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Determination of Farm-Level Adaption Diversity to Cyclone and Flood: Insights from a Household-Level Survey in Eastern India

Chandra Sekhar Bahinipati

Gujarat Institute of Development Research

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Gujarat Institute of Development Research
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Abstract

The livelihoods of farmers in the eastern coastal states of India are susceptible to cyclones and floods. Farmers are known to adopt various farm-level adaptation measures to mitigate, either partially or fully, the impacts of past shocks. Previous studies have examined the factors that influence farmers' decision to undertake various not mutually exclusive options and to choose distinct options over no adaptation. However, these studies do not factor in the points of adaptation, mainly, ex-ante and ex-post, which has direct relationship with the nature and intensity of extreme events. It is also imperative to identify factors influencing farmers' decision to undertake an additional option, particularly during ex-ante and ex-post periods as this could assist policy makers to raise adoption rate of the farm-level options. Using survey data of 285 farm-households in the eastern coastal Indian state of Odisha, this study aims to assess the determinants of adaptation diversity or the number of adaptation mechanisms undertaken by the farmers, with respect to cyclones and floods. The study finds that the likelihood of undertaking adaptation diversity is high during ex-post period than ex-ante period, and the cyclone affected farmers are likely to take up higher levels of adaptation diversity than those of flood affected. Size of household, farming experience, per capita income, agriculture as major source of income and received formal crop loss compensation are found to be some of the important determinants of adaptation diversity. These findings lend support to the call for augmenting investment in scientific modeling for better prediction of extreme events, and restructuring the existing institutions to promote farm-level adaptations.

Keywords : Cyclone and Flood, farm-level mitigation, adaptation diversity, determinants, Eastern India

JEL Classification : Q12, Q15, Q54

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Determinants of Farm-Level Adaptation Diversity to Cyclone and Flood: Insights from a Farm Household Survey in Eastern India

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1. Introduction

Agriculture, a major source of income for a large number of households in India (54.6 per cent of labour force as of 2011 Census), is affected by cyclones and floods (Rao, 2010), and such impact is likely to increase in the foreseeable future (Intergovernmental Panel on Climate Change, hereafter, IPCC, 2012). An average of 3.79 million ha of crop area was damaged due to floods during 1953-2011 in the country.[1] The farm households in the eastern coastal Indian states of West Bengal, Odisha, Andhra Pradesh and Tamil Nadu have been experiencing relatively higher impacts of such extreme events. For instance, these states have come across a higher number of cyclonic storms as compared to the western coastal states of India (India Meteorological Department, hereafter, IMD, 2008). It is therefore imperative to promote farm-level adaptation options to mitigate expected crop loss due to cyclones and floods. The previous studies have observed that farmers in these states have taken measures to adapt to past climate extremes (Roy et al., 2002; Panda et al., 2013) though ability to adapt differs from farmer to farmer. Assessing the present adaptive behaviour of the farmers will have policy implications in the context of successful implementation of adaptation in the disaster prone regions of eastern India.

Recently, farmers' adaptive behaviour to climate change is analysed by various studies for Africa, Latin America, China and South Asia (Maddison, 2007; Kurukulasuriya and Mendelsohn, 2007; Nhemachena and Hassan, 2007; Seo and Mendelsohn, 2008; Hassan and Nhemachena, 2008; Gbetibouo, 2009; Deressa et al., 2009 and 2011; Bryan et al., 2009;

Chandra Sekhar Bahinipati (chandrasekharbahinipati@gmail.com) is Assistant Professor at Gujarat Institute of Development Research, Ahmedabad.

[1] These information have been gathered from *State wise Flood Damage Statistics* provided by Central Water Commission, Government of India, New Delhi, Vide Letter No. 3/38/2011-FFM/2200-2291 dated: 27th November 2012.

Deressa, 2010; Wang et al., 2010; Hisali et al., 2011; Di Falco et al., 2011 and 2012; Panda et al., 2013; Piya et al., 2013; Gebrehiwot and van der Veen, 2013; Wood et al., 2014). These studies examine factors influencing farmers' decision to adapt (Maddison, 2007; Bryan et al., 2009; Deressa et al., 2011; Di Falco et al., 2011 and 2012), to undertake various not mutually exclusive options (Nhemachena and Hassan, 2007; Piya et al., 2013; Panda et al., 2013) and to choose options (either mutually exclusive or inclusive) over no adaptation (Kurukulasuriya and Mendelsohn, 2007; Seo and Mendelsohn, 2008; Hassan and Nhemachena, 2008; Gbetibouo, 2009; Deressa et al., 2009; Wang et al., 2010; Hisali et al., 2011; Gebrehiwot and van der Veen, 2013). Findings of these studies are relevant for promoting specific adaptations. During a production season, the decision to adopt an option is decided at different points depending on the nature and intensity of extreme events. While some options are undertaken during ex-ante period (i.e., pro-active adaptation measures), others are adopted during ex-post period (i.e., reactive adaptation mechanisms). In view of this it is also imperative to identify factors influencing farmers' decision to undertake an additional option not only during a production season but also during ex-ante and ex-post periods. Unlike the previous studies, this could assist the policy makers to enhance any farm-level options. Therefore, the present study aims to assess determinants of adaptation diversity (i.e., a number of adaptation mechanisms undertaken by the farm households). For empirical assessment, a farm household-level survey was conducted in the cyclone and flood prone villages in the state of Odisha, located at the eastern coastal part of India and susceptible to both cyclones and floods (Bhatta, 1997; Chittibabu et al., 2004; Government of Odisha, hereafter, Government of Orissa, 2004 and 2011; Patnaik et al., 2013).

2. Farm-level Adaptation Diversity to Cyclone and Flood

Based on the cross-sectional survey data collected from 285 farm households during 2010/2011 production season, this section describes farm-level adaptation diversity to cyclone and flood. Detailed description on the sampling technique is given in Section 4.

During the household-level survey, the respondents were asked to report the farm-level adaptation measures which they have undertaken to reduce impacts of the previous cyclones and floods. The surveyed farmers have reported various adaptations undertaken at the farm-level. In particular, seven farm-level measures practiced widely in the study area were selected for empirical analysis. As per the farmers' perception, these measures are improving their livelihood, but the empirical estimation is beyond the scope of this study. The selected options are, using salt and flood tolerant indigenous/ traditional paddy seeds, adoption of soil conservation techniques[2], mixed paddy cropping, crop-diversification, land holiday[3], increasing frequency of seedling preparation and re-planting[4], and pest and disease management. Through the field survey, it is observed that the options like salt and flood tolerant indigenous/traditional paddy seeds, soil conservation techniques, mixed paddy cropping, crop-diversification and land holiday are undertaken during ex-ante period, i.e., before the cyclone and flood occurred. Measures like land holiday, re-cultivation of seedling and re-planting, and pest and disease management are adopted during ex-post period, i.e., after the occurrence of cyclone and flood. A major proportion of farmers are taking up at least one of the adaptation options (i.e., 95.09 per cent of the farmers adopted at least one option out of seven), and nearly 75 per cent of farm households adopted at least four adaptation strategies (Table 1).

