachal Pradesh, under the 12th Plan, there is a proposal for State Skill Development Mission under the chairmanship of the chief minister, along with a steering committee representing the industry. The nodal department has set a target to train 50,000 people by 2022. The project implementation unit will work with the government's Industrial Training Institutes as vocational training providers along with private agencies in training for different sectors. In Assam, Employment Generation Mission (EGM), an autonomous body under the government, spearheads the skill development initiatives. Their major objective is to stimulate the economy of Assam through skill development through Project Implementation Agencies (PIAs). EGM has registered in its account several success stories, enumerating the various workshops and seminars held in training the youth in diverse skill sectors such as the bell metal unit, printing press and horticulture. The EGM started with 7 lakh and proliferated from 1 unit to 18 units in just one and a half years. Skill-based training is also carried out through Assam State Livelihood Mission and National Urban Livelihoods Mission. The Manipur state has created various committees and sectors to create a stimulus in enabling youth to undergo skill education and training. The main agenda of these committees is to identify and suggest ways and means of skill upgradation and to discover why the youth are not very much enthusiastic about enrolling in these programmes.

Also, another important agenda that they have is to review the existing approach, strategies, priorities and ongoing policies and the loopholes in their implementation. The Government of Manipur has also been striving to create an effective linkage between different organisations connected to skill development. With the constitution of Meghalaya State Skill Development Society, the government has taken skill development in their state to another level by training 7,700 youth in the state. Under the DDU-GKY and state-level skill development plans, the government aims to train rural youth and provide them with jobs with decent wages. Their primary agenda is to fill in the gaps in the skill sectors

which were once the pride of Meghalaya and the main source of employment generation in the state. The endeavour of the Government of Mizoram is to impart need-based training to employees so as to develop the right attitude, necessary skills, duty consciousness, competence and self-motivation to take on the challenges in their work. The Government of Nagaland has started preparation to put in action the schemes under the National Skill Development Corporation, which is helping it conduct skills and to have better ideas about the capabilities and the aspirations of the youth in the state. Most of the initiatives are also guided by PMKVY to the trainees to get jobs for themselves or be able to set up some enterprises, thereby not only employing themselves but also providing others with opportunities to prosper.

Sikkim has inaugurated livelihood schools which train the youth in various livelihood options and sectors of employment such as hospitality and tourism, driver and tour guide, computer software, medical transcription, organic farming, veterinary training, electrical trade, horticulture and teacher training. So far, Sikkim has been quite successful in initiating and running these livelihood schools. Crafts are essentially an important sector and skill for the people of Sikkim. The major goals and objectives of the Directorate of Handicrafts in Sikkim are to preserve and revive the languishing ethnic cultures of the state. The Tripura Government has decided to set up State Skill Development Mission to enable youth to experience employment. A separate directorate committee is to be formed to run various programmes of skill development in various sectors. Under these sectors, the youth of Tripura will be trained based on skill, capabilities, merit and interests. However, the government is keen on enhancing employability and making the youth skill enabled.[1]

To complement all government-initiated efforts and to meet the need-based simple skills required by the rural youth of the North East region which will enable them to take up self-employment without much external support like credit, etc., Rajiv Gandhi National Institute of Youth Development (RGNIYD), an Institution of National Importance of the Union Ministry of Youth Affairs and Sports, Government of India whose mission is the empowerment of the youth of the country, is training the youth of North Eastern states on rural technologies in collaboration with the National Institute of Rural Development and Panchayati Raj (NIRD & PR), the apex institution of the Ministry of Rural Development, Government of India, initiated skill training of the youth of the Northeast through simple rural technologies.

The unemployed youth of the Northeast are being trained on rural technologies skills such as mushroom cultivation and mushroom products, compressed stabilised earthen blocks making, sustainable hosing technologies, home-based products—phenyl, dishwash powder, detergent powder, solar lights assembling installation and maintenance, leaf plate and cups making, herbal beauty care products, neem products, vermi compost and vermi wash liquid, handmade paper into value-added products such as bags, honey processing and packaging, ethnic bag making and food processing through solar dehydration. During 2019–2020,

a series of skill training on the above-mentioned rural technologies was initiated by RGNIYD and NIRD & PR for the youth from the North Eastern states in the Rural Technology Park in Hyderabad in India. One such skilling of the youth of the state of Mizoram in the North Eastern region of India is described in the following section.

Case Study on Leaf Plate and Cup-Making Technology

Thirty youth (24 males and 6 females) from the districts of Mamit, Champhai and Aizawl of Mizoram were trained on 'leaf plate and cup making'. They were exposed to different kinds of leaves that are available in plenty in the Northeast and could be converted into plates, cups, glasses and spoons for replacing similar plastic products in their state, thereby using nature to preserve nature. Hands-on training was given on the machinery which is manufactured by the partner institution of the Rural Technology Park.

The youth trainees were provided inputs on introduction to leaf plate and cup-making scope, and entire process of leaf plate and cup making. Also, these youth were trained on market analysis, and developing a business plan.

The trainees were oriented on the details of machinery, leaf-stitching machines, types of moulding machines for manufacturing leaf plates and cups (pedal operated, motor operated with single die hydraulic type, motor operated with double die hydraulic type), various models of machines including automatic machines, power consumption, production capacities of various machines per hour, power/electricity requirement, motor capacity in terms of horsepower, parts of machines, dies for machines, cost of machines of different types and sources of availability of machinery.

The trainees were trained on various aspects of product pricing and its elements including the manufacturing capacity, assessing the nature and types of customers/clients, mapping the market demand (local, national, international), pricing the product, providing discounts, offers, subsidy, etc. Calculating the economics of raw material, processing the raw material, production cost, marketing cost, delivery cost, cost of utilities and overheads, labour cost and miscellaneous costs. Furthermore, they were also trained on functional aspects of marketing such as identifying the potential customers, assessing the market demand, branding, advertising, product life cycle, expanding the production capacity and marketing assistance.

The trainees were taken to a field visit to a successful small-scale industry involved in manufacturing leaf plates and leaf cups and industrial facility manufacturing various types of machines and dies for manufacturing leaf plates and cups, models of machines, operations of various types of machines (visit to M/s. Annapurna Cottage Industries, Hyderabad). They were provided opportunity to witness the actual production of leaf plates and cups with various types of raw material, the machine fabrication facility of the industry that also sells the machines for the prospective entrepreneurs.

The trainees undertook a task analysis of breaking down all the operations that involved in production of leaf plates and cups with minute details of do's and

don'ts. They later were engaged in Q&A session to clarify their doubts regarding the production process and machinery. Later, they interacted with the owner of the unit from the perspective of a Successful Entrepreneur who has won several awards including the President of India Award. The trainees were trained on the functional aspects of the computers in the computer lab of the Centre for Information Technology, NIRD & PR. They were oriented on the basic aspects of computers and the essential operations and functions that a rural entrepreneur needs to be equipped with for correspondence, marketing, sales and billing. Furthermore, they were oriented on various e-commerce platforms on which they could easily register their products for marketing globally. Later, the trainees were provided various simulation exercises for registering and creating profile of their products online. The trainees were oriented on the basics of entrepreneurship and qualities of an entrepreneur including exercises on self-assessment of entrepreneurial skills of the trainees through questionnaires. Furthermore, they were provided details on developing a business plan for starting a small business enterprise which included assessment of technical, economic and financial viabilities besides the managerial competencies which are required for managing an enterprise. The trainees were also trained on preparing a project proposal and the content of the proposal document for submission to various statutory bodies/ institutions and other financial institutions for seeking financial support apart from the skills for making presentations about their proposed projects for various departments/officials.

The youth were taught about the steps to start a small enterprise, registration/ statutory licences/clearances required for an enterprise, procedures and requirements for provisional and permanent registrations. The session on finance included the type of financial requirements for setting up an enterprise, types of financial assistance available through various institutions and schemes, skills for managing financial resources, books and records keeping, taxes applicable for small enterprises and means of securing exemption from various taxes. The highlight of the session was the different sources and schemes for entrepreneurship, financial support under various schemes, particularly for the youth of Mizoram, schemes for financial assistance in the Northeast, etc. were provided. They were also oriented about the use of social media tools for developing online content for marketing their products, making audio-visual promotional material on their products through use of simple online tools, e-marketing, etc.

This kind of holistic skill training is enabling the youth of the Northeast to set up their own enterprises using simple rural technologies, thereby facilitating them a reasonable livelihood. Majority of the 120 youth trained have started their own small business using the skills they were trained on.

Conclusion and Policy Implications

Youth, particularly women, from the North Eastern states have to be trained in industry-relevant skills to enable them to secure a better livelihood and to ensure that they get mainstream roles in new sectors. Efforts should also be made to

ensure they can start their own entrepreneurial ventures giving thrust to several sectors to promote employment and entrepreneurship in rural areas. The task can be made effective by leveraging the innate qualities of hard work and sincerity of the people of the Northeast.

There is a strong need to bring scale to the skill development agenda in the North Eastern region of India while creating a way-forward plan keeping in mind the local rural skills based on rural technologies that are key focus for the youth in the Northeast. There are success stories of young entrepreneurs who have started on small scale, overcome the difficulties and have grown to make a name for themselves in the region. Although small now, their number is likely to grow as more youth travel outside the region, attain education, training and skills; investment is made attractive by the states; markets linkages are developed; substantial buyers are attracted to the products from the region and trained and skilled youth can be gainfully employed within the region. There is a need to motivate the youth to undertake skills training on simple rural technologies by facilitating free boarding and lodging where they are exposed to different rural-based skill training and provided with bank loan linkages, ensuring forward and backward linkages that will boost their production and marketing thereby providing the necessary fillip to the rural economy of the North Eastern region of India.

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A Comparative Analysis of the Government and NGOs in Delivering Quality Services for the Rural People of Pakistan: Community Perspectives

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Abstract

Often the government and the non-governmental organisations (NGOs) are criticised for their poor performances in delivering services particularly in rural areas. However, there has been limited research on the assessment of their relative performances in service delivery as well as on the perceptions of people on the quality of such service delivery. This study examines the relative performances of NGOs and the governmental development interventions that provide basic services including public health, education, drinking water and sanitation. The study explains the impact of agricultural extension services and infrastructure such as access to roads and markets on the rural people and measures the satisfaction level of the rural community. For this purpose, 225 households (HHs) in 8 villages of Phalia Tehsil, district Mandi Bahauddin, Punjab, Pakistan were first surveyed in 2010 and then in 2014 using a structured questionnaire. The findings

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reveal different satisfaction levels of HHs, with most of them expressing less satisfaction on government service delivery compared with NGOs. They reveal satisfaction over the performance of NGOs in health, drinking water supplies and agriculture extension services. Further, the study shows an increasing satisfaction of people on access to road, transport, agri-market and price of agri-commodities by the government.

