Vulnerability and Coping to Disasters: A Study of Household Behaviour in Flood Prone Region of India

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1. Introduction

Disaster risk is a major concern in a developing country like India as people living in disaster prone regions of the country are subject to variety of risks concerning their livelihoods. The risks arise mostly because of the dependence of the majority of the population in these countries on climate sensitive factors for their livelihoods. The poor in developing countries are more vulnerable to these disasters due to less favourable economic, social and institutional conditions. Preliminary assessments reveal that the severity and intensity of floods in various parts of India might increase due to climate change. Findings of Intergovernmental Panel on Climate Change (IPCC, 2001a; 2001b) indicate that climate change is going to impose significant stress on resources. Specifically, with respect to India, preliminary assessments reveal that the severity of droughts and intensity of floods in various parts of India might increase (NATCOM, 2004). Studies by Kavikumar and Parikh (2001) and Kavikumar, (2002) point out that the inter-annual variability in rainfall will have major impact on food grain production in India and also on the economy of the country as a whole. Predicted increase in frequency and intensity of floods and droughts are likely to have unfavorable impacts on the occupational structure, food security, health, social infrastructure etc. of the hotspots (Roy et. al., 2005).

The negative impacts of climate change and increased frequency of natural disasters in developing countries further the livelihoods risk of people living in these countries. In view of this, as the probability and intensity of extreme events increase, due to

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climate change it can also pose a strain on poverty reduction strategies. In this context, it is particularly important to note that natural catastrophes have the potential to throw many developmental programs aimed at balanced growth of the country out of gear since some regions are more vulnerable to natural disaster than others. For example, in a developing country like India, majority of the population is employed in the agricultural sector which is highly dependent on natural rainfall. The risks to agriculture are very likely to increase due to climate change as the intensities of natural disasters like droughts, floods and cyclones will increase and there will be shifts in rainfall patterns. These disasters pose a significant problem for the people living in these developing countries already struggling with a high incidence of poverty and increasing economic inequalities.

To hedge against negative shocks associated with natural disasters like floods, households develop a variety of ex-ante and ex-post risk coping mechanisms. The ex-post mechanisms may include coping strategies like dissaving, insurance, borrowing, sale of assets etc. These mechanisms aim at mitigating risk by reducing income instability thereby smoothening consumption streams. For example, farmers manage agricultural production risks via crop diversification, intercropping, use of low risk technologies and use of contracts such as sharecropping. However, when it comes to natural disasters, ex-ante measures may not be effective in providing compensations ex-post disasters. Since natural disasters are rare events and occur on an unprecedented scale, it may not be possible to fully hedge against them and some negative impacts are likely to happen. Ex- post coping strategies at a household level, typically aim at consumption smoothening after the disaster. In other words, these strategies try to cover up the shortfall in consumption of households after the post disaster phase. The ex-post coping mechanisms (adopted by national governments) are designed on top down hierarchical approach like infrastructural solutions and focus of hard resilience solutions. Hence the target is more at macro level than compared to micro level (societies and population and not individual households). Based on these aspects the present analysis is an attempt to examine the effectiveness of various coping strategies (coping strategies adopted by national governments as well as by coping strategies adopted by individual households) in the study area to hedge negative impacts of climate related disasters on consumption levels of the households.

Given this background, the present paper attempts to understand the various risks faced by households living in disaster prone (flood affected) regions of rural India and specifically examine the effectiveness of coping mechanisms adopted by households living in these areas to hedge against the risks. Further, an attempt is also made to study the relationship between household specific characteristics like economic status, presence of migrants, presence of social networks, age of the head of households and the choice of a particular coping strategy.

1.1 The Study Area

The state of Uttar Pradesh (UP) is one of the largest and underdeveloped states in India. The state is bounded by the states Uttarakhand and Himachal Pradesh in the north, Haryana in the west, Madhya Pradesh in the south and Bihar in the east. It also shares an international border with Nepal in the north. Uttar Pradesh is also one of the most populous states in the country accounting for 16.4 percent of the country's population. In terms of the Human Development Index (HDI), the state ranks 13 among the other Indian states with a HDI value of 0.38. The state is one of the most vulnerable regions in India to climate related disasters like floods. The eastern part of the state in particular is highly vulnerable to floods with a major flood occurring every ten years and smaller ones happening every one-two years. The present study area (Gorakhpur and Maharajganj districts) have witnessed around 25 flood events during the period 1950-2007.

1.2 Data and Methodology

The data is drawn from primary household surveys undertaken in the study area for flood affected households. The methodology adopted to study the vulnerability faced by the households and the effectiveness of coping mechanisms adopted by them is derived from a complete risk sharing and self insurance framework. The risk coping strategies are identified based on the relative practice of these strategies in the study area and the most preferred strategies adopted by households are chosen for analysis. The analysis is carried out by estimating a multivariate probit model for the household level data. There are limited studies which have used household level data sets to investigate quantitatively the role of savings, borrowing, and other risk-coping mechanisms adopted by households and study the role of household specific characteristics in choosing a particular coping strategy. The use of primary household

level data on floods in the present study in one of the first attempts to study the household responses to natural disaster related shocks in the study area (Eastern Uttar Pradesh) as well as in India and we examine the following cases of coping strategies that are employed by the households in the study area to cope against negative shocks from natural disasters; (i) borrowing (ii) transfers (iii) relief and (iv) selling of livestock.