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[2] Includes activities like reducing salinity level of soil through using 'gypsum' and more tillage operation, and enhancing height of field bund to protect intrusion of salt water and also to reduce soil erosion (Roy et al., 2002).

[3] Farmers in general keep their susceptible land as barren to avoid expected loss due to cyclones and floods.

[4] While paddy crop gets damaged due to cyclone and flood, the farmers resort to seedling preparation and re-planting based on the stage of crop growth. In the earlier stage (i.e. germination and transplanting), farmers go for re-cultivation of seedling. They purchase seedlings from farmers in the neighbouring villages for re-panting in the case of middle stage (i.e. tillering and panicle stages). They leave their land barren in case the crop has reached maturity stage (i.e. milk stage, dough stage and mature grain stage – harvesting stage).

Table 1: Farm-level Adaptation Diversity undertaken by Farm Households

No. of farm-level adaptation measures	No. of farm households
0	14 (4.91)
1	7 (2.46)
2	21 (7.37)
3	30 (10.53)
4	80 (28.07)
5	80 (28.07)
6	44 (15.44)
7	9 (3.16)
Total	285 (100.00)

Source: Computed from primary data.
Note: Figures in parentheses indicate percentages.

3. Empirical Model

The response variable (i.e., number of options undertaken by the farm households) is an ordered data, and hence, an ordered discrete choice model is used in the present study. It is generated by a continuous unobserved latent variable, which, on crossing a threshold, leads to an increase in the observed number of adaptations. Here, the threshold represents the farm households' decision to adopt or not to adopt an additional option (see Nagarajan et al., 2005). Ordered probit model is often applied to a context where an individual or a household chooses among the ordered response outcome, and such a model is widely applied in the crop diversity literature (e.g., Ndjeunga and Nelson, 2005; Nagarajan et al., 2005). As described in Wooldridge (2002), and Cameron and Trivedi (2005), the ordered probit model is based on latent regression and denoted as,

$$y_h^* = \mathrm{x}_h\beta + e, \quad e \mid \mathrm{x} \sim \text{Normal } (0,1) \cdots\cdots (1)$$

Where y_h^* represents latent and continuous measure of adaptation strategy by a farm household h, x_h is a vector of explanatory variables, β is a vector of parameters to be estimated, and e describes a random error term, which follows a normal distribution.

Here, y_h^* is unobservable but we do have an observed choice, and y_h^* is determined from the model as follows:

$$y_h = 0 \quad if \; y_h^* \le \alpha_0 \; (\text{Zero adaptation measure})$$
$$y_h = 1 \quad if \; \alpha_0 < y_h^* \le \alpha_1 \; (\text{One adaptation measure})$$
$$y_h = 2 \quad if \; \alpha_1 < y_h^* \le \alpha_2 \; (\text{Two adaptation measures})$$
$$\cdots\cdots\cdots$$
$$y_h = n \quad if \; \alpha_{n-1} \le y_h^* \; (\text{'n' adaptation measures}) \cdots\cdots (2)$$

The parameter α represents thresholds or cut off points, which can be estimated along with the parameter β. Given the standard normal assumption for e, we can derive the conditional distribution of y given x:

$$\text{Prob}(y_h = 0 \mid \text{x}) = \text{Prob}(y_h^* \le \alpha_0 \mid \text{x}) = \text{Prob}(\text{x}\beta + e \le \alpha_0 \mid \text{x}) = \Phi(\alpha_0 - \text{x}\beta)$$
$$\text{Prob}(y_h = 1 \mid \text{x}) = \text{Prob}(\alpha_0 < y_h^* \le \alpha_1 \mid \text{x}) = \Phi(\alpha_1 - \text{x}\beta) - \Phi(\alpha_0 - \text{x}\beta)$$
$$\text{Prob}(y_h = 2 \mid \text{x}) = \text{Prob}(\alpha_1 < y_h^* \le \alpha_2 \mid \text{x}) = \Phi(\alpha_2 - \text{x}\beta) - \Phi(\alpha_1 - \text{x}\beta)$$
$$\cdots\cdots\cdots$$
$$\text{Prob}(y_h = n \mid \text{x}) = \text{Prob}(\alpha_{n-1} < y_h^* \mid \text{x}) = 1 - \Phi(\alpha_{n-1} - \text{x}\beta) \cdots\cdots (3)$$

Where $\Phi(\cdot)$ is the cumulative standard normal distribution. The sign of the estimated parameter β can be directly interpreted because of the increasing nature of the ordered classes: a positive β indicates more adaptation diversity as the value of associated variable increases, while negative signs suggest the opposite. The ordered probit model can be estimated using maximum likelihood (ML). The log likelihood function is numerically maximised subject to $\alpha_0 < \alpha_1 < \alpha_2 < \alpha_3 < \ldots\ldots < \alpha_{n-1}$. The maximum likelihood estimates β and α are consistent and asymptotically efficient and, accordingly, it is assumed that the error term also follows a normal distribution. Further, to interpret the effects of explanatory variables on the probabilities, the marginal effects $\Pr(y_h = j \mid x_h)$ are derived as (Wooldridge, 2002):

$$\frac{\partial \Pr(y_h = j, \; j = 1, 2, \ldots\ldots, n)}{\partial x_h} = \left\{ \phi(\alpha_{j-1} - x_h\beta) - \phi(\alpha_j - x_h\beta) \right\} \beta \; \ldots\ldots (4)$$

The cross sectional econometric analysis is associated with the problem of multicollinearity and heteroskedasticity. A variance inflation factor (VIF) for each of the explanatory variable was estimated to check multicollinearity, and a robust standard error was calculated to address the possibility of heteroskedasticity (ibid.). The mean of VIF value for all the independent variables is 2.45 which is below 10 (i.e., in between 1.14 to 6.82), suggesting no problem of multicollinearity. The information was gathered at the household-level and not at plot-level, and the results of this estimation should be interpreted under this caveat.

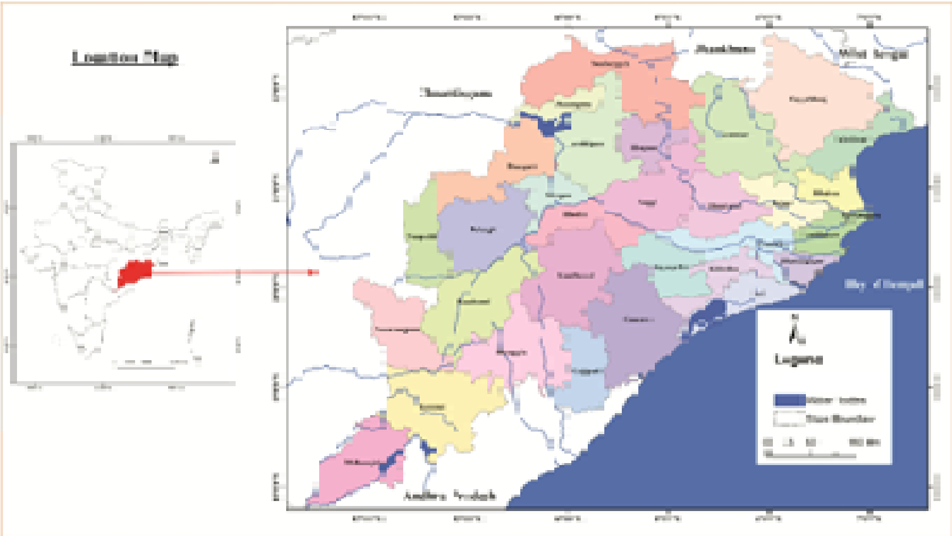
4. Study Area, Data and Empirical Specification of Model Variables