Keywords

Non-governmental organisations (NGOs), local government, service delivery, rural community development, community perception

Introduction

A large segment of over 200 million population of Pakistan live in rural areas facing a myriad of socio-economic challenges. Over 35% of its rural population live in extreme poverty where 54% of rural people are poor in terms of health, education, housing and other indicators of living standard compared with less poverty in urban areas (UNDP Pakistan, 2016). Public initiatives such as basic democracy (1959–1970), integrated rural development programme (1971–1978), people's rural programme (1972–1978 and 1990–1992), National Rural Support Programme (1980) and farmers field schools (1989, 2001) were introduced by successive governments to strengthen agricultural growth, reduce poverty and regional inequality, transform rural economy, create more employment opportunities and improve livelihood of rural population (Khisa, 2004). However, the performance of these programmes has little impact on reducing poverty and achieving the other desired objectives (ADB, 2002; Government of Pakistan, 2013, 2014; Gill et al., 1999; Honigmann, 1960; Maqbool & Bashir, 2009; NRB, 2002; Shamim et al., 1992).

Since after martial law in 1999, the new government introduced Local Government Ordinance (2001) followed by 18th amendment in constitution, allowing more power and autonomy to provincial governments to improve the socio-economic condition of communities particularly of the rural areas through participatory development. These major breakthroughs resulted in decentralisation of authority to the people and empowered non-governmental organisations (NGOs), community-based organisations (CBOs) and provincial rural support programmes to work effectively for rural development (Majeed et al., 2006; Zaidi, 2005). In contrast to the prevalence of government utilities in urban areas, the majority of community services in rural areas, including improving agricultural, safe drinking water, sanitation, public health and education, are provided by the local government and NGOs or CBOs. However, both local government institutions and some CBOs and NGOs leave consumers exposed to poor public service delivery (Zaidi, 2005), and the pace of human and rural development in Pakistan remained very slow (UNDP Pakistan, 2016), hindering the country from achieving its millennium development goals (MDGs) in 2015 and have severe implications for achieving sustainable development goals (SDGs). Similarly, a

series of adverse developments such as political turmoil and 'politicized development' made these efforts less effective and efficient (Saima et al., 2011).

The local government has been considered to lack commitment, have poor organisational and financial performance and showed greater red-tapism, coupled with low participation and ownership of local communities, which further jeopardises the effectiveness of their community services (Luqman et al., 2013; Shamim et al., 1992). Interestingly, contrary to public institutions, NGOs and CBOs are considered to be effective in community development and in improving the socio-economic condition of rural areas (Alvi et al., 2020; Hameed, 2017; Shakeri, 2004). Furthermore, the past studies such as Shamim et al. (1992), Luqman et al. (2013), Padawangi (2010), Turnhout et al. (2010), Turnhout and Van der Zouwen (2010), Rafique and Khoo (2018) or Hameed et al. (2017) either examined the role and effectiveness of the local government or analysed the impact of NGOs in a particular sector or project (i.e., water, sanitation and hygiene (WASH), education or agriculture) in developing countries, and it was found that no comprehensive study have been conducted so far. Therefore, it is evident that despite grave concerns about local government and NGOs and their effectiveness, a very diminutive in-depth study has been conducted to investigate influencing factors, people's perceptions of community development initiatives, and what is actually happening on the ground, and to identify the effectiveness of both institutions at the local level.

Hence, this study has been carefully designed to investigate whether public institutions or those in development organisations or NGOs are more effective in service delivery; what constrained the progress of these projects; and what measures should be taken to improve the performance of the community development programmes in selected eight rural villages of district Mandi Bahauddin in Punjab province, Pakistan. This research is designed as a case study where we asked beneficiaries and ascertained people's perceptions on public service delivery. More specifically, the study contributes to:

1. Ascertain the perception of local community on development interventions of the government and NGOs;
2. identify the strengths and weakness of government and NGOs in delivery of services on poverty alleviation programmes and;
3. recommend changes in policymaking efforts in designing effective development programmes by NGOs and public departments to improve on the perceptions of local communities.

Literature Review

Traditionally, it has been considered that rural development programmes are based on accepted values that determine people's participation and their well-being. This vision is limited to economic aspects and to some indicators of welfare of the rural communities (Chiriboga & Plaza, 1998). In the contemporary world, rural development is a multidimensional phenomenon, analysed in different areas

of knowledge comprising geographical, sociocultural, agro-economical, environmental and psychological realms (Márquez, 2002); for instance, in agriculture productivity, Sarkar and Padaria (2010) computed risk perception of people about climate change. Their findings revealed that 70% people supposed an increment in crop diseases followed by a reduction of 46.7% in agricultural production in Western Bengal. Likewise, Babasanya et al. (2013) assessed farmers' perception on cassava in Igabi of Nigeria and concluded that for ease of adoption of a new variety, there must be similarity between the farmer's indigenous method and proposed practice for cultivating the new variety. This finding corroborates with the work of Ekpe and Obeten (2002) and others, which reveals many perceptions which can hinder development and adoption of socio-economic projects. These differences represent the ways rural producers adapt to new circumstances of rural work, seeking to diversify their activities to manage survival in a globalised world (Schneider (2003).

Upon reconsidering the rural sector, it is no longer productive issues, which are generally understood and related to the rural areas and communities, rather it needs to explore some other areas of knowledge that can ultimately contribute to solving their problems on their own. The anticipated development targets can barely be achieved if the target beneficiaries' opinions are not congruent with those of the public and private sector developmental agents in terms of health, education and the provision of social needs (Kottak, 1991). Similarly, the quality of public services has either declined or remained unchanged in developing countries without acknowledging people's views (Robinson, 2007).

Since active participation is crucial in developmental programmes to minimise wastage of resources, their reallocation is needed most economically and productively. Such kind of perception-based research and data assist in creating new information on participatory-policy-direction and can be used in the planning and implementation of rural development (Kottak, 1991). In this regard, NGOs remained very instrumental across all spheres of human well-being (Omofonmwan & Odia, 2009) to implement participatory programmes. However, some researchers like Jelinek (2009) argued that several projects implemented by NGOs are also non-participatory. However, her results show that people possess less knowledge about NGOs and government organisations, and the perceptions of those communities are shaped by the performance or results of the projects being implemented. In this regard, NGOs are well respected for doing commendable work and thus viewed as favourable partners by the local community.

The Abilities and Success of Local Governmental Organisations

The literature enumerates many interrelated problems common to local authorities in developing countries. Generally, local governments exercise regulatory, revenue raising and eminent domain powers over most local resources within their borders, but their capacity to affect policy issues remains challenging. While ideally, they must address directly varying socio-economic concerns in their

respective territories, structures and population, several studies show that they have become inhibitors for developing inclusive community development initiatives in most of the developing countries (Luqman et al., 2005; Shamim et al., 1992). On the other hand, despite decentralisation in the public sector, the local population in Herat and Balkh perceive the government differently. The study conducted by Jelinek (2009) shows that the government did not actively engage the local communities in the banning of poppy cultivation, which adversely affected people's livelihoods, and the public showed great anger and concerns over government interventions. According to Norad (2013), the local community may not participate in any government and NGO development programmes when they feel that they have no ownership, thus undermining the effectiveness of the aid programmes. Swidler and Watkins (2009) state that if the local community has ownership of any project, they will actively volunteer and participate in its implementation, resulting in sustainability of the project and external financing. Similarly, Anzar (2002) asserts that potential for community participation in any given intervention is generated from the satisfaction with the services provided by the development partners.

In Africa, for instance, the local sources of revenue are poorly developed and administered, and local service needs are not well met (Onyango-Delewa, 2016). In addition to fiscal turbulence, human resource is inadequate, and many employees lack adequate professional training, followed by extensive political interference in local administration (Olowu & Smoke, 1992). Similarly, in Pakistan, where subsequent government propagates to help in improving local governance, the living conditions of the inhabitants of the rural areas remained controversial. While the country faced adverse military dictatorship and political turmoil, the historic tensions between federal and provincial governments further constrained the financial and institutional capacity of local governments, paralysing the local institutions (Archondo-Callao, 2001; Siddiqui, 1992; World Bank, 2007). The federal government adopted the approach to integrate social development in the overall national development plan through the Social Action Programme (SAP). An attempt was made by adopting what was called the Poverty Reduction Strategy (PRSP), which focused back then on achieving broad-based economic growth as a way to reduce rural–urban poverty in Pakistan. However, it failed in its attempt due to lack of direction and lack of participation of local communities and led to a major failure in the integration process (Baig & Khan, 2006).

Likewise, in the post-devolution era of 2001, there was another attempt from the federal government to revive local governance to improve living standards of rural communities, enhance agricultural growth and build an inclusive community emancipation plan. As a result, the scope of local governments in terms of service delivery and resource allocation increased substantially (Cheema et al., 2005) and rural areas witnessed some change. However, these local governments were effectively used for politics of patronage and corruption, limiting attributes of successful government interventions at local level (Cheema et al., 2005; Malik, & Ahsan, 2019; PILDAT, 2013, p. 26).

Abilities and Successes of Non-governmental Organizations

Adebayo (1997) revealed that NGOs focusing on development and poverty alleviation programmes help to mobilise resources beyond the state budget for development. He also remarked positively on the genuineness of few NGOs. He concluded that NGOs like Farmers Development Union (FADU) have successfully invested over ₦90 million in their various poverty alleviating programmes with an in-built guarantee for sustainability. Kang (2011) pointed out that NGOs focus on 'bottom-up approaches' as opposed to the predominantly growth-centred development and top-to-bottom approach pursued by many agencies and governments. They have the influence and capacity to promote and involve the local population to participate because they are sometimes rooted in local communities or tend to develop bonds with the people they serve. Likewise, Cernea (1988) added that the close interaction between NGOs and the local community enables them to reach the rural and poor people where the government has little access to delivery services. Hence, they identified the demands of the local community by setting the agenda for development together with the local people during different processes.

Ibrahim and Hulme (2011) explained that NGOs are empowering the local community by inspiring the marginalised and the poor to organise themselves and advocate for their own rights. Similarly, Kang (2011) agreed that NGOs are more flexible, cost-effective, innovative, grass-root oriented and strongly committed to the delivery of the local people from the bondage of poverty. In a nutshell, NGOs have the capacity to innovate and adapt, using the transfer of technologies that were already developed elsewhere and adapting them according to the local conditions (Cernea, 1988). Holmquist (1984) explained that NGOs play a significant role in the alleviation of poverty using different methods. They created wider employment chances for poor people, introduced new livelihood projects, empowered self-help groups and implemented government programmes. Their benefits are seen widely by the local population. Korten (1980) believes that by offering relief and other basic services to the people, NGOs play a vital role since their initiated programmes empower both men and women to change their lifestyle through viable and effective skill-based livelihood projects.

Ehigiamusoe (1998) states that NGOs incorporate other strategies to alleviate poverty; these development programmes can be implemented at the macro level. Khan and Ali (2016) examined various activities of local supportive organisations (LSO) in Northern areas of Pakistan and ascertain their impact on women empowerment. They found that LSO has meaningfully contributed towards increasing women's access to financial resources and enhancing financial and social awareness through training, which has played a vital role in creating opportunities for women and brought social and economic empowerment in rural areas. Ehigiamusoe (1998) mentioned that NGOs offer proper socio-economic services to the poor. Ohiorhenuan (2003) believed that NGOs are helping the poor by introducing various developmental programmes, for example, skill and agricultural training programmes.