The paper is organized as follows: section two provides the background along with the literature review. In section three we look at the flood vulnerability in the study area. Section four focuses on examining the effectiveness of coping mechanisms adopted by households to hedge against natural disasters like flood. Here, section 4.1 describes the econometric specification adopted in the paper, section 4.2 describes the data and the variables used in the study and section 4.3 discusses the results. Finally, section six discusses the summary and conclusions of the paper.

2. Background

Recurring natural disasters in the study area over the years have been causing severe damage and adversely affecting all aspects of human life, property and the environment. The ongoing flood control measures in the study area are primarily based on top-down approach. Various government and semi-government agencies are involved in the process. The government and the semi-government agencies comprise of the central and the state machinery involved in the process of disaster risk reduction the study area. The ex-ante flood management programs undertaken by these agencies are (Disaster Management Department, Govt. of Uttar Pradesh) (i) construction of embankments, drainage improvements, building reservoirs detention basins and afforestation programmes, (ii) the improvement of river channels to increase their discharge carrying capacity by straightening, widening and deepening, (iii) the construction of by pass and diversion channels to carry some of the excess floodwater away from the protected areas, and (iv) establishment of "Flood Control Centers" in flood prone districts. The purpose of these flood control centers is to provide shelter to people from the rising water levels during floods.

Apart from the above described measures, households develop a number of ex-post risk coping mechanisms to cope with the negative income and consumptions shocks

due to these events. These ex-post risk coping strategies typically aim at stabilizing the consumption level of households. Examples of these coping strategies are (i) reducing consumption expenditure (ii) use of credit by reallocating future resources for present consumption (iii) selling of physical and financial assets after disasters (iv) remittances etc. Formal mechanisms like general insurance, microinsurance (disaster insurance, crop insurance and livestock insurance), access to credit etc. can help households in hedging against the shortfall in consumption in face of disasters. In addition to the above coping strategies, the government also complements the risk-coping behaviors of households through a number of ways like distribution of relief, direct public monetary transfers, workfare programs and provide formal safety net for vulnerable households who face temporary difficulties due to the disasters. Also, informal arrangements like mutual transfers (monetary remittances) from relatives, friends and neighbors may also exist and households achieve consumption smoothing by depending on these informal mechanisms (Cochrane, 1991; Mace, 1991; Townsend, 1995). The model used for the present analysis is based on the self-insurance model elaborated by Zeldes (1989), Deaton (1991), Ljungqvist and Sargent (2000) Sawada (2006) and Sawada and Shimizutani (2007). As described before the model used for the analysis of the coping strategies of households considers four different coping strategies and is estimated using a multivariate probit model. Estimating the effectiveness of coping strategies using the multivariate probit model allows for testing the seperability of coping strategies. Previous studies are based on the assumption of separability of coping strategies (Mace, 1991) except for the study by Attanasio and Weber (1995) where the results show that considering particular strategies in isolation can lead to misleading results. Study by Sawada and Shimizutani (2007) on Kobe earthquake also rejects the assumption of separability of coping strategies. The authors also point out that in case of extraordinary shocks (shocks experienced by households particulary after natural disasters like flood, cyclone, earthquake, etc.) the assumption of separability of coping strategies can be problematic as large shocks might substantially alter household preferences across goods and affect household's consumption of different items simultaneously and not separately. A number of household specific characteristics are also considered in the model along with the shock variables to study the importance of these variables in choosing a particular risk coping strategy by the household.

3. Flood vulnerability in Uttar Pradesh

Of the various natural disasters, floods are one of the major disasters reported in India as well as Uttar Pradesh. Data from the EM-DAT suggests that the highest damage caused by flood was during the year 2001. A perusal of the number of affected people from the past flood events, one can observe that 1980 floods caused the maximum damage. It can observed from the data that the number of people affected varies from a high of three crore during 1980 floods to a low of one lakh during the 2006 floods. Although nothing substantial can be said about the study area from the above analysis, it can be concluded that the scale of damage varies significantly over the years. As far as the study area is concerned, the available data suggests that the scale of people affected ranges from a high of 3 lakh during the 1987 floods to a low of 35, 000 during the 1971 floods. The following figure shows the decadal pattern of incidence of floods in the region.