Among the eastern coastal states of India, the state of Odisha has a coastal stretch of around 480 km, and is surrounded by a number of perennial rivers, e.g. *Mahanadi*, *Brahmani*, *Baitarani*, *Rushikulya*, *Birupa*, *Budhabalanga* and *Subarnarekha* and their tributaries (Figure 1). This makes the state prone to both cyclones and floods. Over the two centuries spanning 1804-2010, the outbreaks of cyclones and floods were reported in the state for 126 years (Bhatta, 1997; Chittibabu et al., 2004; Government of Orissa, 2004 and 2011). The occurrence of floods had been reported for nine consecutive years during 2001-2010 (Government of Orissa, 2004 and 2011). It is also observed that the frequency and intensity of these events has increased over the years (Mohanty et al., 2008; Pasupalak, 2010; Guhathakurta et al., 2012) and is likely to increase in the years to come (Unnikrishnan et al., 2011). The reported economic loss due to natural hazards was around Rs. 1,050 million during 1970s, which increased to Rs 6,817.5 million, Rs 70,806.35 million and Rs 1,19,155.3 million during the 1980s, 1990s and 2000s, respectively (Government of Orissa, 2004 and 2011). Further, an average of 0.33 million ha agricultural land got damaged in the state due to flood during 1953-2011 creating an economic loss of Rs. 316.2 million per year (Government of Orissa, 2013a). The occurrence of unseasonal cyclonic rainfall in 2010 caused major crop loss across 24 districts in Odisha, the value of which was estimated to be around Rs 60,000 million (Government of Orissa, 2011), while the flood in September 2011 caused damages worth Rs 326.6 million (Samal, 2011). Further, the occurrence of very severe cyclonic storm *'Phailin'* in 2013 caused crop loss across 18 districts worth Rs 23,000 million, and loss to houses, crops and public properties worth Rs 1,43,734.7 million (Government of Orissa, 2013b).

In this study, three cyclone and flood prone districts, namely, Balasore, Kendrapada and Jajpur (Mohapatra et al., 2012; Patnaik et al., 2013), were selected to conduct household-level surveys. These three districts witnessed at least 20 cyclonic storms and floods during 1994-2008. Among the three, Balasore experienced a higher number of these events, i.e., 29 times (see Appendices 1 through 3). While the entire area of Balasore and Kendrapada is prone to cyclonic storms, 46.3 per cent and 35.5 per cent respectively of the total area in Balasore and Kendrapada are prone to flood (BMTPC, 2006). During 1994-2008, an average of 0.95 million people were affected and 0.07 million ha land damaged in Balasore, 0.82 million people were affected and 0.05 million ha land damaged in Kendrapada, and 0.63 million people were affected and 0.05 million ha land damaged in Jajpur due to cyclones and floods (see Appendices 1 through 3).

The farm household-level survey was conducted in the randomly selected seven disaster prone villages - Dagara, Kudmansingh, Bhateni, Suniti, Rajapur, Fulupur and Bandhapada - in the three districts during November 2010 to March 2011 (see Figure 1). The study villages were selected based on two criteria: (i) distance from sea and river, and (ii) high dependency on agriculture. Among the selected villages, five villages (e.g., Dagara, Kudmansingh, Rajapur, Fulupur and Bandhapada) are affected by both cyclone and flood, and the remaining two villages are affected by only cyclone. Except for Rajapur village (i.e., around 60 per cent of the total labour force), around 80 per cent of the total labour force is dependent on agriculture as of Census 2001. In order to cover households representing different categories of land ownership, a two-stage stratified random sampling method was used to select farm households from the villages. Firstly, all the households at village-level were stratified into five categories on the basis of land ownership: landless (0 ha), marginal (< 1 ha), small (1-2 ha), medium (2-10 ha) and large (> 10 ha). Secondly, with following a simple random sampling method 10 per cent of the farm households was drawn in proportion to the total households within each stratum. In total, 285 farm households were interviewed; out of them, 160 households (56.14 per cent) belonged to the villages affected by both cyclones and floods, and the remaining 125 households (43.86 per cent) were from villages affected by only cyclones. Based on the socio-economic characteristics, it is observed that farm households in the former areas are better off in comparison to the latter (see Appendix 4). A structured questionnaire was developed to collect information on households, and also climate shocks and farm-level adaptation strategies used by farm households to cope with cyclones and floods.

Figure 1: Map of the Study Region



Since the present analysis aims to identify determinants of adaptation diversity in a production season, and ex-ante and ex-post periods, three dependent variables were considered in the empirical estimation; these are non-negative ordered data. While an average of four options are adopted by the farm households during a production season, three measures are undertaken during ex-ante period and two measures are followed during ex-post period. The choice of explanatory variables was based on the review of previous studies (Nhemachena and Hassan, 2007; Hassan and Nhemachena, 2008; Di Falco et al., 2011 and 2012; Panda et al., 2013) and field experience. The explanatory variables include socio-economic characteristics of household/ household head (HH), access to formal and informal institutions, nature of cyclone and flood, and unobserved district-level heterogeneity characteristics. Table 2 presents the description of the independent variables. The hypothesis on how the explanatory variables influence farm-level adaptation diversity to cyclone and flood are presented below.

The analysis included variables like intensity of crop damaged due to past cyclones and floods, i.e., highly, moderately and less[5], to account the influence of these events on farm households' adaptive behaviour. This helps to

[5] Less affected means crop damaged less than half of the times of occurrence of cyclones and floods during last decade, moderately affected implies crop damaged around half of the times, and highly affected means crop damaged more than half of the times.

examine whether a household affected by cyclones and/ or floods in the past is opting for more adaptation diversity at present. Household and HH characteristics are captured by variables like size of household, years of education of HH, years of farming experience of HH, agriculture as major source of income and per capita income. Based on previous studies (e.g., Hassan and Nhemachena, 2008; Bryan et al., 2009; Gbetibouo, 2009; Di Falco et al., 2011), a positive relationship is expected between size of household and adaptation diversity. The influence of size of household is viewed from two ways: (i) the adult members of a large household size could opt off-farm activities to reduce variability of income, and (ii) the availability of labour endowment could motivate households to undertake more number of adaptations, especially labour intensive (Deressa, 2010). Previous studies found a positive correlation between the level of education of HH and adaptation (Maddison, 2007; Deressa et al., 2009) because an educated farmer is more likely to access information on improved technology as well as agronomic and agro-climatic aspects. This study posits a positive relationship between years of education by HH and number of adaptation mechanisms chosen.