However, despite these success stories, a great chunk of writers in developing countries criticised NGOs for their fewer effective programmes, poor service delivery and incapacity to influence the larger population. According to Kang (2011), NGOs are implementing foreign interests, which can be dangerous to the local community, for example, free distribution of condoms in the villages. Mohan (2002) believes that the reality with NGOs are hidden since what they do appears different. Mohan (2002) recorded that NGOs give out inadequate information to the community, and the inadequate information flows and lack of participation at the planning level are making NGOs lose their popular trust from the community. Similarly, Mawdsley et al. (2002) observed that there are common problems of NGOs where they just rush to implement whatever their foreign donors wanted them to do without taking into consideration the due demands of the community. A report from the regional NGOs workshop (2015) explained that NGOs lack enough funds to implement all their programmes that are meant to improve the lives and the standards of the poor people. The report recorded that Lack of Funds and donor conditions, absence of strategic planning, poor networking, poor communications, poor development approaches, the bad relationship among NGOs, and limited capacity to implement some programmes.

Material and Methods

The data were collected through personally administered questionnaires in randomly selected eight villages in Tehsil Phalia of District Mandi Bahauddin of the province Punjab, Pakistan. These eight villages were selected based on several characteristics including its agriculture, social and economic profile, outreach of the agricultural and development initiatives and road and communication services. We used a 4-point Likert scale owing to its simplicity and popularity to measure perceptions and compared with our baseline data in 2010. These scales are commonly used in survey instruments designed to measure employee performance, political opinions and psychometric research (Creswell, 2003; Kulas & Stachowski, 2013; Purdey, 2013; Raaijmakers et al., 2000).

A 4-point Likert scale measured satisfaction level from highly satisfied to highly dissatisfied on a range of questions. The method was particularly effective as it provides ordinal scale and effectively describes a summary of ordinal data with frequencies or percentages of responses in each category (Jamieson, 2004). For the survey, a sample size of 240 households (HHs) was determined from all selected villages. However, after baseline in 2010, we found several HHs reluctant to provide information on questions, and some had not answered the questionnaires. These HHs were then discarded and only 225 responses were included in the next survey in 2014. Owing to limited time and budget, the sample size might not be representative of a larger population; however, the HHs from each village were chosen randomly to ensure result significance. All the HHs, through its representative or HH-head, were personally interviewed. We used SPSS to analyse and depict descriptive statistics and for measuring and comparing frequencies obtained from the HH survey.

Results and Discussion

Profile of Villages and Households

To evaluate private–public services across villages under investigation, it is important to investigate the resource base of the region such as population, public and educational services and occupation of the HHs. There are over 6,600 HHs with 50,720 total population (Bureau of Statistics, 2018), with the highest population in village Hellan and lowest in Kot Hamid Shah, living in this area. Some of the key descriptive statistics are summarised in Table 1. The level of education is so low that the maximum years of schooling are merely 9 classes, while the average was just 1–2 classes. It means that there is an almost illiterate population in the study area. Family size was as high as that of the national and provincial figure (6 persons) though the maximum family size consisted of 18 members. Around two and a half persons are living in 1 room and in the extreme case, 10 persons are occupying a single room.

The selected eight villages also share similar characteristics, such as farming as a major source of employment, providing about 85% contribution towards the livelihood of rural people. The crops grown in the area include sugarcane, rice and wheat. Rice and sugarcane are processed in the local mills situated across villages and adjoining areas. The land is irrigated, and the availability of water and suitable weather conditions provide farmers to grow rice and sugar cane of very good quality. The famous rice variety 'Colonel Basmati' provides a good source of income after selling at a good price. After the agriculture productivity and landholding, the significant indicator of socio-economic status in villages is the livestock. They sell their products in the local markets, such as milk, ghee (desi ghee), butter and animals. Furthermore, HHs who have more livestock than the others are considered higher in socio-economic status. Besides farming, both labour and skilled people are settled in the Gulf and European countries for employment.

Table 1. Household Characteristics Across Villages.

HH Characteristics	*N*	Mini	Max	Mean	Sd. Deviation	Variance
Age of head of the HH	225	18	90	47.93	13.495	182.125
Age of the respondent	225	14	90	42.13	14.920	222.616
Year of schooling	223	0	9	1.69	1.568	2.458
Family size	225	2	18	6.27	2.315	5.359
Family member sleeping per room	220	1	10	2.43	1.517	2.301

Source: Author's estimate from field survey 2010–2014.

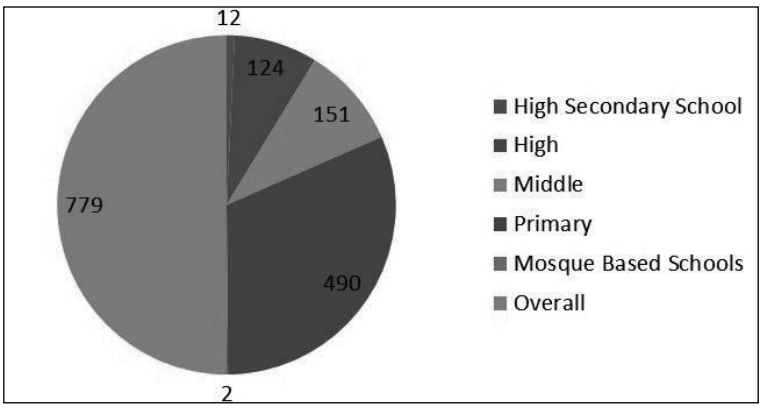

Figure 1. Educational Profile of Mandi Bahauddin.

Source: Punjab Education Department, 2014 online portal.

Profile of Educational Services

According to Punjab School Census report (2013), the number of educational institutes in Mandi Bahauddin is 779 having 190,904 students enrolled with a total of 5,232 teachers, as shown in Figure 1. Punjab Multi-Cluster report 2008 manifested that around two-thirds of the HHs over 10 years of age are literate in Mandi Bahauddin. Besides, more than two-thirds of the HHs with age ranging between 15 and 24 were also literate in both Tehsils.

Likewise, our survey results also describe a similar pattern. While most of the villages have both public and private schools, there is gender parity for the availability of schools in the villages (see Table 2). The results have shown almost equal number of schooling facility for boys and girls in both Tehsils till 10th grade. However, college facilities (HSSC) for girls were available at the Tehsil level, while none of the colleges exist so far for boys in the eight surveyed villages. It is worth mentioning that the government of Punjab has initiated different educational programmes, whereby new schools were constructed in the locality.

Table 2. Village Educational Infrastructure Profile.

	Educational Institutes							
Villages	Primary School (5th grade)		Middle School (8th grade)		Secondary School (10th grade)		Higher Secondary School (12th grade)	
	M*	F*	M	F	M	F	M	F
Kot Nabi Shah	1	1	0	0	0	0	0	0
Bumbli	1	1	1	0	0	0	0	0
Dhal	1	1	1	0	0	1	0	0

(Table 2 Continued)

(Table 2 Continued)

Villages	Educational Institutes							
	Primary School (5th grade)		Middle School (8th grade)		Secondary School (10th grade)		Higher Secondary School (12th grade)	
	M*	F*	M	F	M	F	M	F
Kot Hamid Shah	1	1	0	0	0	1	0	1
Hellan	0	1	1	0	1	0	0	1
Baho Manga	1	1	0	0	0	0	0	0
Chak Mano	1	1	0	0	1	0	0	0
Dhreekan Khurd	1	1	0	0	1	1	0	0
Overall	7	8	3	0	3	3	0	2

Source: Author's calculation from Survey in 2010–2014.

Note: *Male and Female.

Health and Safe Drinking Water Facilities in Villages

We also ascertained the health and safe drinking water facilities in each selected village. The findings revealed most of the villages lack better health facilities for children and women. Despite the existence of health units and traditional health care systems (fewer in number) in some of the villages under investigation, people usually go to the district and tehsil municipal hospitals in Phalia city or Mandi Bahauddin, which might cause additional cost due to distance. Besides public medical facilities, there are some private clinics and hospitals (homeopathic, allopathic, *hakeem* (traditional doctor), etc.) in villages and city area. The average lady health worker (LWH) across villages is 1.6, showing only 1 or 2 LHWs cover the population of 4,434 people (average population in 8 villages) and that only 1–2 basic health units (BHU) provide health facilities (Table 3). Even though most of these villages are situated at the bank of River Chennab and Jehlum, which provide enough water for irrigation purposes, these villages are deprived of proper drinking water facilities. Our baseline survey in 2010 received several complaints about safe drinking water, and most of them were using water from either 'wells or tube well' for drinking purpose. The waste from neighbouring industrial units, such as sugar and rice mills, affects the quality of groundwater severely.

Table 3. Health and Water Facilities in Villages.

Villages	Basic Health Units (f)	Lady Health Worker (f)	Private Clinic/ Medical Center (f)	Water Supplies Points	Total Volume of Water (00 Gallons)
Kot Nabi Shah	0	0	0	16	2,500
Bumbli	1	2	0	18	
Dhal	0	0	2	28	3,000

(Table 3 Continued)

(Table 3 Continued)

Villages	Basic Health Units (f)	Lady Health Worker (f)	Private Clinic/ Medical Center (f)	Water Supplies Points	Total Volume of Water (00 Gallons)
Kot Hamid Shah	0	0	1	25	3,500
Hellan	4	7	3	56	2,700
Baho Manga	1	2	1	43	3,500
Chak Mano	3	2	1	61	3,000
Dhreekan Khurd	0	0	0	41	3,000
Overall	9	13	8	288	21,200
Mean	1.1	1.6	1	36	3,029

Source: Authors Field Survey and MICS (2014).

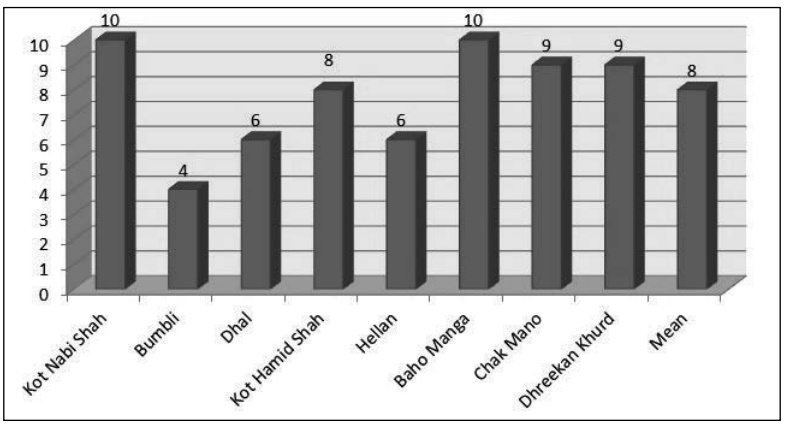

Figure 2. Distance to Phalia City from Each Village.