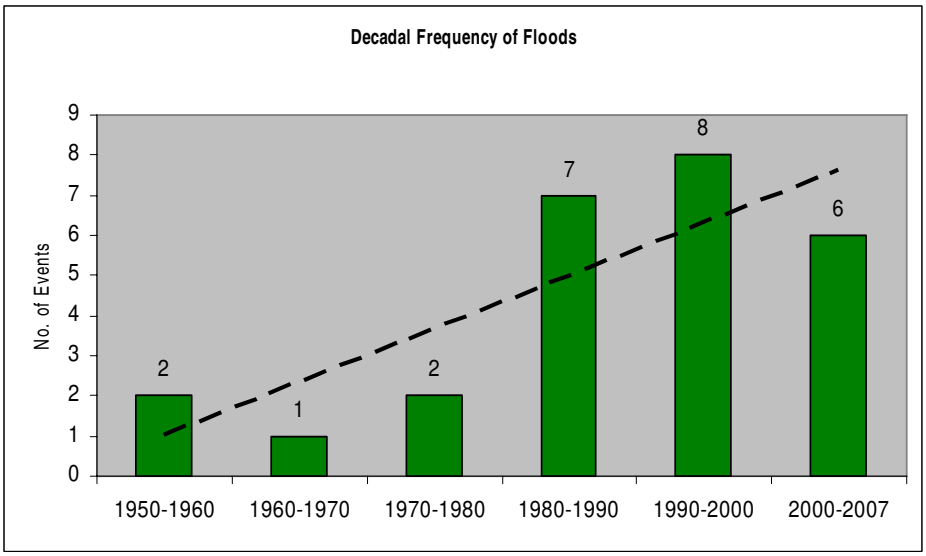

Figure 1: Decadal Frequency of Floods; Data Source: EM-DAT, CRED, Disaster Database

From figure 1, it can be observed that there is an upward shift pattern in the incidence of floods. In other words, the number of floods reported during the past decades is increasing at an alarming rate from 1980 onwards. While the number of floods during 1970-1980 stood at two, that for time periods 1980-1990, 1990-2000 and 2000-2007 stood at seven, eight and six respectively. Further, analyzing the trend of incidence of the floods from 1950 to 2007, a positive sign for the dependent variable (incidence of

floods) is obtained, suggesting that the incidences of floods are rising over the years and if the same trend continues it is going to rise in future also.

Around nine districts of the eastern UP were severely affected due to the floods in 2007. The study area (Gorakhpur and Maharajgang districts) were the worst affected in the region in terms of exposure with around 4 lakh people over an area of over 95, 000 hectares suffering in these two districts. Around 600 villages were affected and around 53, 730 hectares of sown area was destroyed due to these floods. The area had a large number of permanent water bodies which developed over time, due both to changing river courses and abandoned channels becoming blocked by silt. The flooding in the area is due to encroachments of the water bodies over time. Additionally the reason for flood is also the disruption in the natural flow of the water due to the small slope of the area. Floods are recorded during the monsoon months due to cloudbursts and intense rainfall events in the Nepal terai region. There is always some annual flooding in the area, with major floods occurring in 1954, 1961, 1974 and 1993. One can observe that in the last ten years, the intensity and frequency of floods appear to have increased and three major floods have occurred within a decade: 1998, 2001 and 2007 (Moench et.al., 2008).

4. The Effectiveness of Coping Strategies adopted by Households

The analysis undertaken in this section attempts to identify the significant ex-post coping behavior adopted by the households to hedge against the consumption shortfall after the incidence of floods. The study attempts to investigate possible factors that inhibit consumption insurance by comparing the effectiveness of different risk-coping strategies. The comparison is carried out between four coping strategies. The identification of the coping strategies undertaken by the households was done through the household questionnaire surveys. The different options of the coping strategies that were to be listed in the questionnaire were finalized after an exhaustive review of literature, the pilot survey and the pre-testing of the questionnaires in the study area. The questionnaire provided the households with the following seven options for coping strategies namely; (i) receiving monetary transfers from government agencies as well as friends and relatives (ii) relief from the government (iii) selling of livestock (iv) selling of household assets (v) borrowing (vi) help from other members in the community and (vi) past savings. Out of the above listed options for coping strategies

the following coping strategies were identified in the study area that households reported to often resort to during post flood phase.

(a) Borrowing
(b) Receiving Monetary Transfers (from friends and relatives)
(c) Relief
(d) Selling of Livestock

The coping options, selling of household assets, help from other members in the community and past savings were dropped while undertaking the analysis as only 0.01 percent, 0.05 percent and 0.01 percent of the households reported of having resorted to these strategies respectively. The analysis involves finding out the relationship between the above described coping strategies and the shocks suffered by the households because of disasters. In other words the attempt is to identify which coping strategies are employed by the household for hedging against specific shocks. Also, an attempt is made to study whether there is any relationship between household specific characteristics and the choice of a particular coping strategy by the household in the study area.