The experienced farmers are likely to notice impacts of climate variability (Maddison, 2007) and climate induced extreme events. Hence the present analysis expects that they could have undertaken more number of adaptations. This relationship is also supported by various studies (Hassan Nhemachena, 2008; Bryan et al., 2009; Gbetibouo, 2009; Panda et al., 2013). It is observed from the field that a highly agriculture-dependent household is likely to undertake more number of options to smooth consumption. Since adaptation requires sufficient financial wealth (Franzel, 1999; Hassan and Nhemachena, 2008; Panda et al., 2013), rich farmers are expected to adopt more number of farm-level options.

The factors representing formal and informal institutions are access to agricultural extension, formal/informal credit, MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Scheme), received crop loss compensation, and received remittances. Extension assists the farmers to avail information about new technology, salt and flood tolerant seeds, availability of subsidised seeds immediately after the cyclone and flood, and agronomic aspects in rural Odisha. The present analysis, therefore, hypothesises that access to extension increases adoption of a higher number of farm-level options. In addition, a number of studies underline the fact that access to formal credit and compensation on crop loss positively influenced adoption behaviour of the farmer (Jodha, 1981; Nhemachena and Hassan, 2007; Hassan and Nhemachena, 2008; Deressa et al., 2009; Bryan et al., 2009). While the former directly motivates farmers' adaptation decision through pooling resources into agricultural system, the later has an indirect bearing on their adaptive behaviour as this assists them in smoothening consumption (Jodha, 1981). The present analysis, therefore, anticipates a positive impact of both the variables on farmers' decision on adaptation diversity.

Table 2: Description of the Independent Variables

Dependent Variables	Mean	SD	Description
Number of farm-level adaptation measures	4.16	1.61	Categorical
Number of farm-level adaptation measures during pre-cultivation	2.67	1.16	Categorical
Number of farm-level adaptation measures during cultivation	2.2	0.97	Categorical
Explanatory Variables			
Highly affected by cyclones	0.48	0.50	Binary (Yes, no)
Moderately affected by cyclones	0.17	0.37	Binary (Yes, no)
Less affected by cyclones	0.20	0.40	Binary (Yes, no)
Highly affected by floods	0.26	0.44	Binary (Yes, no)
Moderately affected by floods	0.02	0.13	Binary (Yes, no)
Less affected by floods	0.09	0.29	Binary (Yes, no)
Size of household	5.89	2.52	Numerical
Years of education of HH	1.57	2.70	Numerical
Years of farming experience of HH	24.04	13.16	Numerical
Log (Per capita income)	3.74	0.18	Continuous
Agriculture as major source of income	0.71	0.46	Binary (Yes, no)
Formal agricultural extension	0.17	0.38	Binary (Yes, no)
Formal credit	0.38	0.49	Binary (Yes, no)
Access to MGNREGS	0.48	0.50	Binary (Yes, no)
Received crop loss compensation	0.60	0.49	Binary (Yes, no)
Informal credit	0.84	0.37	Binary (Yes, no)
Remittances received	0.67	0.47	Binary (Yes, no)
Balasore district	0.35	0.48	Binary (Yes, no)
Kendrapada district	0.46	0.50	Binary (Yes, no)
Jajpur district	0.19	0.39	Binary (Yes, no)

Source: Computed from primary data.

Previous studies find that access to MGNREGS reduces the vulnerability level of rural households to climate change (Tiwari et al., 2011; Esteves et al., 2013), not only by working as a safety net through increasing overall income but also by enhancing the likelihood of adopting various options through constructing rural development projects, e.g., watersheds, flood embankment and sea dyke etc. (Tiwari et al., 2011; Esteves et al., 2013). It may be noted that around 1483 projects on flood control and protection from cyclonic storms were completed under MGNREGS during 2006-13 in Odisha[6]. The existing studies suggest that the informal institutions play a major role in smoothing both income and consumption (Bryan et al., 2009), particularly in the rural areas of the developing nations where there is an imperfect formal insurance (Morduch, 1999; Dercon, 2002). The variables capturing the role of informal institution, such as access to informal credit and received remittance, are likely to have a positive impact on farmers' decision on adaptation diversity. We have included dummy variables for two study districts, i.e., Balasore, and Jajpur. These variables are capturing some of the variation in undertaking adaptation measures arising from district-level unobserved heterogeneity.

5. Results and Discussion

The results of the ordered probit models are presented in Tables 3 through 5. While Table 3 reports determinants of farm-level adaptation diversity during a production season, Tables 4 and 5 show determinants of farm-level adaptation diversity during ex-ante and ex-post periods, respectively. According to Wooldridge (2002), the threshold coefficients or α_is should exhibit the following relationship: $\alpha_0 < \alpha_1 < \alpha_2 < \alpha_3 < \ldots\ldots < \alpha_{n-1}$, and must be positive. In the present models, all the threshold coefficients satisfy this condition and are also positive. This implies that there is no specification error in the present models. The Wald χ^2 values of these models are statistically significant at 0.1 per cent level. The following section summarises the results.

5.1 Intensity of Cyclones and Floods

It is observed that the coefficients of variables capturing intensity of cyclone (highly, moderately and less) are positive in all the models. This means that the farm households experiencing cyclones are likely to choose a higher

[6] Information was collected from MGNREGS webpage.

level of adaptation diversity not only during a production season but also during both ex-ante and ex-post periods. As expected, the farmers who are highly affected by cyclones are probably taking up more number of adaptations than the rest (i.e. moderate and low affected farmers). For example, the probability of adopting five and six adaptation measures during a production season increases by 20.9 per cent and 20.6 per cent, respectively if a farm household is highly affected by cyclone. These figures are 10.5 per cent and 15.8 per cent in the case of moderately cyclone affected, and are insignificant for less cyclone affected farmers (Table 3).

While only the highly cyclone affected variable is significant in the case of ex-ante period, all the intensity variables are significant during ex-post period. This suggests that the cyclone affected farmers are likely to maintain more adaptation diversity during ex-post period as compared to the ex-ante period. For instance, there is a 17.3 per cent and 2.7 per cent chance that a highly cyclone affected farmer adopts four and five options during ex-ante period (Table 4). The same farmer has 51.7 per cent probability of choosing three options during ex-post period (Table 5). Likewise, the highly flood affected farmers are likely to adopt a high number of options, especially during the ex-post period than that of ex-ante period. A highly flood affected farmer, for example, has 27.7 per cent chance to adopt three measures during ex-post period, while the same farmer has 4.9 per cent chance of opting three options during ex-ante period. This reveals that both the cyclone and flood affected farmers are more likely to undertake a higher number of options during ex-post period as compared to the ex-ante period. The farmers might not show any interest to invest on adaptation options during ex-ante period due to uncertainty of occurrence of cyclones and floods. But, the farmers are taking up more adaptation diversity once their crop is damaged due to cyclones and floods to smoothen their consumption.

This finding underlines the importance of investing in effective forecasting and warning systems for better prediction of the occurrence of cyclonic storms and floods, so that farmers could undertake better adaptation decision to mitigate expected crop loss. For instance, Patt et al. (2005) find that seasonal climate forecast information significantly improved harvest decision (e.g., time of planting and planting different varieties of crops) of subsistence farmers in Zimbabwe. Likewise, Wood et al. (2014) find that access to weather information has positively influenced the probability of adopting various options across different regions of Africa and South Asia. None of the farmers in the present study sample has accessed agro-climatic information.