Source: Authors estimates from survey, 2010--14.

However, with the support of the Korean government, the Public Health Engineering Department Punjab provided safe drinking water to 25 villages in 2014. The present study was conducted in the premises of those affected villages, particularly Dhreekan Khurd, which was badly affected by the waste of the mills. Now, they are at least provided with safe drinking water at their doorstep at a reasonable cost.

Roads, Transportation and Telecommunication

As shown in Figure 2, the average distance between Phalia city and villages is 8 kilometers, and these villages are connected through concrete roads. However, among the villages, few villages (Hellan, Mano Chak near to roads, Bumbli and Dhal) have proper roads. There is no specific transportation facility provided to

the villages except a general bus stand at Phalia City and an auto stand. Most of the villagers use self and private autos for locomotion. Much improved transportation and access roads are essential for agricultural development, for farmers to supply crops and other agricultural goods to the markets with ease.

The mobile and landline telephone is the main source of communication for the people in a few villages. However, Internet facility is not properly available in the area. Internet facility is available mainly in Hellan and Phalia City. Telenor and Ufone mobile money transfer facilities are also available in a few village shops.

Comparison of Service Quality: Government Versus Non-governmental Organisations

People's Perceptions over Educational Facilities

Local communities' perception on the performance of the available educational facilities provided by government organizations and NGOs over two time periods were studied by asking them whether they are satisfied with the available educational facilities. The finding shows a higher level of satisfaction with government educational facilities (13.8%) as compared to NGOs (0.9%) in 2014. Similarly, the dissatisfaction level on public schools has also decreased from 64% in 2010 to 18% in 2014. On other hand, dissatisfaction with NGO schools is reported to be much higher in both 2010 and 2014. This is primarily due to the availability of public schools in the villages and perhaps fewer schools being administered by NGOs. These findings contradict the traditional argument that private or non-government funded schools are more popular among parents and students and have better educational programmes (Andrabi et al., 2002; Ashraf, 2012; Sattar et al., 2012). These results might also appear due to several reasons such as higher tuition fee (Khan & John, 2006) and lower parental income, which restrict parents from sending their children to these private or NGO-led schools. Further, Punjab government's 'educational reform programmes' have also improved rural educational system and increased enrolment, teaching quality with greater monitoring and accountability through parent–teacher meetings In addition to that, "Government introduced school management committees (SMCs) that had a positive impact on educational services provided in public schools." Therefore, overall, district Mandi Bhauddin outperformed in these in educational scenario as supported by reports from Annual Status of Education Report (2014, 2016) and School Information System Government of Punjab (2019).

People's Perceptions over Health Facilities

One of the key public challenges in rural areas is the health and health-related infrastructure. Government health centres and hospitals are relatively few and widely dispersed. On the other hand, private sector health centres often favour urban areas. In the absence of a concrete health system, strengthening community-

based health services helps in providing more reasonable access to health services (Chaya, 2007). Therefore, we compared the health services administered by the government and NGOs and assessed the level of the rural HHs on these health services. Our findings revealed that in 2014, only 0.4% of HHs were satisfied with the Government health facilities provided in villages, whereas in 2010, no one was satisfied with these facilities. Similarly, their dissatisfaction level with governmental health facilities was higher (93% in 2010 and 88% in 2014).

In contrast to public health facilities, HHs were somehow satisfied with NGOs regarding the provision of health services in the area. These results conformed to Riaz et al. (2018) who showed that rural communities were highly satisfied with the Punjab Rural Support Programme (PRSP). Also, a low level of public satisfaction over public health services is primarily due to the unavailability of BHUs or health facilities, doctors, etc. in their villages (Table 3). However, the percentage of moderately satisfied people increased from 4.4% to 8.4% in 2014, since the government of Punjab tried to bring health service reforms under the 18th amendment and devolution plan in the province; however, those efforts are not being fully translated to these rural areas (Ansari, 2011).

People's Perceptions over Safe Drinking Water and Sanitation Facilities

Since various studies indicate that safe drinking water and proper sanitation systems can reduce health expenditure by reducing the prevalence of water-related diseases, which has a positive impact on human health and overall well-being (Hoddinott, 1997; Kro, 2017; WHO, 2014), we assessed the satisfaction level of respondents on available drinking water resources and sanitation (overall sanitation, which includes drainage system and street pavement).

The overall satisfaction level of respondents for water supplies by NGOs has been increased from 0.9% in 2010 to 15.6% in 2014, whereas dissatisfaction decreased from 92.9% to 17.3% in 2014. The findings correspond to those by Khalid et al. (2018) who also reported that out of 72 respondents, only 29.1% indicated that the water quality of their area was good. Since most of the villages in our study area were highly affected by the effluents from sugar and rice mills in the area, and there was no proper drinking water facility available in the villages, the respondents expressed the highest dissatisfaction over water supply for both public and NGOs in 2010. However, as the Punjab and the Korean governments provided safe drinking water facilities in the villages in 2014, the satisfaction level on NGOs has increased dramatically (KOICA Project Completion Report, 2014).

Proper sanitation including the drainage system is one of the major challenges associated with severe health and economic implications in both urban and rural areas. Considering its significant role, we asked respondents about the sanitation in their respective villages. The findings of our survey show that the satisfaction level on public sanitation facilities was very low as 0.4% were satisfied and 5.8% were moderately satisfied in 2014. However, the moderate satisfaction level on sanitation facilities provided by NGOs had increased from 3.1% to 9% in 2014.

These villages were frequently flooded during rainy periods, which not only affected their drinking water but also damaged the drainage systems and street pavements. However, since 2014, the Korean government has provided millions of dollars as aid to improve water, health and sanitation and for developing the capacity of local administration to improve these services. Consequently, this has resulted in an increased satisfaction level.

People's Perceptions over Public Transportation and Rural Road Network

There has been a greater influence of farmer's mobility on poverty reduction and its association with public transportation and roads in the rural context (Archondo-Callao, 2001; Bryceson, 2006; Familoni, 2004). Therefore, it is necessary to assess the conditions and perceptions of the farming community over access to roads and transportation. Since the government mostly provides transportation and networks, we only assessed people's perceptions of public sector development. Our findings show that the satisfaction level on public transportation has increased from 14.7% to 20.9%. Likewise, the dissatisfaction level has also reduced from 64% in 2010 to 57% in 2014. There is still a higher level of dissatisfaction among rural communities on available transportation facilities despite a 15.4% increase in transportation in Pakistan (Government of Pakistan, 2013). However, considering the larger population, transport vehicles are still less than people's requirements.

Similarly, roads provide easy access to districts and Tehsils/towns where farmer and rural communities can have access to the market and other social/recreational services. Rural roads are the backbone of the economy (Carapetis et al., 1979). In this regard, our results reflect the satisfaction level of the respondents on the availability of rural roads in their respective areas. We also found that the dissatisfaction level decreased from 47.1% (2010) to 28.4% (2014), while 35.1% of respondents showed satisfaction over the condition of roads. We also examined the level of satisfaction over agriculture goods mobility (crops, fruits and livestock and inputs such as seeds, fertilisers and pesticides/chemical) and found a decrease in dissatisfaction from 68.9% in 2010 to 55.6% in 2014. This decreasing trend is attributed to Punjab and federal government loan schemes for purchasing tractors and other transportation facilities as well as an increase in the monetary income of the farmers. Furthermore, in some villages, collective transportation is available, which allows farmers and rural communities to use these facilities (on a self-help basis) cost-effectively.

People's Perceptions over Agricultural Extension Services

The effective and efficient delivery of agricultural extension services has been of great concern in the world and for agriculture-based countries like Pakistan, which ultimately results in increased productivity of crops and livestock. However, like other developing countries, this country is also facing severe problems in agricultural extension departments. Since rural poverty and agriculture

development are interlinked, the researcher also investigated the satisfaction level of respondents over the extension services. Several NGOs and Punjab agriculture extension and livestock and dairy development departments are responsible for providing relevant services, and it might be difficult to measure people's perceptions individually on each dimension/department. Therefore, the present research divided the services into two: (a) the overall performance of agriculture extension services (which includes quality of seeds and fertilisers, training, etc.) and (b) veterinary services (livestock/animal health).

The results show that the satisfaction level of the community has reduced on government agriculture extension services from 8.9% in 2010 to 2.7% in 2014, whereas the level of satisfaction on NGOs has slightly increased from 6.5% in 2010 to 11.5% in 2014. Similarly, in terms of veterinary services, only 11% of respondents show moderate satisfaction on government services compared to 35% on NGOs. Overall, people were more satisfied with agricultural extension services by NGOs than the government, primarily due to better services provided by these organisations in the field. These results correspond to the findings by Sarker and Yoshihito (2009) and call for regular training for extension agents so that reasonable knowledge and experience in adult learning principles could be acquired to enhance their effectiveness (Aphunu & Otoikhian, 2008; Ayansina, 2011).

People's Perceptions over Access to Agricultural Market

The rural economy is largely based on farmer's access to the agriculture market and the price of agricultural goods. Better government policy and legislation have a greater impact on farmer's welfare and ultimately on rural development. Ensuring a fair price policy and access to the market is the prime responsibility of the government in Pakistan. Hence, we asked the community how they perceive agriculture market. The findings from our survey revealed that there is increased satisfaction over the condition of markets from 16% in 2010 to 23.1% in 2014. Similarly, there is an increasing trend of satisfaction with the price of agricultural commodities in the agricultural market from 45% in 2010 to 59% in 2014. Our finding confirms the results of Rehman and Selvaraj (2013) who showed that there is an overall positive perception of respondents towards agricultural markets, but it contradicts our findings with price stability in the market, etc. In addition to that, the rise in the level of farmer's satisfaction over prices/market is associated with government's effective policy. Prime Minister's Agriculture Package worth US$34.1 billion to support farmers to buy agricultural inputs (reduce input cost such as fertiliser, seeds, machinery) and crop insurance aims to benefit 0.7 million small farmers (Government of Pakistan, 2015–2016).

People's Perceptions over Access to Formal and Informal Credit Markets

Microfinance or microcredits are considered as an instrumental tool for alleviating poverty in poor economies. In Pakistan, various micro-finance institutions (MFIs) are operating including commercial and public banks and

NGOs, providing loan facilities to poor people in both rural and urban areas. Likewise, non-institutional microfinance/microcredit or personal loan services also exist. The rich or landlords in the area also provide a borrowing facility to the needy. The findings show interesting results where a large number of respondents, that is, 89.3% and 90.2% in 2014 and 2010, respectively, are dissatisfied with the microfinance schemes introduced by NGOs in the villages, and only a small proportion (0.9%) are satisfied with NGO's microfinance/microcredits schemes. These findings are consistent with the findings of Long (2009) who claimed that people perceive MFIs as profit-oriented rather than to reduce poverty-oriented in the community. Another reason for the higher dissatisfaction level on NGO-based MFIs is the higher interest rate charged to offset the increased cost of managing numerous small loans (Harris et al., 2007; Kamran & Faheem, 2012; Littlefield et al., 2003). Similarly, dissatisfaction on personal or non-institutional burrowing has also been very high both in 2010 and 2014, that is, 82% and 72%, respectively, calling for more institutionalised MF schemes, as satisfaction level sharply increased on banks from 0.05% in 2010 to 18% in 2014. Though the public and commercial banks' interest rate or mark-up grew at a higher level from 12.5% in 2010 to 14% in 2014 (State Bank, 2015), people still showed satisfaction on their services due to bank's better compliance and facilities (Siddiqui & Gilal, 2012).