4.1 Econometric Specification

The econometric model used for estimation is derived from Flavin (1999) and Sawada and Shimizutani (2007). The model used for the flood case is described below;

$$\Delta b_i = S_i\theta_1 + H_i\beta_1 + \varepsilon_{1i} \quad (1)$$

$$\Delta y_i^t = S_i\theta_2 + H_i\beta_2 + \varepsilon_{2i} \quad (2)$$

$$\Delta r_i = S_i\theta_3 + H_i\beta_3 + \varepsilon_{3i} \quad (3)$$

$$\Delta l_i = S_i\theta_4 + H_i\beta_4 + \varepsilon_{4i} \quad (4)$$

where,

$$p_{1i} = 1, if\ \Delta b > 0; and\ 0 otherwise \quad (5)$$

$$p_{2i} = 1, if\ \Delta y^t{}_i > 0; and\ 0 otherwise \quad (6)$$

$$p_{3i} = 1, if\ \Delta d_i > 0; and\ 0 otherwise \quad (7)$$

$$p_{4i} = 1, if\ \Delta l_i > 0; and\ 0 otherwise \quad (8)$$

In equations 1-4, *S* represents a matrix of household-specific shock variables generated by the disasters and that *H* is a matrix of household characteristics and other control variables, some of which are proxy variables of credit constraints. The

variance-covariance matrix of ε_{mi} is symmetric and the covariances are assumed to be non-zero with the restriction condition var(ε1i) = …… = var(εn_i) = 1 for identification purposes. Under the assumption of joint normality of the error terms a four variable multivariate probit model is estimated for the flood case. Since, one cannot directly observe the intensities of the risk-coping strategies, i.e., Δb, Δy^T, Δd and Δl; the dependent variables in above equations indicate, whether a household adopted a particular risk-coping device against the disasters can be represented by a discrete variable, p_m, m = 1, 2, 3and 4 as four coping strategies as identified. In other words, the dependent variable is represented by a dummy variable suggesting whether a particular household adopted a particular risk coping strategy.

The independent variables in the above equations are a matrix of household specific shock variable generated by the disaster and a matrix of household characteristics and other control variables. In order to estimate the parameters under this setting, a log likelihood function is employed, which depends on the multivariate standard normal distribution function. The empirical framework involves estimating multivariate binary - dependent variable models. The analysis undertaken in this chapter utilizes the estimation process outlined by Cappellari and Jenkins (2003) in order to estimate the multivariate probit model using the method of simulated maximum likelihood, also known as the Geweke- Hajivassiliou- Keane (GHK) estimator. The GHK estimator expresses the multivariate normal distribution function as the product of sequentially conditional univariate normal distribution functions that can be easily and accurately evaluated. In the case of multivariate normal limited dependent variable models the simulated probabilities of the GHK simulator are unbiased and are bound within the (0,1) interval and is more efficient in terms of variance of the estimator of probabilities than other simulators like acceptance-rejection or stern simulator. It is consistent as the number of draws and the number of observations tends to infinity and thus satisfies the asymptotic property of maximum likelihood estimator (Cappellari and Jenkins, 2003).

4.2 Data and Variables

The variables used in the present analysis consist of variables capturing shocks to the households from natural disaster, coping variables (coping mechanisms used by

households in post disaster phase) and variable capturing household specific characteristics. Table 1 below describes the variables used in the estimation.

Table 1: Variables and their Construction Procedure for the Flood Case

Variables	Description of the Variable
Shock Variables	
Housing Damage	Dummy = 1, if housing damage was caused due to flood; 0, otherwise
Crop Damage	Dummy = 1, if crop damage was caused due to flood; 0, otherwise
Crop Area Damage	Dummy = 1, if crop area damage (water logging) was caused due to flood; 0, otherwise
Health Shock	Dummy = 1, if health-related shocks were caused to the family due to flood; 0, otherwise
Livestock Shock	Dummy = 1, if livestock shocks were caused due to flood; 0, otherwise
Occupational Shock	Dummy = 1, if the household reports of a change in income derived from present source of occupation due to flood; 0, otherwise
Household Specific Variables	
Age	Age of the Head of the Household in years
Age Square	Square of the Age of the Head of the household in years
Migration	Dummy = 1, if the household reports of having migrant member; 0, otherwise
Households Below Poverty	Dummy = 1, if the household was below poverty line; 0, otherwise
Level of Education (Secondary)	Dummy = 1, if the highest level of education of the head of the household was high school; 0, otherwise
Level of Education (Diploma/Higher Secondary)	Dummy = 1, if the highest level of education of the head of the household was Diploma/Higher Secondary; 0, otherwise
Level of Education (Graduate)	Dummy = 1, if the highest level of education of the head of the household was Graduation; 0, otherwise
Marital Status of the Head of the household	Dummy = 1, if the head of the household is married; 0, otherwise
Presence of Children in the Household	Dummy = 1, if there is a child below 16 years in the household; 0, otherwise
Regional Dummy Variables	
Upper Basin	Dummy = 1, if the household lived in upper basin; 0, otherwise
Lower Basin	Dummy = 1, if the household lived in lower basin; 0, otherwise
Coping Variables	