Among the cyclone and flood affected farmers, it is observed that the cyclone affected farm households are more likely to take up higher levels of adaptation diversity in all the models. For instance, a highly cyclone affected farmer has 20.9 per cent probability of adopting five options in the production season, whereas the probability is 10.2 per cent if the farm household is highly affected by flood (Table 3). Similarly, there is 51.7 per cent chance of undertaking more adaptation diversity if a farmer is highly affected by cyclone during ex-post period, whereas it is 27.7 per cent if a household is highly flood affected. It is a priori expected that farmers in the cyclone and flood affected regions are likely to undertake more adaptation diversity as they are socio-economically and financially better off than farmers of the cyclone affected region (see Appendix 4). This can be attributed to the lack of adaptation mechanisms available to the flood-affected farmers to reduce possible loss due to flooding.

5.2 Household Characteristics

In the three models, the coefficients of four variables, namely, size of household, farming experience of the household head (HH), log of per capita income and agriculture as major source of income, are expected to positively influence farm households' decision on adaptation diversity.

Table 3: Determinants of Farm-level Adaptation Diversity during a Production Season

Variables	Coefficients	Marginal effects							
		Pr(Y=0|X)	Pr(Y=1|X)	Pr(Y=2|X)	Pr(Y=3|X)	Pr(Y=4|X)	Pr(Y=5|X)	Pr(Y=6|X)	Pr(Y=7|X)
Intensity of Cyclone and Flood									
Highly affected by cyclones	1.19*** (0.354)	-0.043* (0.023)	-0.028** (0.014)	-0.097*** (0.035)	-0.135*** (0.039)	-0.143*** (0.037)	0.209*** (0.052)	0.206*** (0.064)	0.031* (0.017)
Moderately affected by cyclones	0.749** (0.343)	-0.014** (0.007)	-0.012** (0.006)	-0.047** (0.019)	-0.081** (0.032)	-0.137** (0.071)	0.105*** (0.028)	0.158* (0.085)	0.027 (0.023)
Less affected by cyclones	0.366 (0.336)	-0.009 (0.008)	-0.007 (0.006)	-0.027 (0.023)	-0.043 (0.038)	-0.058 (0.060)	0.067 (0.053)	0.069 (0.070)	0.009 (0.011)
Highly affected by floods	0.601 (0.392)	-0.014 (0.010)	-0.011** (0.007)	-0.043* (0.026)	-0.069* (0.041)	-0.099 (0.072)	0.102** (0.052)	0.117 (0.085)	0.017 (0.017)
Moderately affected by floods	-0.178 (0.874)	0.007 (0.039)	0.005 (0.026)	0.017 (0.088)	0.023 (0.113)	0.019 (0.067)	-0.039 (0.202)	-0.027 (0.121)	-0.003 (0.010)
Less affected by floods	0.634** (0.249)	-0.011** (0.005)	-0.009** (0.004)	-0.039*** (0.013)	-0.068*** (0.024)	-0.119** (0.056)	0.088*** (0.022)	0.135** (0.062)	0.023 (0.018)
Household/ Household Head Characteristics									
Size of Household	0.093*** (0.033)	-0.003** (0.001)	-0.002* (0.001)	-0.008** (0.003)	-0.012*** (0.004)	-0.012** (0.005)	0.019*** (0.007)	0.016*** (0.006)	0.002* (0.001)
Years of education of HH	0.019 (0.025)	-0.001 (0.001)	-0.0004 (0.001)	-0.002 (0.002)	-0.002 (0.003)	-0.003 (0.003)	0.004 (0.005)	0.003 (0.004)	0.0004 (0.0005)
Farming experience years of HH	0.011* (0.006)	-0.001* (0.001)	-0.0002* (0.0002)	-0.001** (0.0005)	-0.001** (0.001)	-0.002* (0.001)	0.002** (0.001)	0.002** (0.001)	0.0002* (0.0001)
Log(Per capita income)	1.288*** (0.436)	-0.039** (0.019)	-0.029** (0.015)	-0.109*** (0.042)	-0.161*** (0.061)	-0.170*** (0.066)	0.267*** (0.097)	0.219*** (0.078)	0.024* (0.013)
Agriculture as major source of income	0.325** (0.148)	-0.012 (0.008)	-0.008* (0.005)	-0.030* (0.016)	-0.041** (0.019)	-0.036** (0.015)	0.070** (0.034)	0.051** (0.022)	0.005* (0.003)
Formal and Informal Institutions									
Formal agricultural extension	-0.067 (0.151)	0.002 (0.005)	0.002 (0.004)	0.006 (0.013)	0.008 (0.019)	0.008 (0.018)	-0.014 (0.032)	-0.011 (0.025)	-0.001 (0.003)
Formal credit	0.192 (0.158)	-0.006 (0.005)	-0.004 (0.004)	-0.016 (0.013)	-0.024 (0.020)	-0.027 (0.024)	0.039 (0.031)	0.034 (0.029)	0.004 (0.004)

Access to MGNREGS	0.032 (0.140)	-0.001 (0.004)	-0.001 (0.003)	-0.003 (0.012)	-0.004 (0.018)	-0.004 (0.019)	0.007 (0.029)	0.005 (0.024)	0.001 (0.003)
Received crop loss compensation	0.663*** (0.158)	-0.025** (0.012)	-0.017** (0.008)	-0.060*** (0.019)	-0.082*** (0.023)	-0.071*** (0.019)	0.138*** (0.036)	0.105*** (0.026)	0.012** (0.006)
Informal credit	0.009 (0.203)	-0.0003 (0.006)	-0.0002 (0.005)	-0.001 (0.017)	-0.001 (0.026)	-0.001 (0.026)	0.002 (0.042)	0.002 (0.034)	0.0001 (0.004)
Received remittances	0.083 (0.151)	-0.003 (0.005)	-0.002 (0.004)	-0.007 (0.013)	-0.010 (0.019)	-0.011 (0.019)	0.017 (0.032)	0.014 (0.025)	0.002 (0.003)
Location Characteristics[a]									
Balasore	-1.007*** (0.282)	0.485* (0.025)	0.030** (0.015)	0.097*** (0.035)	0.119*** (0.033)	0.077*** (0.024)	-0.209*** (0.058)	-0.146*** (0.038)	-0.016** (0.008)
Jajpur	0.138 (0.471)	-0.004 (0.011)	-0.003 (0.009)	-0.011 (0.036)	-0.017 (0.057)	-0.020 (0.074)	0.027 (0.089)	0.024 (0.087)	0.003 (0.011)
Equation statistics									
No. of observation	285								
Wald χ^2 (19)	176.58								
Prob. > χ^2	0.0000								
Pseudo R^2	0.158								
Log likelihood ratio	-426.991								
α_0	4.821								
α_1	5.082								
α_2	5.632								
α_3	6.177								
α_4	7.222								
α_5	8.314								
α_6	9.563								

Source: Computed from primary data.

Note: Figures in the parentheses are robust standard error; a – the omitted district is Kendrapada; *** p<0.01, ** p<0.05 and * p<0.1 respectively.