People's Perceptions over Rural Electrification

In theory, the provision of electricity can improve socio-economic conditions in developing countries through its influence on key components of poverty, health, education, income and environment (Kanagawa & Nakata, 2008). Khandker et al. (2009) claimed that lack of access to energy, more precisely electricity is one of the major impediments to economic development in rural areas. Likewise, Chaurey et al. (2004) argued that a strong correlation exists between rural poverty and access to electricity because electricity is a prerequisite for productive activities. A study by Aklin et al. (2016) in India found that continuous electricity can also increase user satisfaction level. Hence, we asked the respondents to rate the performance of government intervention on the provision of electricity in the area. The satisfaction over provision and condition of electricity in the villages has decreased from 4% in 2010 to 2.7% in 2014, whereas 25% of respondents showed dissatisfaction with the condition of electricity in 2014. In Pakistan, particularly the rural areas have been facing a huge electricity shortfall (since 2002–2014) due to less production and more demand (Economic Survey of Pakistan, various editions). Moreover, the survey was conducted in summer and winter; thus, it may also alter the perceptions of people over the provision of electricity, its quality (voltage, numbers of hours) and services of Water and Power Development Authority (WAPDA) in respective areas.

Finally, people's perceptions over law enforcing agencies were also elicited. Sound Law and order situation, security and peace are essential for social and economic development. Concerning better police service, respondents were asked

how satisfied they were with the law and order situation and police services. The percentage of respondents satisfied decreased from 4.9% in 2010 to 1.8% in 2014. Likewise, 64.4% of people showed dissatisfaction over police services. The major reasons described by people were corruption, overpopulation and infiltration of people from other provinces, especially from tribal areas.

Conclusion and Recommendations

Community perceptions play a significant role to guide the development and public sector in measuring the effectiveness, efficiency and assessing the challenges and feelings of the community. This research indicates that the level of satisfaction from various development interventions varies across organisations (i.e., NGOs and public sector) over time. Overall, the rural areas under investigation have poor educational and health services. Contrary to local government, NGOs tend to provide better services in health, education and safe drinking water (social sector), whereas the local government was effective in providing agricultural and agricultural extension services, improving infrastructure such as roads and access to market, reducing the price of agricultural commodities, etc. Hence, the consequences of these findings raise concerns about the quality of local governance and NGO performance. However, these perceptions are even more pronounced for those who live in rural Punjab. Besides, it entails new insights on how to ascertain NGO–government performance differently and NGO–government partnership to improve the social sector. Finally, it calls for the central government to invest in health, water and education. The growing dissatisfaction over the local institution in the social sector while a low level of satisfaction on development organisations have serious implication for their future and it must be built up through mutual trust among people.

For the government and NGOs to build public confidence and improve efficacy, we strongly recommend:

1. To build strong relationships with community and CBOs and work together to address the human well-being in the rural areas;
2. strengthen their partnership with private and humanitarian sector to develop projects for improving health, ensuring adequate health facilities, providing safe drinking water, and improving educational quality and sanitation; and
3. to improve their governance structure and create accountability and governance mechanisms to regulate, monitor and appraise rural and community development programmes in order to bring a real change in the rural areas.

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Rental Market of Pump-sets in the Central and Western Parts of Nepal Plains

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Abstract

Using data collected from the central and western parts of Nepal plains, we examine the extent of rental market of pump-sets therein, and identify the factors affecting the decision of farm households to purchase the service of pump-sets. Further, the article investigates whether cropping intensity and extent of crop diversification for non-users, owner users and rental users of pump-sets are significantly different. Our analysis suggests that there exist rental markets of considerable sizes in the field study locations. Access to extension service, proportion of high yielding varieties in total cropped land, availability of pump-sets, caste and locational characteristics have been identified as the determinants of the decision to purchase the service of pump-sets. Cropping intensity and extent of crop diversification for the rental users have been found to be higher than those of the non-users and the owner users, and this finding establishes the positive impact of the rental market.

Keywords

Rental market, pump-sets, determinants, cropping intensity, crop diversification, Nepal

Introduction

The resource endowments across rural households are usually not uniform, especially in the developing countries (Lin, 1995). The glaring example of uneven possession of resources is the skewed distribution of agricultural lands in

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the poor agrarian economies (Cervantes-Godoy & Dewbre, 2010). Generally, while a small percentage of households possess land in large size relative to their family labour, an overwhelming proportion of them owns a small amount of land compared to their endowment of labour. Such type of mismatch can be observed in the case of other resources also. For instance, usually only a few rich and big farmers in a village own agricultural machineries such as tractors and pump-sets. On the other hand, most of the marginal and small farmers are not sufficiently endowed with financial resources to possess such agricultural capital goods. Given the scale of operation, it may not, in fact, be viable for the small farmers to make bulky investment on procuring such capital goods (Goswami, 2017). The existing literature suggests that the mismatch in the ownership of resources across households inhibits their fuller and efficient utilisation resulting in a level of agricultural productivity and output, which is lower than the potential level (Das, 2015).

The existence of rental markets however can bring about a better matching of resource endowments among the rural households (Aryal Holden, 2012; Lin, 1995). In case of the capital goods, rental market allows the separation of service flows from ownership, and thereby the indivisible agricultural machineries can contribute to improving productivity on small farms as well (Timmer, 1988). Small and marginal farmers can utilise these capital goods without having to own them. Rental markets may even encourage ownership of capital goods. The financially well off farmers may like to invest on such machineries as they can sell the excess capacities after own use in the rental markets, and earn the rent. Thus, the rental markets could be beneficial for both the sellers and the buyers of the services of agricultural machineries, and thereby can contribute to improving agricultural production, productivity and overall rural development (Goswami, 2016a). Against this backdrop, the present study explores some dimensions of the rental market of pump-sets in Nepal plains, which is one of the major sources of irrigation therein.[1]

In the context of Nepal, the issue under investigation bears ample significance. Nepal's agriculture, which contributed 34.30 per cent of the Gross Domestic Product and employed 74 per cent of the population in 2012, confronts a challenge in terms of predominance of small and fragmented land holdings. Agricultural holdings below one hectare constituted 74.2 per cent of total agricultural holdings, and the average land holding size was only 0.8 ha in 2010 (APCAS, Asian Pacific Commission on Agricultural Statistics, 2010). Niroula and Thapa (2005) note that fragmentation of land holdings in Nepal has been increasing owing to the custom of equal distribution of family land among the heirs. As discussed above, farmers owning small or fragmented parcels of land may lack incentive to own agricultural machineries. As far as the irrigation machinery such as pump-set is concerned, lack of investment on such capital good may result in reduced level of cropping intensity, lower extent of crop diversification and so on owing to inaccessibility to irrigation.[2] Consequently, the performance of the entire agriculture sector could be adversely affected. The presence of a rental market may, however, encourages investment on pump-sets. Further, by providing access to irrigation to even the

small farmers, the rental market of pump-sets can facilitate the cultivation of a diversified portfolio of crops throughout the year.

Compared to the large number of studies on the rental markets for land and livestock, there are not many studies on the rental markets of agricultural capital goods (Sharma, 2017). In the context of Nepal, Takeshima et al. (2015, 2016, 2017), Biggs and Justice (2013), and Gauchan and Shrestha (2017) are the only few studies that explore the extent, nature and effect of the rental market of agricultural capital goods. While some of these studies focused only on the rental market of tractors, some others studied those of threshers and harvesters also. To the best of our knowledge, this article is the only study on the rental market of pump-sets in Nepal, and hence makes a contribution to the literature.[3] The study has two specific objectives. First, it examines the extent of rental market of pump-sets in the plains of Nepal and identifies the factors affecting the decision of the farm households to purchase the service of pump-sets. Second, it investigates whether the values of the indices of cropping intensity and crop diversification for non-users, owner users and rental users of pump-sets are significantly different, which allows us to gauge the effect of the rental market. The study is confined to the Plains of Nepal only, since the plains, which contribute about half of the country's agricultural GDP, are agriculturally more vibrant as compared to the hills and the mountains.

The rest of the article is organised as follows. Section 2 elaborates on data and methodology. Extent of the rental market of pump-sets, which has been found to be of considerable size, is presented in Section 3. This section also identifies the factors that affect the decision of farm households to purchase the service of pump-sets. Section 4 assesses the effect of the rental market on cropping intensity and extent of crop diversification. Section 5 concludes with implications of the findings of the empirical analysis for policy.

Methodology

Data

The study is based on the primary data collected between December 2016 and January 2017 from the plains of Nepal. A multi-stage sampling design was followed to collect data in order to make the sample representative of the population and the geographical scope of the study. The study selected the Central and Western parts of the plains as board locations of field study on the basis of the information presented in Takeshima et al. (2015). The study by Takeshima et al. (2015) does not present information on the use of pump-sets; rather it computes and analyses the percentages of farmers who used tractor in different regions of Nepal based on the nationally representative data from the Nepal Living Standard Survey (2010–2011).[4] This article makes the assumption that the farmers who had used a particular type of agricultural machinery were also likely to be the users of other agricultural machineries unlike those who had not used any machinery at

all. In other words, if a farmer had used a tractor, then he was likely to use a pump-set also compared with a farmer who had not used a tractor. Western and Central parts of the plains were found to have experienced highest penetration of tractors in the above-mentioned study. Consequently, these two regions were selected as board locations of field investigation for this study also. The criterion adopted at the next stage of sampling to select field study locations was the same as at the first stage. While there was not much variation in tractor-use across districts within the western region, district-wise variations were very high within the central region. Hence, at the second stage, the district within the western region with the highest percentage of farmers using tractor was selected. On the other hand, two districts with lowest and highest percentages of farmers using tractors from the central region were selected in order to capture the variations in the use of the agricultural machineries. In the next stage, in consultation with the district agriculture officers of the selected districts, two village development committees (VDCs) from each selected district were selected keeping in view the representation of the district in terms of socio-economic characteristics and cropping patterns prevailing therein. At the fourth stage, three wards from each of the selected VDCs were chosen keeping in mind the proper representation of the VDCs. Finally, 20 per cent of the farm households from each of the chosen wards operating on agricultural land were selected randomly. Thus, a total of 291 households formed the final sample covered in the survey.