Monetary Transfer	Dummy = 1, if the household used monetary transfers as a means of coping after the flood; 0, otherwise
Relief	Dummy = 1, if the household used relief as a means of coping after the flood; 0, otherwise
Selling of Livestock	Dummy = 1, if the household used selling of livestock as a means of coping after the flood; 0, otherwise
Borrowing	Dummy = 1, if the household used borrowing as a means of coping after the flood; 0, otherwise

From table 1 above it can be observed that six variables are used to capture the household specific shocks. Floods are associated with damages to crops, property, life and health. Households also resort to occupational shifts after the event to meet the shortfall in consumption caused due the event. Therefore the shock variables used in the present analysis aim to capture the relationship between these shocks and the coping mechanisms used by the households. These variables are represented in the analysis as dummy variables depicting a particular shocks suffered by the household due to floods. The next set of variables aims to capture the household specific characteristics that are unique to each household. These variables used in the present analysis represent the age, level of education, marital status of the head of the household, migration and the economic status of the households (whether a household belongs to below poverty line group or is above the poverty line). Here the variable representing the age of the head of the household is a nominal variable representing the age of the head of the household whereas the other variables are again dummy variables. The third sets of variables are the region specific variables (upper / lower basin) that show whether a household lies in the upper basin or lower basin of the catchments area. To capture the coping aspects of households four dummy variables are used which depict if the households coped using these coping mechanisms. For the construction of all the dummy variables the value one is used to represent the positive attribute of the variables and zero represents the negative attribute.

4.2 Results and Discussion

This section describes the estimation results obtained from the multivariate probit regression for the risk sharing and self insurance model for the flood case. The following table (Table 9.3) below describes the construction of the variables used in the estimation process and the respective descriptive statistics. From table 9.3 it can

be observed that the average age of the head of the household in the sample is around 51 years. Around 35 percent of the sample reports of having a migrant member in the household. About 47 percent of the population belongs to the category of below poverty line as they own the below poverty line (BPL) card. Around 80 percent of the sample in the study area reports of being married and living with spouse. Further, majority of the households in the sample (81 percent) report the presence of children in the household. Around 47 percent of the sample resides in the upper basin and 30 percent of the sample resides in the lower basin. The rest of the sample (around 23 percent) has their houses in the middle basin. As far as educational level is concerned, the majority of the sample has secondary level of education.

Table 2: Description of the Variables and the Descriptive Statistics

Explanatory Variables	**Mean**	**S.D.**
Housing Damage	0.21	0.41
Crop Damage	0.68	0.47
Crop Area Damage	0.67	0.47
Health Shock	0.70	0.46
Livestock Shock	0.15	0.35
Occupational Shock	0.34	0.48
Age of the Head of the Household	50.71	14.03
Migration	0.35	0.48
Households Below Poverty	0.47	0.50
Level of Education (Secondary)	0.75	0.43
Level of Education (Diploma/Higher Secondary)	0.45	0.50
Level of Education (Graduate)	0.04	0.18
Upper Basin	0.47	0.50
Lower Basin	0.31	0.46
Marital Status of the Head of the household	0.79	0.41
Presence of Children in the Household	0.81	0.39
Number of Observations = 200		

With regard to the shock variables, maximum households in the sample report crop related damages. The mean values for the crop damage and crop area damage variable (the dummy variable representing water logging in the field after the flood event) are 0.68 and 0.67 respectively for the 2007 floods. A majority of the sample also reports having suffered health related shocks due to the floods. The mean of the variables housing damage and occupational shock are low as compared to the mean of other shock variables and a small proportion of the sample also reports of having suffered

livestock losses due to the floods in 2007. Table 3 shows the results of the multivariate probit estimation. As discussed in the preceding section, the study compares the effectiveness of four different coping mechanisms adopted by households in the study area.