Table 4: Determinants of Farm-level Adaptation Diversity during Ex-ante Period

Variables	Coefficients	Marginal effects					
		Pr(Y=0|X)	Pr(Y=1|X)	Pr(Y=2|X)	Pr(Y=3|X)	Pr(Y=4|X)	Pr(Y=5|X)
Intensity of Cyclone and Flood							
Highly affected by cyclones	0.799** (0.347)	-0.037* (0.023)	-0.057** (0.029)	-0.206*** (0.080)	0.010** (0.044)	0.173** (0.074)	0.027* (0.017)
Moderately affected by cyclones	0.442 (0.336)	-0.015 (0.010)	-0.026 (0.018)	-0.121 (0.090)	0.037** (0.017)	0.106 (0.086)	0.019 (0.020)
Less affected by cyclones	0.182 (0.333)	-0.007 (0.013)	-0.012 (0.021)	-0.050 (0.091)	0.022 (0.035)	0.041 (0.078)	0.006 (0.013)
Highly affected by floods	0.547 (0.391)	-0.019 (0.014)	-0.033 (0.022)	-0.148 (0.102)	0.049** (0.022)	0.129 (0.097)	0.023 (0.023)
Moderately affected by floods	0.759 (0.906)	-0.016* (0.009)	-0.033 (0.021)	-0.197 (0.196)	-0.001 (0.132)	0.196 (0.239)	0.051 (0.114)
Less affected by floods	1.339*** (0.249)	-0.023*** (0.008)	-0.047*** (0.013)	-0.307*** (0.044)	-0.081 (0.058)	0.323*** (0.052)	0.135** (0.056)
Household / Household Head Characteristics							
Size of Household	0.060* (0.032)	-0.003 (0.002)	-0.004* (0.003)	-0.016* (0.009)	0.008* (0.005)	0.013* (0.007)	0.002 (0.001)
Years of education of HH	0.032 (0.030)	-0.001 (0.001)	-0.002 (0.002)	-0.009 (0.008)	0.004 (0.004)	0.007 (0.007)	0.001 (0.001)
Farming experience years of HH	0.015** (0.006)	-0.001** (0.0003)	-0.001** (0.001)	-0.004** (0.002)	0.002** (0.001)	0.003** (0.001)	0.0004** (0.0002)
Log(Per capita income)	0.447 (0.439)	-0.020 (0.020)	-0.032 (0.033)	-0.121 (0.119)	0.063 (0.062)	0.097 (0.096)	0.013 (0.014)
Agriculture as major source of income	0.231 (0.152)	-0.011 (0.009)	-0.017* (0.013)	-0.061 (0.040)	0.036 (0.027)	0.048 (0.031)	0.007 (0.006)
Formal and Informal Financial Institutions							
Formal agricultural extension	-0.143 (0.154)	0.007 (0.008)	0.011 (0.012)	0.038 (0.041)	-0.022 (0.026)	-0.030 (0.031)	-0.004 (0.004)
Formal credit	0.218 (0.168)	-0.009 (0.007)	-0.015 (0.011)	-0.059 (0.046)	0.028 (0.021)	0.048 (0.038)	0.007 (0.006)

Access to MGNREGS	-0.048 (0.142)	0.002 (0.006)	0.003 (0.010)	0.013 (0.038)	-0.007 (0.019)	-0.011 (0.031)	-0.001 (0.004)
Received crop loss compensation	0.720*** (0.173)	-0.039** (0.017)	-0.057*** (0.018)	-0.182*** (0.042)	0.111*** (0.035)	0.146*** (0.034)	0.020** (0.008)
Informal credit	-0.072 (0.210)	0.003 (0.008)	0.005 (0.014)	0.020 (0.058)	-0.009 (0.026)	-0.016 (0.047)	-0.002 (0.007)
Received remittances	0.036 (0.153)	-0.001 (0.007)	-0.003 (0.011)	-0.009 (0.041)	0.005 (0.022)	0.008 (0.033)	0.001 (0.004)
Location characteristics[a]							
Balasore	-1.053*** (0.299)	0.071** (0.034)	0.089*** (0.033)	0.240*** (0.056)	-0.176*** (0.059)	-0.197*** (0.049)	-0.027** (0.011)
Jajpur	0.376 (0.509)	-0.013 (0.013)	-0.023 (0.027)	-0.103 (0.139)	0.036 (0.026)	0.089 (0.128)	0.015 (0.026)
Equation statistics							
No. of observation	285						
Wald χ^2 (19)	157.80						
Prob. > χ^2	0.0000						
Pseudo R^2	0.173						
Log likelihood ratio	-358.697						
α_0	1.388						
α_1	1.918						
α_2	3.238						
α_3	4.471						
α_4	5.773						

Source: Computed from primary data.
Note: Figures in the parentheses are robust standard error; a – the omitted district is Kendrapada; *** p<0.01, ** p<0.05 and * p<0.1 respectively

Large farm households are likely to take on more adaptation diversity than households with smaller size. The analysis indicated that each additional member in the household increases the probability of adopting five adaptation measures by 1.9 per cent, and six adaptation options by 1.6 per cent during a production season (Table 3). During ex-ante period, addition of each member enhances adoption of four options by 1.3 per cent (Table 4) and of three options by, it is 6.3 per cent (Table 5). This is due to two reasons: (i) requirement of more manpower to undertake labour intensive adaptation options, especially during ex-post period (i.e. re-cultivation of seedling and re-planting), (ii) engagement of young adult members for off-farm activities that enhances households' income and ultimately increases adaptation diversity. Though the farmers in disaster prone regions of Odisha have the option to hire labour to adopt labour intensive adaptations, they are not able to undertake this method most of the times due to the shortage of labour as well as high wage rate during peak seasons. Due to continuous distress situation, rural farmers could have migrated[7] and there could be shortage of labour force in rural Odisha. In line with this, Bryan et al. (2009), Deressa (2010) and Di Falco et al. (2011) also find a positive impact of size of household on farmers' adaptive behaviour. Farmers with higher experience maintained higher levels of adaptation diversity. An additional year of farming experience, for instance, increases the probability of adopting five or six adaptation measures by 0.2 per cent during a production season (Table 3). Since the experienced are usually considered as leaders and also progressive farmers among the rural farming communities, they can be targeted for promoting adaptation options to lead other farm households (Nhemachena and Hassan, 2007).

Log of per capita income is also found as a major determinant of enhancing adaptation diversity. It is a priori expected that finance is required to undertake adaptations. This increases the probability of adopting five and six adaptation measures by 26.7 per cent and 21.9 per cent, respectively during a production season (Table 3). The coefficient of income variable was found significant in the case of ex-post period implying that high level of income enhances the probability of undertaking three options by 77.1 per cent during ex-post

[7] For example, in a study village in India Prasad and Rao (1997) find that 70 per cent of total households have seasonally migrated over a period of 20 to 25 years. A recent study by Kumar and Viswanathan (2013) suggests that weather has significant role in explaining temporary migration in India.

period (Table 5). Since ex-post adaptations require immediate finance and it is hard to insure such shocks within a community as almost everyone is likely to be affected (Dercon, 2002), the richer farmers are more likely to undertake more adaptation diversity.

