Are traditional coping mechanisms effective in managing the risk against extreme events? Evidences from flood-prone region in rural India

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Abstract

Livelihoods of rural poor in developing countries like India are exposed to risks due to natural disasters like floods. Although these risks are covariate, households are affected in varying degrees due to their location and their relative capacity to cope with them. These in turn are household-specific and are decisive in defining the efficacy of coping mechanisms adopted by households to hedge against the impact of floods. The paper attempts to study the nature of risks faced by households in a major flood-prone region of rural India and examine the effectiveness of coping mechanisms adopted. Findings suggest that (i) floods significantly reduce the consumption of households, (ii) traditional coping mechanisms used to manage the impacts are ineffective in safeguarding the risks to their livelihood and (iii) designing comprehensive coping measures, targeting vulnerable groups and combining informal insurance with safety nets will be useful.

Keywords: Coping mechanism; Multivariate probit model; Natural disaster; Rural India

1. Introduction

Risks arising out of climate-related natural disasters disrupt the livelihoods of people. The rural population in developing countries is susceptible to a greater extent due to the dependence on climate-sensitive sectors like agriculture for their living. Natural disasters like droughts, floods and cyclones are the primary sources of risk to agriculture and in turn livelihoods. This holds true for India also since agriculture here is still highly dependent on rainfall (Pandey et al., 2007). In recent years, vulnerability of rural households living in disaster-prone regions of India has increased mainly due to the climate change related factors like higher intensity of floods as per India’s Initial National Communication to the United Nations Framework Convention on Climate Change (NATCOM, 2004). Risks
associated with climatic extremes such as earthquakes, cyclones and floods can cause devastating environmental and socioeconomic losses (Mechler, 2004; Hochrainer, 2006; Tran & Shaw, 2007; Noy, 2009). Especially, the poor bear the greatest risk of the negative impacts due to their limited coping capacities as well as their higher physical vulnerability (Benson & Clay, 2004).

Although the risks faced by households due to climatic extremes like floods are covariate, the impacts may vary across households based on their capacity to cope with these shocks. This results in shocks to key idiosyncratic variables that are crucial in defining the livelihood of the households (like reduction in income, consumption expenditure, etc.). The severity of impacts differs across households and results in immediate increases in poverty for some and longer-term impacts on others. Continuous exposure to risk also proves detrimental to the adaptive capacity and the standard of living of the households. If the households are able to successfully cope with the impacts of extreme events like floods, then there is a possibility for the households to reduce their level of poverty and raise the level of their income and consumption as Dercon (2002) observes that risks faced by the households are crucial in determining the level of assets and endowments maintained by them. Therefore, in essence the vulnerability stems from the exposure to risk and the inability to manage the same, and the pertinent questions are (i) Do the households change their consumption practices? (ii) What are the primary reasons for this change? (iii) How do the households cope with these impacts and are they different for households belonging to different income groups or residing in different regions? (iv) Are these coping mechanisms helpful in hedging against the impacts?

In India, the majority of the rural population depend on agriculture as their primary source of income (DAC, 2004), and hence the vulnerability to the livelihood arises from the risks faced to crop production. The present study is an attempt to examine the following issues in one of the worst disaster-prone regions of India, i.e. the districts Gorakhpur and Maharajganj in eastern Uttar Pradesh region bordering with Nepal. As the nature of impacts due to flood varies with respect to the location of the households (for example, households living in closer proximity to river and embankments are at a greater risk than those residing far off), we choose households residing in diverse locations: the upper and middle basins and the tail end, for analysis. Specifically, we attempt to analyze (i) the risks faced by households living in the flood-affected region of rural India, (ii) the risks to consumption practices of households due to floods, (iii) the effectiveness of coping mechanisms adopted by households living in these areas to hedge against the risks and (iv) the relationship between household-specific and regional characteristics and the choice of a particular coping mechanism. The remainder of the paper is organized as follows: Section 2 provides the background along with the literature review, and Section 3 describes the data source and the sampling framework. In Section 4, we describe the model for analyzing the flood vulnerability and effectiveness of coping mechanisms in the study area, while Section 5 presents the results and discussion, and Section 6 concludes the paper.

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1 Agriculture provides livelihood to 65% of the population and direct employment to 58% of the workforce (DAC, 2004). It accounted for around 24% of the gross domestic product (GDP) and 15% of total exports during the decade 1990–2000. Currently the contribution of the agriculture sector to the Indian GDP is around 15%. However, for the state of Uttar Pradesh, the share of the agriculture sector in the Net State Domestic Product was around 38% during 1990–2000 and currently it accounts for 33% (Nayak et al., 2010).
2. Background and literature review