Estimation Method

The extent of the rental market of pump-sets has been determined through tabular analysis. A binary Logit model has been estimated to identify the factors affecting the decision of the households to purchase the service of pump-set. Further, Tobit models have been used to gauge the effect of the rental market on the adoption of production enhancing practices considered in this article. What follows next is the formulation of the regression models.

Logit Model

The decision with regard to the purchase of service of a pump-set, which is a binary variable, is the dependent variable (Y). Here, $Y = 1$ if the households purchase the service of pump-sets in rental market, $Y = 0$ otherwise. In this regression model, we have only two categories of farmers, namely, rental users and non-users, and the owner users have been excluded. None of the rental users and non-users own pump-sets in our sample. In other words, we have used only a sub-sample to estimate the model that identifies the factors affecting the service purchase decision. Given that the cohort of farmers considered for this regression analysis does not include the owners, the analysis is relevant only for the decision to purchase and not to sell the service a pump-set.[5]

Table 1 shows the explanatory variables used in the regression model, and Table 2 presents the descriptive statistics of some of these variables. These variables have been identified from the relevant literature and based on impression from the field as well.

Table 1. Explanatory Variables Included in the Logit Model

Explanatory Variables	Notations	Definitions	Expected Signs
(1)	(2)	(3)	(4)
Gender	Gend	Gender of the head of the household; gender = 1 for female, 0 otherwise	±
Age	Age	Age of the farmer	±
Education	Edu	Education of the farmer in terms of the year of schooling	+
Household size	Hs	Number of adult persons in a household	+
Farm size	Fs	Operational holding in hectares is used to capture farm size	+
Access to finance	Credit	This is a dummy variable where credit = 1 if the farmer has access to credit, 0 otherwise	+
Government extension services	Ext	It is a dummy variable where JTA = 1 if the household has consulted the junior technical agricultural officer of their region, 0 otherwise	+
Tenure status	Tenure	This represents the proportion of the total leased-in land out of the total operating land size	±
Migration	*Mig*	It is a dummy variable where Mig = 1 for the household who has at least one migrants in household (either national/ foreign), 0 otherwise	±
Area under non-grain crops	*Ng*	Area on which non-grain crops were grown as a proportion of total cropped area	+
Area under high yielding varieties	HYV	Percentage of area under HYV rice as a percentage of total rice acreage	+
Availability of pump-sets	Avail	Availability of pump-sets at the ward level	+
Caste/ethnic group	C_1, C_2, C_3 and C_4	Taking Muslims as a reference category, four dummies have been used, namely C_1 = 1 for General (Brahmin/Chhetri), 0 otherwise, C_2 = 1 for Dalits, 0 otherwise; C_3 = 1 for Janajati, 0 otherwise; C_4 = 1 for Terai other caste, 0 otherwise	±

(Table 1 Continued)

(Table 1 Continued)

Explanatory Variables	Notations	Definitions	Expected Signs
Location dummies	D_1 and D_2	Two dummies have been used taking Chitwan as a reference category, namely D_1 = 1 for Mahottari, 0 otherwise; D_2 = 1 for Nawalparasi, 0 otherwise.	±

Table 2. Descriptive Statistics of Some of the Explanatory Variables Used in the Logit Model

Variables	Mean		Difference in Mean
	Non-user	Rental User	
(1)	(2)	(3)	(4)
Age	49.69	49.28	0.42
Number of years of schooling	5.20	4.95	0.26
Household size	3.39	3.97	−0.58
Farm size	0.40	0.74	−0.34***
Tenure status	0.31	0.22	0.09
Area under high-yielding rice varieties	0.55	0.39	0.16*
Area under non-grains crops	0.03	0.04	−0.02
Availability of pump-sets	1.88	2.07	−0.19*

Source: Authors' calculation based on field survey data.

Notes. ***$P < .01$, **$P < .05$, *$P < .10$ indicate the levels of significance as per the *t*-test on difference in mean between the two groups.

Functional Specification of the Model:

After incorporating the variables mentioned in Table 1, the binary Logit model is specified as below

$$\text{Log}\,(p_i) = \ln\,(p_i/1 - p_i) = \beta_0 + \beta_1 \text{gend}_i + \beta_2 \text{age}_i + \beta_3 \text{edu}_i + \beta_4 \text{hs}_i + \beta_5 \text{fs}_i + \beta_6 \text{credit}_i + \beta_7 \text{ext}_i + \beta_8 \text{tenure}_i + \beta_9 \text{mig}_i + \beta_{10} \text{ng}_i + \beta_{11} \text{hyv}_i + \beta_{12} \text{avail}_i + \beta_{13} C_1 + \beta_{14} C_2 + \beta_{15} C_3 + \beta_{16} C_4 + \beta_{17} D_1 + \beta_{18} D_2 \quad (1)$$

The maximum likelihood estimates of the parameters have been obtained using STATA 13.0. Results of the regression analysis have been summarised in Table 7.

Tobit Model

The effect of the rental market has been examined by answering the question whether cropping intensity (CI) and extent of crop diversification (CD) of the

rental users differ significantly from those of the non-users and owner users of pump-set, and Tobit models have been estimated to answer this question.

Cropping intensity shows as to how many times a farmer cultivates his/her land during one agricultural year, and is defined as: CI = (Gross Cropped Area/ Net Sown Area)*100. If CI = 100, it implies that the land has been cultivated only once in the year. Similarly, any value of CI above 100 implies that the land, or at least part of it, has been cultivated multiple times during the year.

On the other hand, CD reflects the allocation of cultivable areas by a farmer to facilitate a diverse crop portfolio. Herfindhal Index (H) is used to measure the extent of crop diversification. Herfindhal Index is constructed by using the formula: S_i^2, where s_i the share of the ith crop in the total cropped area. The value of the index lies between 0 and 1. The value 1 implies more concentrated cropping pattern or complete specialisation of single crop whereas 0 for complete diversification. For the convenience of interpretation, we have used $(1 - H)$ as the measure of crop diversification where the value of the index still lies between 0 and 1 but with the opposite interpretation. The value 1 in this case implies complete diversification.

In the regression analysis, CI and CD are the dependent variables.

Independent Variable

Three Categories of Farmers: We are interested in finding out whether the cropping intensity and extent of crop diversification of three groups of farmers, namely, *non-users, owner users* and *rental users* are significantly different. Accordingly, taking the non-users as the reference category, two dummies for *owner users* and *rental users* have been incorporated.

Control variables used in the regression models are presented in Table 3. The control variables have been identified from relevant literature (Bezbaruah & Roy, 2002; Goswami, 2012; Joshi et al., 2006; Pope & Prescott, 1980). Table 4 presents the summary statistics of some of the control variables used in the Tobit models.

Table 3. Control Variables Used in the Regression for CI and CD

Control Variables	Notation	Definition	Expected Sign	
			CI	CD
(1)	(2)	(3)	(4)	(5)
Farm size	Fs	Operational holding in hectare	±	±
Education	Edu	Education of the farmer in terms of year of schooling	±	±
Access to finance	Credit	It is a dummy variable where credit = 1 if a household has access to credit (formal/ informal), and 0 otherwise	+	+

(Table 3 Continued)

(Table 3 Continued)

Control Variables	Notation	Definition	Expected Sign	
			CI	CD
Government extension service	Ext	It is a dummy variable where JTA = 1 if the household has consulted the junior technical agricultural officer of their region, and 0 otherwise	+	+
Area under high-yielding rice varieties	HYV	Percentage of area under HYV rice as a percentage of the total rice acreage	±	+
Labour per hectare	Lab	Number of adults per hectare of operational holding in a household	+	±
Extent of irrigation	Eoi	Proportion of the irrigated area in the operational holding	+	+
Caste/ethnic group	C_1, C_2, C_3 and C_4	Taking Muslims as a reference category, four dummies have been used, namely C_1 = 1 for General (Brahmin/Chhetri), 0 otherwise; C_2 = 1 for Dalits, 0 otherwise; C_3 = 1 for Janajati, 0 otherwise; C_4 = 1 for Terai other caste, 0 otherwise	±	±
Location dummies	D_1 and D_2	Two dummies have been used taking Chitwan as a reference category, namely D_1 = 1 for Mahottari, 0 otherwise; D_2 = 1 for Nawalparasi, 0 otherwise	±	±

Table 4. Descriptive Statistics of Some of the Control Variables Used in the Tobit Models

Variables	Mean		Difference in Mean
	Non-user	Owner User	
(1)	(2)	(3)	(4)
Farm size	0.42	1.33	−0.92***
Number of years of schooling	5.26	7.83	−2.58***
Area under high-yielding rice varieties	0.56	0.60	−0.047

(Table 4 Continued)

(Table 4 Continued)

Variables	Mean		Difference in Mean
	Non-user	Owner User	
Labour/ha	11.93	5.29	6.64***
Extent of irrigation	0.61	1.37	−0.76***
	Non-user	Rental User	Difference in Mean
Farm size	0.42	0.74	−0.32***
Number of years of schooling	5.26	4.95	0.31
Area under high yielding varieties	0.56	0.39	0.16*
Labour/ha	11.93	9.64	2.28
Extent of irrigation	0.61	1.04	−0.42***
	Owner User	Rental User	Difference in Mean
Farm size	1.33	0.74	0.59***
Number of years of schooling	7.83	4.95	2.89***
Area under high yielding varieties	0.60	0.39	0.21***
Labour/ha	5.29	9.64	−4.35***
Extent of irrigation	1.37	1.04	0.33***

Source: Authors' calculation based on field survey data.

Notes. ***$P < .01$, **$P < .05$, *$P < .10$ indicate the levels of significance as per the *t*-test on difference in mean between the two groups.

Functional Specification of the Model for CI:

The value of the dependent variable, i.e. the index of cropping intensity, is either 100 or any other value >100, which implies that the lower end of the value is 100 with no limit for the upper end. Given the nature of the dependent variable, a linear regression may not be appropriate; instead a Tobit model with censoring at the lower end is considered suitable in the present context. The Tobit model is formulated with the help of a latent variable Y_i^* as shown below, which may take any probable value but is not always observable.

$$Y_i^* = \beta_0 + \beta_1 \text{ owner user}_i + \beta_2 \text{rental user}_i + \beta_3 \text{fs}_i + \beta_4 \text{edu}_i + \beta_5 \text{credit}_i + \beta_6 \text{ext}_i + \beta_7 \text{hyv}_i + \beta_8 \text{lab}_i + \beta_9 \text{eoi}_i + \beta_{10} C_{1i} + \beta_{11} C_{2i} + \beta_{12} C_{3i} + \beta_{13} C_{4i} + \beta_{14} D_{1i} + \beta_{15} D_{2i} + u_i \quad (2)$$

Where u_is are the random disturbances, which are assumed to be normally distributed with zero mean.