The last variable, agriculture as major source of income, is significant for both production season and ex-post period models, but not in ex-ante period model. The households whose major share of income are derived from agriculture might have shown more interest to adopt options, especially, during ex-post period to smoothen their consumption.

Table 5: Determinants of Farm-level Adaptation Diversity during Ex-post period

Variables	Coefficients	Marginal effects			
		Pr(Y=0|X)	Pr(Y=1|X)	Pr(Y=2|X)	Pr(Y=3|X)
Intensity of Cyclone and Flood					
Highly affected by cyclones	1.407*** (0.388)	-0.069** (0.032)	-0.176*** (0.052)	-0.271*** (0.060)	0.517*** (0.120)
Moderately affected by cyclones	0.960*** (0.345)	-0.022** (0.009)	-0.088*** (0.025)	-0.236*** (0.082)	0.346*** (0.104)
Less affected by cyclones	0.531* (0.332)	-0.016* (0.009)	-0.058* (0.031)	-0.130 (0.084)	0.205* (0.121)
Highly affected by floods	0.729* (0.404)	-0.022* (0.013)	-0.079** (0.037)	-0.176* (0.097)	0.277** (0.141)
Moderately affected by floods	-1.262** (0.505)	0.169 (0.131)	0.215*** (0.076)	0.027 (0.103)	-0.411*** (0.102)
Less affected by floods	0.378 (0.250)	-0.011 (0.007)	-0.041* (0.023)	-0.093 (0.065)	0.146 (0.093)
Household/ Household Head Characteristics					
Size of Household	0.160*** (0.039)	-0.006** (0.003)	-0.021*** (0.006)	-0.036*** (0.010)	0.063*** (0.015)
Years of education of HH	-0.010 (0.023)	0.0004 (0.001)	0.001 (0.003)	0.002 (0.005)	-0.004 (0.009)
Farming experience years of HH	0.005 (0.007)	-0.0002 (0.0002)	-0.0007 (0.0009)	-0.001 (0.002)	0.002 (0.002)
Log(Per capita income)	1.937*** (0.574)	-0.078** (0.032)	-0.255*** (0.086)	-0.437*** (0.143)	0.771*** (0.228)
Agriculture as major source of income	0.378** (0.180)	-0.018 (0.012)	-0.053* (0.028)	-0.077** (0.034)	0.149** (0.070)
Formal and Informal Institutions					
Formal agricultural extension	0.011 (0.205)	-0.0004 (0.008)	-0.001 (0.026)	-0.002 (0.046)	0.004 (0.081)
Formal credit	0.298* (0.180)	-0.011* (0.007)	-0.037* (0.022)	-0.068 (0.043)	0.118* (0.070)
Access to MGNREGS	0.069 (0.192)	-0.003 (0.008)	-0.009 (0.025)	-0.015 (0.043)	0.027 (0.076)
Received crop loss compensation	0.409** (0.205)	-0.018 (0.012)	-0.056* (0.030)	-0.087** (0.041)	0.162** (0.080)
Informal credit	0.049 (0.228)	-0.002 (0.009)	-0.006 (0.031)	-0.010 (0.049)	0.019 (0.090)
Received remittances	0.094 (0.173)	-0.004 (0.008)	-0.012 (0.023)	-0.020 (0.037)	0.037 (0.069)
Location Characteristics[a]					
Balasore	-1.821*** (0.329)	0.165*** (0.060)	0.261*** (0.047)	0.199*** (0.043)	-0.625*** (0.083)
Jajpur	-2.194*** (0.456)	0.357** (0.146)	0.287*** (0.043)	-0.009 (0.081)	-0.634*** (0.069)
Equation statistics					
No. of observation	285				
Wald χ^2 (19)	176.95				
Prob. > χ^2	0.0000				
Pseudo R^2	0.288				
Log likelihood ratio	-239.624				
α_0	7.021				
α_1	7.864				
α_2	9.113				

Source: Computed from primary data.

Note: Figures in the parentheses are robust standard error; a – the omitted district is Kendrapada; *** p<0.01, ** p<0.05 and * p<0.1 respectively.

5.3 Access to Formal and Informal Institutions

The coefficient of received crop loss compensation is positive and significant. In the study area, farmers who avail compensation for crop loss due to cyclone and/ or flood are 13.8 per cent and 10.5 per cent more likely to undertake five and six adaptation measures during a production season, respectively (Table 3). If the farmers have prior information that some portion of loss could be covered by government compensation (i.e. risk diffusion), they could undertake ex-ante adaptations to enhance production. As pointed out by Jodha (1981), this indirectly influences farmers' decision on adaptation. It is also found that the coefficient of formal credit is significant in the ex-post period model. It is obvious because ex-post adaptation requires immediate finance, and farmers who avail formal credit are able to adopt more number of ex-post options. The coefficients of agricultural extension, informal credit and remittances received are found to be statistically insignificant. This suggests that the variables representing formal institutions in the present models are not acting as strong determinants to enhance farm-level adaptation options. But, we cannot deny that these variables could motivate farmers to undertake specific adaptation options, a finding reported by previous studies (e.g., Panda et al., 2013). District fixed effects were also included and the results for Balasore and Jajpur are shown in the models (Tables 3 through 5).

6. Concluding Observations

The present study identifies the determinants of farm-level adaptation diversity during a production season as well as ex-ante/ex-post periods, based on cross-sectional survey data collected during 2010-11 production season in the cyclone and flood prone villages in eastern India. The farm-level adaptations widely practiced by the sampled farmers are salt and flood tolerant indigenous/ traditional paddy seeds, soil conservation techniques, mixed paddy cropping, crop-diversification, land holiday, re-cultivation of seedling and re-planting and pest and disease management. While a large number of farmers are adopting at least one option, at least four strategies are undertaken by two-third of them.

An ordered probit model was employed to explore the determinants of adaptation diversity, and the following salient points emerged from the analysis. It is observed that the likelihood of undertaking adaptation diversity is higher during ex-post period than during ex-ante period, which could be because of lack of prior information about the occurrence of cyclones and floods. This finding indicates the need to enhance government investment on scientific modeling for prediction of cyclones and floods so that farmers' could undertake better adaptation decisions. It is found that the cyclone affected farmers are likely to adopt higher levels of adaptation diversity than those affected by flood. This calls for providing farm households, especially flood affected ones, with more adaptation options. Further, size of household, farming experience, per capita income, agriculture as major source of income and received formal crop loss compensation are some of the important determinants of adaptation decision making. There seems to be a need to organise exposure meetings and shared-learning dialogues with the experienced farmers mainly to reduce the existing misperceptions about the employability of different adaptation mechanisms. Among the variables considered under formal and informal institutions, only one variable - received crop loss compensation - is found as a strong determinant. This suggests that existing institutions are not playing an important role to enhance farm-level adaptation diversity; but, this could not deny that the existing institutions could motivate farmers to undertake specific adaptation options; analysis of this is beyond the scope of this study. This emphasises modification in the existing institutions to enhance farm-level adaptations, so that farmers can prevent expected crop loss due to cyclones and floods.