Table 3: Estimation Results for the multivariate probit regression

Explanatory Variables	**Monetary Transfers**	**Relief**	**Selling of Livestock**	**Borrowing**
Constant	-4.361 (2.044)**	-3.238 (1.496)**	-3.364 (2.096)	1.235 (1.107)
House Damage	-0.050 (0.297)	-0.028 (0.24)	0.164 (0.298)**	0.031 (0.229)
Crop Damage	-0.156 (0.567)	0.252 (0.414)	0.908 (0.495)	0.081 (0.404)
Cropped Area Damage	0.439 (0.584)	0.028 (0.404)	-0.583 (0.476)	0.211 (0.39)
Health Shock	-0.446 (0.238)**	0.129 (0.217)	0.216 (0.323)	0.207 (0.211)
Livestock Shock	0.418 (0.32)	0.395 (0.285)	-0.111 (0.348)	0.53 (0.276)**
Occupational Shock	0.641 (0.232)***	0.617 (0.216)***	0.659 (0.3)***	0.179 (0.21)
Age of the head of the household	0.081 (0.073)	0.065 (0.054)	0.069 (0.078)	-0.044 (0.042)
Age Square	-0.0006 (0.001)	-0.0005 (0.0004)	-0.0007 (0.0007)	0.0003 (0.0003)
Migration	0.542 (0.238)**	-0.021 (0.219)	0.288 (0.314)	0.045 (0.204)
Households below poverty line	-0.058 (0.265)	-0.052 (0.223)	-0.238 (0.298)	0.087 (0.214)
Level of Education (Secondary)	-0.425 (0.289)	0.009 (0.292)	-0.11 (0.333)	0.199 (0.247)
Level of Education (Higher Secondary/Diploma)	0.453 (0.258)*	0.476 (0.22)**	-0.567 (0.303)*	-0.023 (0.215)
Level of Education (Graduation)	-4.503 (0.538)***	-0.276 (0.611)	-4.277 (0.592)***	-0.008 (0.552)
Marital Status of the head of the household	-0.299 (0.309)	-0.431 (0.241)*	-0.038 (0.381)	0.056 (0.244)
Presence of Children in the household	0.143 (0.303)	-0.201 (0.263)	0.041 (0.392)	-0.239 (0.266)
Upper Basin	0.270 (0.311)	0.556 (0.277)***	0.250 (0.335)	0.125 (0.262)
Lower Basin	0.374 (0.34)	0.526 (0.291)**	-0.467 (0.448)	0.04 (0.276)
Log Pseudo likelihood = -319.613; Wald chi^2 = 1215.9***;				

LR Ratio Test: chi^2 (6) = 40.751***
Note: Huber White consistent standard errors are shown in parentheses;***, indicates statistical significance at 1% level; ** indicates significance at 5% level; * indicates statistical significance at 10% level

The results obtained from the multivariate probit estimation suggest that, none of the coping strategies adopted by households are able to completely protect against the damages suffered from floods. The analysis also suggests that risk-coping strategies are specific to the nature of the loss caused by the disasters. For instance, households resort to borrowing to cope against livestock shock created due to floods in the study area. This implies the existence of a hierarchy of risk-coping measures where the risk coping. The next paragraphs discuss in detail the results obtained for each specific coping strategy considered in the analysis.

Monetary transfers from friends and relatives are likely to be ineffective against negative shocks, particularly for co-resident households. In the case of monetary transfers, the results suggest a negative relationship between the health shocks and the monetary transfers. The coefficient is also highly significant at five percent level implying that households do not depend on transfers as a medium of coping to cover for health related shocks. With respect to occupational shock the results show that the coefficient has a positive sign and is highly significant. This indicates that households use monetary transfer as a coping mechanism against occupational shocks. In other words households use monetary transfers in meeting the shortfall in income caused due to occupational shifts during the post disaster phases. Since none of the coefficients associated with other shock variables turn out to be significant it nothing can be about the role of monetary transfers in hedging against these shocks. With respect to household specific variables, migration and level of education (higher secondary / diploma) turn out to be significant. The coefficients depict positive signs for the both the variables suggesting that households reporting migrant members in the family use monetary transfer as a coping mechanism. Similarly, households where the head of the household is educated till the higher secondary / diploma level uses these transfers as a coping mechanism for the flood. The coefficient of the dummy variable level of education (graduation) has a negative sign and is also highly significant. Therefore, one can infer that households where the level of education of the head of the household is till secondary level of schooling do not use monetary

transfer as a means of coping in the event of flood. Since the coefficients for other variables (household specific and locational dummy variables) are not significant one cannot conclude with certainty about the relationship between these variables and the adoption of monetary transfer as a coping strategy.

The role of relief as a means of coping is the next case. Here also as in the case of monetary transfer, the coefficient for the shock variable occupational damage is highly significant with positive sign. This implies that relief as a means of coping was employed households reporting occupational loss due to the floods. From the set of variables depicting household specific characteristics level of education (higher secondary / diploma) turns out to be significant in this case also with a positive sign. This implies that households educated till this level used relief as a means of coping for the 2007 floods in the study area. Further, the variable showing the marital status of the head of the household is significant. The coefficient has a negative sign suggesting that households where the head is married didn't use relief as a means of coping for the floods in 2007. Relief is distributed by the government agencies as well as by non governmental organizations during the post flood phase therefore intuitively one can say that households with families are not to reach out to these sources. The variables lower basin and upper basin describe the location of the household (basin to which the household belongs to). While the variable upper basin is significant at one percent level the variable lower basin is significant at five percent level with positive signs This implies that households which are located in the upper basin and lower basin of the study area (upper and lower basin of the Rohini river catchments) benefited from relief operations undertaken by agencies (government, local and non-governmental) after the floods. Again this can be due to accessibility conditions. While the households living in upper basin could have received relief if it was air dropped the households in the lower basin could have moved to safer locations with the onset of the flood. The households living in the middle basin were not able to benefit from the relief operations as that area gets water logged making it difficult to reach for the relief distributing agencies as the constant term is significant with a negative sign indicating that other omitted variables in the model have a negative relationship with the dependent variable.