The observed dependent variable Y_i is linked to the latent variable Y_i^* as per the following formulation:

$Y_i = 100$ for $Y_i^* < 100$

$= Y_i^*$ for $Y_i^* \geq 100$

Functional Specification of the Model for CD:

The value of the dependent variable is bounded between 0 and 1. Hence, a linear regression might not be suitable, as the predicted value form the linear regression model will not be necessarily contained within the interval of 0 and 1. Hence, we use Tobit model with censoring at both the ends.

The Tobit model is formulated with the help of latent variable Y_i^* as follows.

$$Y_i^* = \beta_0 + \beta_1 \text{ owner user}_i + \beta_2 \text{rental user}_i + \beta_3 \text{fs}_i + \beta_4 \text{edu}_i + \beta_5 \text{credit}_i + \beta_6 \text{ext}_i + \beta_7 \text{hyv}_i + \beta_8 \text{lab}_i + \beta_9 \text{eoi}_i + \beta_{10} C_{1i} + \beta_{11} C_{2i} + \beta_{12} C_{3i} + \beta_{13} C_{4i} + \beta_{14} D_{1i} + \beta_{15} D_{2i} + u_i, \quad (3)$$

where u_is are the disturbances which are assumed to be normally distributed with the zero mean.

The observed dependent variable Y_i is linked to the latent variable Y_i^* as per the following formulation:

$Y_i = 0$ for $Y_i^* < 0$
$= Y_i^*$ for $0 \leq Yi^* 1$
$=1$ for $Y_i^* > 1$

The maximum likelihood estimates of the parameters have been obtained using STATA 13.0 and Table 8 shows the estimated results.

Purchase Decision of the Service of Pump-sets

Extent of Rental Market

It is clear from Table 5 that on the whole only 22.71 per cent of the surveyed households did not use pump-sets. On the other hand, while 30.77 per cent households were users of owned pump-sets, 46.52 per cent households used rented pump-sets. The extent of use of pump-sets across locations of field study, however, is not uniform. While 52.08 per cent households in Chitwan were non-users, the corresponding percentages in Mahottari and Nawalparasi were only 9 and 3.9, respectively. On the whole, 76 per cent of households in Mahottari and 44.16 per cent of households in Nawalparasi were rental users. In terms of land-size classes, there is no non-user among the large farmers. Overall, 74.07 per cent of large farmers were owner users and 25.93 per cent of them were rental users. In Nawalparasi, all the large farmers were owner users. The proportions of rental users among the large farmers in Mahottari and Chitwan were 60 per cent and 33.33 per cent, respectively. Among the small and medium farm households, notwithstanding variation across field study locations, it can be observed that majority of them were users of pump-sets, and percentages of farmers using rented pump-sets were higher than those of owner users. While 43.75 per cent of all small farmers used rented pump-sets, 52.99 per cent of medium farmers were rental users. The finding that majority of large farmers are owner users and most of the small and medium user farmers are rental users is as expected given their endowment of resources.

Table 5. Extent of Usage of Pump-sets Among the Surveyed Households Across Land Size Classes (in %)

Field Study Locations	Mahottari			Nawalparasi			Chitwan			Overall		
Land size	NU	OU	RU	NU	OU	RU	NU	OU	RU	NU	OU	RU
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Small	14.29	3.57	82.14	4.17	29.17	66.67	60	23.33	16.67	36.61	19.64	43.75
Medium	8.06	16.13	75.81	5.13	48.72	46.15	42.42	39.39	18.18	15.67	31.34	52.99
Large	0	40.00	60.00	0	100	0	0	66.67	33.33	0	74.07	25.93
Overall	9	15	76	3.9	51.95	44.16	52.08	30.21	17.71	22.71	30.77	46.52

Source: Field study.

Notes. NU, non-users; OU, owner users (users of owned pump-sets); RU, rental users (users of rented pump-sets. As per the Nepal Living Standard Survey, 2010, land size classifications are as follows. Small: 0.013–0.5 ha, medium: 0.5–2 ha, and large: 2 ha and above. It may be mentioned that only 9.27% of sample farmers fall in the large category.

Table 6. Percentage Distribution of the Surveyed Cropped Area in Terms of the Usage of Pump-sets Across Land-size Classes

Field Study Locations	Mahottari			Nawalparasi			Chitwan			Overall		
Land size	NU	OU	RU	NU	OU	RU	NU	OU	RU	NU	OU	RU
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Small	47.12	6.22	46.66	22.50	22.81	54.69	37.54	51.08	11.39	36.34	34.79	28.87
Medium	48.21	15.60	36.19	12.46	58.13	29.41	34.28	58.17	7.56	34.11	38.36	27.53
Large	34.86	35.98	29.16	6.11	81.58	12.31	18.52	80.25	1.24	15.77	68.11	16.12
Overall	44.91	19.73	35.36	10.17	66.72	23.11	33.25	58.78	7.97	28.72	47.10	24.18

Source: Field study.

Notes. NU, not used; OU, land on which owned pump-sets were used; RU, land on which rented pump-sets were used. As per the Nepal Living Standard Survey, 2010, land size classifications are as follows. Small: 0.013–0.5 ha, medium: 0.5–2 ha, and large: 2 ha and above.

Table 6 shows the extent of the rental market of pump-sets in terms of cropped area in the field study locations. On the whole, pump-sets were not used only on 28.22 per cent of the total cropped area of the surveyed households. 24.10 per cent of the cropped area was irrigated by using rented pump-sets, and the remaining 47.10 per cent was irrigated by using owned pump-sets. The percentages of cropped areas irrigated with rented pump-sets in Mahottari, Nawalparasi and Chitwan were 35.36, 23.11 and 7.97, respectively.[6] In terms of land-size classes, rented pump-sets were used on 16.12 per cent of the cropped area of the large farmers.[7] The corresponding figures for the small and medium farmers were 28.87 per cent and 27.53 per cent, respectively. It can however be observed that there were substantial variations across locations and land-size classes in terms of cropped area irrigated with rented pump-sets.

Thus, it can be concluded from the discussion on Tables 5 and 6 that the size of the rental market of pump-sets in the field study locations is of significant size. The fact that on the whole 46.52 per cent of surveyed farm households used rented pump-sets and 24.18 per cent of total cropped area was irrigated with those pump-sets testifies the considerable size of the rental market.

Factors Affecting the Purchase Decision

Results of the Logit regression presented in Table 7 show the factors that affect the decision of households to purchase the service of pump-sets in the rental market. It has been found that the households with access to government extension service and those who devote a larger share of cropped land to cultivating high yielding varieties (HYVs) are likely to purchase the services of pump-sets. The households with access to extension services may have been motivated by the extension workers to cultivate such crops which require water along with other inputs. Consequently, these households are likely to use irrigation and buy the service of pump-sets. On the other hand, since the cultivation of HYVs requires assured irrigation, it is obvious that the households devoting a larger part of cropped area to HYVs are likely to purchase the service of pump-sets. The availability of pump-sets also affects the purchase decision. Higher is the availability of pump-sets in a locality; larger is the chance of purchasing the service from the rental market in that locality. In terms of caste, it has been found that General, Dalit and Ganajati households are more likely to purchase the services of pump-sets from the rental markets relative to a Muslim household. Given the fact that the Muslim households are comparatively economically backward, this finding is not surprising. Finally, households in Mahottari and Nawalparasi are more likely to purchase the service of pump-sets as compared to a household in Chitwan. Presence of canal irrigation and wetland in Chitwan reduce the necessity of a household in this location to buy the service of pump-sets.

Table 7. Determinants of Households' Decision to Purchase the Services of Pump-sets

Variables/Constant/Statistic	Coefficients/Values
(1)	(2)
Gender of the head of the household	−0.233 (0.68)
Age of the farmer	0.0152 (0.02)
Education of the farmer	−0.0737 (0.0927)
Household size	−0.178 (0.15)
Farm size	0.795 (0.90)
Access to finance	−0.642 (0.60)
Access to government extension service	2.894** (1.16)
Tenure status	−0.793 (0.63)
Migration	−0.423 (0.68)
Area under non-grain crops	0.631 (2.24)
Area under high yielding varieties	1.480** (0.75)
Availability of pump-set	1.014* (0.592)
General	3.502*** (1.05)
Dalit	1.653* (0.95)
Janajati	3.434*** (1.13)
Terai-other caste	1.870 (1.35)
Mahottari	7.134*** (1.06)
Nawalparasi	5.624*** (1.42)
Constant	7.428*** (1.98)
Number of observations	186
Wald $chi^2(16)$	63.85
Prob. > chi^2	0
Log pseudo likelihood	−59.4365
Pseudo R^2	0.4885

Source: Authors' estimation.

Notes. Standard errors are in parentheses.
Significance levels: *** $P < .01$, ** $P < .05$, * $P < .1$.

Effect of Rental Market

It has been found that the owner and rental users have significantly higher values of the indices of cropping intensity and crop diversification relative to the non-users of pump-sets (Table 8). This finding is in conformity with Das and Bezbaruah (2017) who conducted their study in the plains of Assam. Further, in the context of our sample farmers in Nepal, it has been found that the rental users have higher cropping intensity and a more diversified crop portfolio than even those of the

owner users.[8] While the owner users cultivate rice and/or wheat, the rental users cultivate winter vegetables also besides rice and/or wheat. Winter vegetables, being short duration crops, allow the farmers to cultivate the lands more frequently.[9] Thus, in view of the above findings, it can be inferred that the rental market of pump-sets has positive impacts in terms of facilitating the intensive use of agricultural land, and also the cultivation of a diversified portfolio of crops.

Among the control variables, farm size and area under HYVs are found to have positive and significant impact on crop diversification. The positive coefficient of farm size implies that the higher is the size of operational holding, the higher is the extent of crop diversification. Further, the positive coefficient of the area

Table 8. Results of Regression for Cropping Intensity and Crop Diversification

	Coefficients/Values	
Variables/Constant/Statistics	Cropping Intensity	Crop Diversification
(1)	(2)	(3)
Own user	22.51* (12.05)	0.0887* (0.05)
Rental user	44.02*** (11.11)	0.156*** (0.05)
Farm size	−3.898 (3.62)	0.0570*** (0.02)
No of years of schooling	−0.00884 (0.77)	0.00156 (0.00)
Access to finance	−3.215 (5.56)	0.0181 (0.03)
Government extension service	0.155 (8.73)	−0.0377 (0.04)
Area under high yielding varieties	−0.157 (8.42)	0.0641* (0.04)
Labour per hectare	0.408 (0.63)	−0.000217 (0.00)
Extent of irrigation	36.19*** (5.89)	0.104*** (0.03)
General	−0.107 (13.34)	−0.0234 (0.07)
Dalit	−7.238 (13.86)	0.00440 (0.07)
Janajati	2.606 (15.41)	0.00645 (0.08)
Terai other caste	−4.163 (12.27)	0.0220 (0.07)
Mahottari	−20.88** (9.74)	0.0446 (0.04)
Nawalparasi	−24.48*** (9.15)	−0.0626 (0.04)
Constant	109.1*** (15.83)	0.196** (0.08)
Observations	273	273
Pseudo R^2	0.0388	0.8943
Prob. > *F*	0.0000	0.0000
Log pseudo likelihood	−1189.0741	−4.7963398

Source: Authors' estimation.