Our results do need to be interpreted with caution in two respects. The first has to do with limitation of empirical design. In comparison to other studies, the sample size of the present study was smaller that makes it difficult to generalise the findings in the context of the disaster prone regions of eastern India. That could lead us to fail to identify important determinants that are in fact there. Household is taken as the unit of the present analysis, which is the second limitation. The result could be more robust if the analysis is undertaken at the plot-level.

Appendix 1: Impact of Cyclones and Floods in Balasore District during 1994-2008

Year	Cyclone/ Flood	Frequency	No. of villages affected (Nos.)	Total people affected (in millions)	Human casualties (Nos.)	Total houses damages (Nos.)	Crop lands damaged (in thousand hectares)
1994	Flood	5	647	0.60	3	227	162.13
1995	Flood	1	2819	1.48	2	6464	127.12
1996	Flood	2	217	0.14	0	25	13.74
1997	Flood	4	2497	1.73	0	24910	46.34
1998	Flood	1	1227	0.86	1	4996	-
1999	Flood	1	830	0.49	2	1274	75.89
1999	Cyclone	2	1812	1.72	99	91690	141.00
2001	Flood	2	204	0.11	0	6	18.67
2003	Flood	1	1340	0.67	6	15797	24.02
2004	Flood	1	140	0.07	0	3	19.73
2005	Flood	2	1263	0.08	2	10910	-
2006	Flood	3	1405	0.90	1	1043	58.18
2007	Flood	3	3632	3.50	36	16036	128.00
2008	Flood	1	1114	0.94	10	38077	49.85
Total (1994-2008)		29	19147	13.28	162	211458	864.67

Source: Government of Orissa (1999a, b and 2011), Special Relief Commissioner, Government of Odisha, Bhubaneswar and District Emergency Office, Balasore

Note: Blank entries in the Table denote 'not available'.

Appendix 2: Impact of Cyclones and Floods in Kendrapada District during 1994-2008

Year	Cyclone/ Flood	Frequency	No. of villages affected (Nos.)	Population affected (in millions)	Human casualties (Nos.)	Total houses damages (Nos.)	Crop Lands damaged (in thousand hectares)
1994	Flood	1	435	0.39	10	-	30.42
1995	Flood	2	1506	1.17	4	3017	-
1999	Flood	1	359	0.25	4	80	14.65
1999	Cyclone	2	1567	1.65	473	308733	123.75
2001	Flood	1	821	0.82	0	31926	64.29
2003	Flood	2	585	0.62	14	7744	22.65
2005	Flood	3	378	0.41	3	-	-
2006	Flood	4	1021	0.94	2	5444	69.94
2007	Flood	4	1918	1.23	5	2214	29.27
2008	Flood	2	684	0.76	16	58429	64.99
Total (1994-2008)		22	9274	8.24	531	417587	419.96

Source: Government of Orissa (1999a, b and 2011), Special Relief Commissioner, Government of Odisha, Bhubaneswar and District Emergency Office, Kendrapada.

Note: Blank entries in the Table denote 'not available'.

Appendix 3: Impact of Cyclones and Floods in Jajpur District during 1994-2008

Year	Cyclone/ Flood	Frequency	No. of villages affected (Nos.)	Population affected (in millions)	Human casualties (Nos.)	Total houses damaged (Nos.)	Crop lands damaged (in thousand hectares)
1994	Flood	2	585	0.53	7	-	49.05
1995	Flood	2	3620	1.09	0	7107	-
1996	Flood	1	354	0.25	0	548	19.43
1997	Flood	1	478	0.46	3	2253	100.51
1998	Flood	1	537	0.04	1	67	29.55
1999	Flood	1	422	0.42	3	234	23.78
1999	Cyclone	2	1781	2.08	270	257319	188.00
2001	Flood	3	817	0.84	-	20703	185.54
2003	Flood	2	429	0.44	6	14518	8.80
2004	Flood	1	11	0.01	-	0	4.03
2005	Flood	3	711	0.67	5	1543	6.12
2006	Flood	4	754	0.46	1	1587	38.58
2007	Flood	4	639	0.80	0	783	21.70
2008	Flood	1	694	0.73	10	6991	29.52
Total (1994-2008)		28	11832	8.82	306	313653	704.61

Source: Government of Orissa (1999a, b and 2011), Special Relief Commissioner, Government of Odisha, Bhubaneswar and District Emergency Office, Jajpur.

Note: Blank entries in the Table denote 'not available'.

Appendix 4: Socio-Economic Characteristics of Sample Farm Households

Socio-economic Characteristics	Combined	Cyclone	Cyclone & Flood
Details of Farm Household Head			
Average age	49.23	46.91	51.04
Average farming experience	24.04	21.5	26.03
Illiterate (%)	64.56	64	65
Literate (%)	35.44	36	35
Demographic and Educational Indicators			
Average family size	5.88	5.37	6.29
Illiterate (%)	40.27	42.91	38.59
Literate (%)	59.73	57.09	61.41
Assets and Amenities			
Pucca (%)	9.82	4	14.38
Semi-Pucca (%)	16.84	3.2	27.5
Thatched (%)	73.34	92.8	58.12
Availability of Water Within the premises (< 100 meters) (%)	55.44	27.2	77.5
Electricity (%)	34.74	15.2	50
Toilet (%)	22.81	17.6	26.88
Total productive asset (Rs in millions)	0.137	0.042	0.212
Net wealth[a] (Rs in millions)	0.111 (-0.19)	0.023 (-0.44)	0.180 (-0.15)
Land-holding details			
% of landless farmers	40.35	64.8	21.25
% of Small and Marginal Farmers	57.19	35.2	74.38
Gini-coefficient of land holding	0.596	0.689	0.501
Intensity of dependency on agriculture			
> 50 per cent of income (%)	70.88	58.40	80.63
< 50 per cent of income (%)	29.12	41.60	19.37
Income and consumption expenditure (month wise)			
Per capita income (in Rs)	501.99	487.59	513.31
Per capita consumption expenditure (in Rs)	466.67	438.68	488.5
Sources of borrowing			
% of households have outstanding loan	89.47	91.2	88.13
Collateralized (%)	90.2	79.82	98.58
Un-collateralized (%)	9.8	20.18	1.42
Access to Formal sources (%)	37.89	20.8	51.25
Access to Informal sources (%)	83.51	87.2	80.63
Per capita loan amount (in Rs)	4547.5	3502.82	5363.66

Source: Computed from primary data.

Note: Figures in parentheses indicate proportionate declining in comparison to the total productive asset; and a-Net wealth is calculated as total value of productive assets minus total borrowing amount.

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5. **Regional Development, Institutions and Governance**

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Much of the research informs national and regional policies. The Institute also undertakes collaborative research and has a network with governments, academic institutions, international organisations and NGOs. A foray into specialized training and doctoral programme has just been made.

Gujarat Institute of Development Research

Phone : +91-02717-242366, 242367, 242368
Fax : +91-02717-242365
Email : gidr@gidr.ac.in
Website : www.gidr.ac.in

Gota, Ahmedabad 380 060, Gujarat, India.