The third case regarding the coping strategy of household pertains to the role of selling of livestock by households as a means of coping strategy to hedge against the shock created by the floods. Here the coefficient for the shock variable housing damage is positive and significant indicating that households resort to selling of livestock as a coping strategy to cover up the housing damages due to the floods of 2007 in the study area. Similar result is also obtained for the case for occupational shock suggesting that households also sell livestock to cover up shortfall in income due to occupational shock after floods in the study area. The dummy variable showing the level of education (graduation) is also found to significant (one percent level) and level of education (higher secondary / diploma) is significant at ten percent level with positive signs. Hence it can be concluded that households where the head of the household is educated till these levels resort to selling of livestock as a means of coping against floods in the study area.

As far as borrowing as a means of coping is concerned the analysis suggests some interesting finding. Here one shock variable (livestock shock) is significant with a positive sign which was not significant in the other three cases. Therefore it can be said that the households which suffer from livestock losses due to the floods are more likely to use borrowing as a means of coping to hedge against this loss. Since none of the other variables turn out to be significant, the relationship between these variables and the role of borrowing adopted by households as a means of coping is not clear.

The behaviour of the correlation terms between the error terms is of much importance because of the assumption of separation of coping strategies as outlined in the previous section of this chapter. The high value likelihood test statistics rejects the null hypothesis that the correlations are jointly equal to zero. The value of log likelihood function is quite high and result rejects the null hypothesis of independent error terms, a finding that supports the adoption of the multivariate probit model. The correlations for the error terms of transfers and selling of livestock equation, between the relief and selling of livestock and borrowing and selling of livestock equations are negative. These findings imply that transfers / selling of livestock and relief act as substitutes. This suggests that self-insurance acts as a compensation for the lack of mutual insurance. On the other hand, the correlation between the error terms of borrowing and transfers, transfers and relief and relief and borrowing is positive,

suggesting a complementary relation between these variables. The following table (4) shows the correlation coefficients between the error terms of the multivariate probit regression.

Table 4: Correlation Coefficient of the Disturbance Terms for the Flood case

	Correlation Coefficient	**Standard Error**
Correlation between $\varepsilon_1 and \varepsilon_2$	0.801	0.102***
Correlation between $\varepsilon_1 and \varepsilon_3$	-0.102	0.174
Correlation between $\varepsilon_2 and \varepsilon_3$	-0.151	0.154
Correlation between $\varepsilon_1 and \varepsilon_4$	0.096	0.133
Correlation between $\varepsilon_2 and \varepsilon_4$	0.143	0.126
Correlation between $\varepsilon_3 and \varepsilon_4$	-0.062	0.164
Note: Huber White consistent standard errors are shown; ***, indicate statistical significance at 1% level		

The positive relationship between the error terms of borrowing and transfers suggests that that the rich, who can collateralize assets, can obtain both loans and transfer incomes, while the poor are excluded from both a credit market and an insurance network against natural disasters. There is also positive relationship between the error terms of the transfers and relief equations and is also highly significant suggesting that there is complementary relationship between these to forms of coping strategy. In other words, households who get transfers also benefit from the relief activity undertaken after the floods. Another important finding that emerges is that households also resort to mix of coping strategies, like households who gain from transfers might also resort to other coping strategies like borrowing to meet the shortfall in consumption. For example households who report of having suffered through an occupational shock due to the floods in 2007 in the study area resort to monetary transfer, relief and selling of livestock as a means of coping against this shock. It can also be said from this result that the transfers received by the households are not sufficient to meet the shortfall in consumption due to flood. There is evidence of similar relationship between relief and borrowing. Complementary relationship also exists between selling of livestock and borrowing as forms of coping strategy. This relationship might hold true for the case for households who live below poverty line. Since this strata of households are limited in their borrowing ability they might resort

to selling of livestock as a means to cope with the shortfall in consumption due to floods.

5. Summary and Conclusions

In this paper we attempted to analyze the effectiveness of various coping options used by the households to hedge against natural disasters like flood. The strategies chosen for consideration depended on the relative practice of the choice in the affected area. We found that the households adopt a wide variety of risk coping measures. These measures are receiving monetary transfers, relief, selling of livestock and borrowing. The means of coping are specific to the nature of shocks created by the disasters. Receiving monetary transfers are the most effective means of coping for households during floods in the study area (amongst the set of coping mechanisms considered in the present case). While monetary transfers are used by households to cope with occupational shocks they are not likely to be used to cope with health shocks in the study area. There is also evidence of mixed impacts (both positive and negative) of household specific characteristics in the adoption of monetary transfers as a coping mechanism by the households.