Notes. Robust standard errors in parentheses.

Significance levels: *** $P < .01$, ** $P < .05$, * $P < .1$.

under HYVs indicates that the households devoting larger parts of cropped land to grow such varieties can have a diversified cropping pattern. These results are as expected, and have already been reported in many studies (Bezbaruah & Roy, 2002; Goswami, 2012; Goswami & Bezbaruah, 2018; Joshi et al., 2006; Pope & Prescott, 1980). It has also been found that extent of irrigation has positive and significant effect on both cropping intensity and crop diversification. Given that irrigation enables a farmer to cultivate crops even during the winter season, this finding is obvious. Finally, it has been found that cropping intensity of farm households in Mahottari and Nawalparasi is lower than that of farmers in Chitwan. The reason for observed higher cropping intensity in Chitwan is that the households in this location can cultivate during both summer and winter seasons due to the availability of wetland.

Conclusions and Policy Implication

Using primary data, this article measures the extent of the rental market of pump-sets in the central and western parts of Nepal plains. It has been found that while 46.52 per cent of the surveyed households used rented pump-sets, 24.18 per cent of total sample cropped area was irrigated with those pump-sets. These figures suggest the presence of the rental market of a considerable size in the field study locations. On the other hand, access to government extension service, area under HYVs, availability of pump-set, caste and locational characteristics are found to be significant determinants of the decision of the households to purchase the service of pump-set. The article further analyses the effect of the rental market on cropping intensity and crop diversification. The analysis reveals that the values of the indices of cropping intensity and crop diversification are significantly higher for the rental users than not only of the non-users but also of the owner users. This finding establishes the positive impact of the rental market in facilitating the adopting of production and productivity enhancing practices, which in turn can contribute to improving the performance of the agriculture sector in the country. In view of the observed positive impacts, it is important that these rental markets are allowed to flourish. The fact that both sellers and the buyers of services, especially the small and medium farmers, benefit from the rental markets makes the case for nurturing these markets stronger. The government through its *Prime Minister Agriculture Modernisation* (PMAP) project, and the community-level institutions like farmers' organisation or field management committees may also play an important role in the spread of the rental markets. Hence, the article suggests that such kind of community-level institutions can be constituted and given the responsibility of further promoting the rental markets. Acquainted with the local agro-economic realities, community-level institutions may be in a better position to do so for their own interest.

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Notes

1. As per the agricultural census of 2011, tube well or pump-set accounts for 30 per cent of total irrigated area in Nepal.
2. This may especially be the case in absence of canal irrigation.
3. Goswami (2016, 2017) and Das and Bezbaruah (2017) explore the nature and effect of rental market of pump-sets in Assam Plains of India.
4. Though only on tractor-use, at the time of conducting the present study, Takeshima et al. (2015) was the only study available that provided information on the use of agricultural machinery based on nationally representative data.
5. Since we do not have any owner among the rental users and non-users, the possibility of the purchase decision getting affected by ownership of a pump-set that in turn may get influenced by the potentials for renting out does not arise. This also implies that we don't run into an endogeneity problem.
6. It can be observed from Tables 5 and 6 that the size of the rental market in Chitwan is smaller compared to the other two locations. There are two reasons for relatively lower penetration of the rental market in Chitwan. First, Some households in this location could access canal irrigation. Canal being a substitute of pump-sets, the penetration of the rental market of the later got restricted. Second, some households in Chitwan had wet lands, which did not require irrigation. Consequently, the percentage of non-user is more and that of rental user is less in Chitwan relative to other two locations. The same explanation applies for relatively lower proportion of area irrigated with rented pump-set in this area.
7. It appears that while the entire class of medium farmers used either owned or rented pump-set (Table 5), 15.77 per cent of the cropped area (Table 6) belonging to this category of farmers is under 'Not Used (NU)'. This apparently confusing piece of information however needs not necessarily be so. While all the medium farmers used pump-set, some of them might have left certain portions of their cropped land un-irrigated.
8. The average values of the index of cropping intensity for non-users, owner users and rental users have been found to be 140.86, 164.68 and 168.32, respectively. On the other hand, the corresponding values of the index reflecting the extent of crop diversification ($1 - H$) are 0.35, 0.53 and 0.55, respectively.
9. During the field visit, we got an impression that agriculture was the primary source of livelihood for the rental users, and hence they chose to cultivate such crops, which would fetch them better return. As Goswami (2016b), though in the context of Assam but in a similar agrarian set-up as in Nepal Plains, has shown that winter vegetables give relatively better returns within a short period of time provided assured irrigation is available. Functioning of the rental markets provides these farmers with access to irrigation. Further, the availability of controlled water supply motivates them to use other costly inputs such as chemical fertilizer, pesticides and so on. Use of these inputs reduce production risk, increases production and fetches better return, which incentivizes the farmers to cultivate winter vegetables on a commercial basis.

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Book Review

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Rumy Hasan, *Religion and Development in the Global South*. Palgrave MacMillan, 2017. xiii + 225 pp., e-book, €74.89. ISBN: 978-3-319-57063-1

What impact religious ethics and norms have left on the economic development in the Global South is the foundational enquiry of the book, authored by Hasan Rumy, who happens to be a senior lecturer working at the University of Sussex. To reflect on this query, the author has premised his discussion by linking Protestant ethical primacy on individualism with the rise of spirit of capitalism as espoused by Max Weber. Based on this linkage, a particular subsidiary question of Arthur Lewis—as to how compatible economic growth is with various kinds of religious attitude in the Global South—guides Hasan Rumy to investigate the relationship between development and religion. In addition, development is viewed in terms of UNDP's Human Development Index. The author investigates the state of development of the four religiously identical polities living in the Islamic, Hindu, Confucian and Christian worlds. He makes this exploratory journey respectively in the four chapters of the book—other than the introduction and conclusion—largely incorporating some common non-economic developmental issues such as freedom, emancipation of women and corruption.

The second chapter of the book begins with the examination of the state of development in the Muslim-dominated countries and looks into the causes that put them at the lower end of development not only in economic terms but also in terms of corruption and the advancement of women. The analysis made in this chapter is very much based on the work of Timur Kuran, to highlight the civilisational progress once made in the Arab world and the current backwardness compared to some other non-Islamic world. The author also reflects on the five pillars of Islam which include fasting in the month of Ramadan. The author shows what impact this one-month-long ritual leaves on the economy and health of the followers.

For analysing the Hindu world, the author, in the third chapter, mainly investigates the Indian polity representing 94 per cent of the Hindu population living there. Along with the religious doctrine of karma–samsara–moksha, the author analyses the socio-economic impact of the caste system on modern India and its society, offering a comparative analysis of the views of Jotirao Phule, Mahatma Gandhi, B. R. Ambedkar, Ram Manohar Lohia and E. V. Ramaswami Naicker-Periyar.

The fourth chapter of the book makes a similar doctrinal discussion mainly through the ethical lens of Protestantism and Catholicism. To analyse the Christian African states, the author resorts to Pentecostalism. In his analysis, the Christian-dominated states are broadly the better performers than other non-Christian counterparts.

On the basis of the key features such as egalitarianism and distributive justice of Confucianism, the author explains why industrial capitalism did not thrive in China and analyses state of the Chinese economy. He extends his coverage of analysis by reflecting on other South-East and East Asian countries such as Hong Kong, Taiwan, Japan, North Korea, South Korea, Singapore and Vietnam. This chapter also discusses Asian values and modernity. In all the discussions, the Weberian analysis of Confucian culture and tenets gets the main attention.

On the whole, through his analysis, to understand the state of economic development and non-economic progress in the present-day Islamic, Hindu, Christian and Confucian worlds, the author takes a strong position that culture influences human progress. It indeed confirms the existing literature that supports the idea that religious ethics are matters to be reckoned with to understand the work ethic of a polity at both individual and societal levels. Conclusion the author draws at the end offers a very compelling evidence of what he actually seeks to argue after doing a comparative analysis of the development that has so far taken place in the four different civilisational worlds as he makes a judgement that

> For Islam and Hinduism, it is almost entirely negative; for Christianity, it is a mixed picture though tending towards the negative with the proviso that aspects of Protestantism may have a positive influence. Confucianism, by contrast, given its non-dogmatic, human-centred doctrines, can realise a constructive impact.

Still the analysis offered by Rumy Hasan in his book is imbued with certain lacunae and confusion. First is the acceptance of the ideas of development, modernisation, rationality and even religion at face value in terms of the present context and thus in replication of the hegemonic understanding of them centring around development paradigms of economic growth and Human Development Index. In effect, it misses the culture variants of development that are pivotal to understand the interpretations offered by different religious communities. It could have been incorporated in the introduction—to a certain relevant extent—so as to make the readers aware of the religious interpretation of development per se going beyond the hegemonic concepts of development. Second, to be specific, all the chapters contain too many long quotations that probably makes the readers bored and lost. For a greater clarity, the author could have done more paraphrasing, adding his perspectives more in the analysis. Third, each chapter appears to be a comparative literature survey of the state of development of the countries falling in different civilisational and cultural categories founded exclusively on religious ethics and norms. For being so, it might give an impression to the readers that nothing exists beyond the religious framework of analysis to understand the underdevelopment or development of a country, and as if there was no structural evolution of global political and colonial struggle that offered advantage to the

politically advanced industrialised countries other than religious ethics and norms. It also gives an impression that culture solely exists as long as religion does, so it has nothing to do with the cultural adaptation of religion itself in terms of geographical and geological contexts. If that was the case, why all the religious minorities like Christians living in Hindu-dominated India or Hindus or Christians living in Muslim-dominated Bangladesh are not doing socially and economically better than their counterparts because of their so-called ethical and normative 'superiority'. Fourth, we must agree that Christian, Islamic, Hindu or Confucian countries—whatever religious civilisation currently they represent—had not been always the followers of the same set of religious ethics and practices given their non-linear historical struggle or evolutionary trajectories. Nor was civilisational journey automatic, fixed or God-given. Thus, the political economy of domination involving different nation-states still matters and has actually played a determining role in setting the trend towards the evolution along certain civilisational or developmental categories—whatever they are. In the same manner, legacies of colonial practices and institutions hitherto existing in the Global South are also the contributing factors to the development or underdevelopment of the four civilisational worlds. Not to mention that many great non-religious civilisations, for example, Aztec, Maya, or Inca in the Western Hemisphere or elsewhere in the world became the victims of colonisation, unleashed by the powerful 'Christian' states of Europe. It will not also be a bit different, if someone looks into the history of 'Scramble for Africa' and goes through the story of 'the Bible and the Land', once espoused by Bishop Desmond Tutu.

At the end, whatever the certain critics and weaknesses of the book, as discussed, the author must be appreciated for his contribution to growing literature on religion and development given the readers' renewed and resurgent interest in religion-based and developmental discourses in response to economic globalisation and the new political order that emerged after 9/11.

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