Relief is primarily used by households to cope with the shortfall in income / consumption. Household specific characteristics play a significant in role the choice of this strategy as a means of coping. There is evidence that households resort to selling of livestock to cover up the damage suffered by them to their dwelling structures and also to cover up the losses suffered by them due to occupational loss due to floods. Household specific characteristic like the level of education of the head of the households is positively related to the choice of selling of livestock as a coping strategy. Households generally resort to borrowing to cope with the loss experienced by them due to loss of livestock due to floods in the study area. Results are inconclusive regarding how households cope with major shocks like damage crops and inundation of the cropping area with flood water. Household specific characteristics like age of the head of the household, migration, marital status of the head of the household play a mixed role (significant for some variables) in deciding the coping strategies adopted by the households. Location of the household (whether the household belongs to the upper, middle or lower basin) is important in choosing the coping strategies like relief as a means of coping. In other cases the location of the

household has no role to play in decision making of households regarding the choice of coping strategies.

From a policy perspective it can be said that policy makers in developing countries face multiple development challenges like poverty eradication, infant mortality reduction, rural development, provision of access to basic needs like water, health, education etc. It can be concluded that people living in absolute poverty (those who cannot afford US $2 a day) will not be able to cope up with the impacts of disasters which are likely to worsen due to climate change. In view of this concentration should be on increasing the resilience of the households to disasters by empowering them to raise their levels of income by providing them with adequate employment opportunities. The analysis carried in this paper suggests that disaster mitigation policies have to be integrated with sustainable development strategies in general, and poverty alleviation measures in particular which will enable them to hedge against the large scale negative impacts of disasters. Emphasis should also be given for providing social safety nets and empowerment of people by improving their basic quality of life which in turn will be helpful in raising adaptive capacity of households.

In the future research, a larger sample drawn from more districts of Uttar Pradesh and undertaking repeated surveys to build a cross sectional time series data set may result in deriving more conclusive statements. It would also be interesting to study the linkages between income of the households, natural disasters and climate change with a focus on analyzing the differences in impacts due to varying levels of income. Research spatially comparing other vulnerable regions of the country to the present study area would also help in strengthening the policy implications. This paper never the less contributes to the body of literature analyzing the effectiveness of coping mechanisms adopted by household in a rural Indian setting widely exposed to disasters like flood. It also highlights the urgent need for policy intervention to save the vulnerable households.

References

Attanasio, O. and G. Weber (1993), "Consumption Growth, the Interest Rate and Aggregation," *Review of Economic Studies*, 60, No.3, pp. 631–649.

Cochrane, John H. (1991), "A Simple Test of Consumption Insurance" *Journal of*

Political Economy, Volume 99, No. 5, pp. 957-976.

Deaton, A. (1991), "Saving and Liquidity Constraints", *Econometrica,* 59, No. 5, pp. 1221-1248.

IPCC (2001a), *The Scientific Basis,* Contribution of the Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (eds. Hougthon, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell and C.A. Johnson), Cambridge University Press, Cambridge.

IPCC (2001b), *Impacts, Adaptation and Vulnerability,* A Contribution of the Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (eds. McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White), Cambridge University Press, Cambridge.

Kavikumar K.S and J. Parikh (2001), Indian Agriculture and Climate Sensitivity, *Global Environmental Change*, 11, (2), pp. 147-154.

Kavikumar, K. S. (2002), Vulnerability and Adaptation of Agriculture and Coastal Resources in India to Climate Change, *EERC Working Paper Series: NIP 4*. Available at: http://coe.mse.ac.in/eercrep/fullrep/nip/NIP_FR_KaviKumar.pdf

Ljungqvist, L. and T. J. Sargent, (2000), *Recursive Macroeconomic Theory*, MIT Press, Cambridge.

Mace, B. J. (1991), "Full Insurance in the Presence of Aggregate Uncertainty", *Journal of Political Economy* 99, No.5), pp. 928-96.

Moench, M., Fajber, E., Dixit, A., Caspari, E., and Pokhrel, A. (2008), "*Catalyzing Climate and Disaster Resilience: Processes for Identifying Tangible and Economically Robust Strategies*", Eds., Final Report of the Risk to Resilience Study, The Risk to Resilience Study Team, pp 328

NATCOM (2004), India's Initial National Communication to the United Nations Framework Convention on Climate Change, Ministry of Environment and Forests, Government of India, New Delhi.
available at: http://www.natcomindia.org/natcomreport.htm

Roy J, A. Ghosh, A. Majumdar, P. Roy, A.P. Mitra and C. Sharma, (2005), Socio-economic and physical perspectives of water related vulnerability to climate change: results of field study in India, *Science and Culture* 71, (8), pp. 239–259.

Sawada, Y. (2006). "The Impact of Natural and Manmade Disasters on Household Welfare", *Discussion Paper No. 148*, Graduate School of International Development, Nagoya University Japan.

Sawada, Y. and S. Shimizutani, (2007), "Consumption Insurance against Natural Disasters: Evidence from the Great Hanshin-Awaji (Kobe) Earthquake."

Applied Economics Letters, Volume 14, No. 4, pp. 303-306.

Townsend, R. M. (1994), "Risk and Insurance in Village India" *Econometrica*, Volume 62, pp. 539-591.

Zeldes, S. P. (1989), "Consumption and Liquidity Constraints: An Empirical Investigation", *The Journal of Political Economy* 97, No. 2, pp. 305-346.