Developing countries like India are witnessing an increasing occurrence of climatic extremes like floods, which are also expected to increase in the foreseeable future due to climate change (IPCC, 2012). At a macro-level, given the frequent incidence and severity of these climatic extremes in India, the national/state governments along with individual households have been involved in carrying out a number of disaster-specific risk reduction activities to hedge against the impacts. Activities such as creating warning systems, building multi-purpose flood shelters, strong awareness campaigns, construction of flood embankments, etc. have been continuously undertaken to mitigate the impacts of climate extremes. The evidences regarding the effectiveness of these interventions are mixed. A few studies find a remarkable reduction in loss of lives due to storms because of better disaster management and meteorological facilities in Andhra Pradesh (Raghavan & Rajesh, 2003) and Odisha (Bahinipati & Venkatachalam, 2014), India. Other studies have shown the importance of coastal vegetation in the context of reducing physical impacts of cyclonic storms (Adger et al., 2005; Danielsen et al., 2005; Kerr & Baird, 2007), especially in the Indian context (Badola & Hussain, 2005; Das & Vincent, 2009; Das & Smith, 2012). Further, Bahinipati & Patnaik (2015) observe that disaster-specific adaptation measures act as a major determinant in reducing damages from climate extremes in Odisha, India. Similarly, Das & Smith (2012) find that awareness about heatwaves, through print as well as electronic media, has reduced the morbidity rate in the state of Odisha, India. In contrast to these, Somanathan (2013) concludes that building embankments is not a good flood control strategy especially with regard to the Kosi river basin in North Bihar, India. Likewise, Adikari et al. (2013) observe that water-related disaster countermeasures are weak in non-Organisation for Economic Co-operation and Development countries; thus, higher economic losses and younger fatalities are concentrated there. In the context of the Ganges river basin, Hosterman et al. (2012) observe that adaptation to climatic extreme and change should not be viewed as a separate initiative, but rather as a goal and perspective incorporated into every level of planning and decision-making. Based on their examination of flood management systems in Bangladesh, considered to be the world’s most vulnerable and flood-prone country, Barua & Ast (2011) also advocate further innovations to existing flood management systems based on an interactive water management framework. In the context of developed economies, similar conclusions are also drawn by Kang et al. (2013) and Grecksch (2013) that sustainable flood management at the national level can be achieved through the active participation of stakeholders and integrating the elements of flood management, cooperation and information sharing. Likewise, Bhave et al. (2014) consider non-climatic factors to also be important, especially in the water sector, for effective management of climatic extremes and changes.

At a micro-level households develop a variety of risk-mitigating mechanisms to hedge against the impacts (both ex-ante and ex-post). Since the risks are covariate in nature and occur on an unprecedented scale, it may not be possible to fully hedge due to lack of coverage of formal insurance schemes in the developing countries like India. However, as observed by Dercon (2002), individual savings and informal risk sharing arrangements may offer a partial coping capacity. There are numerous studies that have tested the effectiveness of these mechanisms in the context of different countries.

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2 Ex-ante mechanisms include crop and asset diversification, migration and specialization into low-risk activities. The ex-post mechanisms may include strategies like non-saving, insurance, borrowing, sale of assets, help from community, monetary transfers from friends and relatives, etc.
In the context of India, Rosenzweig & Binswanger (1993) find that one standard deviation decrease in weather risk raises average profits by up to 35% among the lowest wealth quintile in semi-arid India. The primary impact of a disaster is creating shocks in production, which are transformed into consumption shocks because of the underdeveloped and ineffective risk management and mitigation schemes. From a developing country perspective, Porter (2008) argues that poor people tend to face greater risks to their already low incomes and are also less equipped to deal with such risks due to fewer assets, fewer opportunities to diversify income, limited or no formal social insurance or social protection provisions, and limited access to incomplete or even missing markets for credit and insurance.

The ex-post risk-coping strategies aim at stabilizing the consumption level of households by reducing consumption expenditure, use of credit by reallocating future resources for present consumption, selling of physical and financial assets after disasters, remittances, etc. Informal arrangements like mutual transfers (monetary remittances) from relatives, friends and neighbors may also exist (Mace, 1991; Townsend, 1994). Studies examining the consumption behavior of households to various kinds of risks do so using the full consumption insurance model. Although studies have shown that perfect risk sharing exists based on a set of assumptions (Arrow & Hahn, 1971; Coate & Ravallion, 1993; Fafchamps & Lund, 2003) in the context of developing economies, the pertinent question is whether informal insurance markets built around community or family relationships are helpful in overcoming the fluctuations in consumption faced by households in the aftermath of natural disasters. It is also observed that households often resort to using more than one coping mechanism to safeguard against shocks such as flood. Therefore, coping mechanisms cannot be considered in isolation, as pointed out by Attanasio & Weber (1993). Further, Sawada & Shimizutani (2007) argue that in the case of extraordinary shocks, the assumption of separability of coping strategies can be problematic since large shocks might substantially alter household preferences across goods and affect a household’s consumption of different items simultaneously and not separately.

With this backdrop, the present study examines the effectiveness of coping mechanisms used by households against covariate shocks generated by natural disasters like floods. We focus on the impact of floods on the livelihood of households and also study the role of household-specific characteristics in choosing a particular coping option in a rural milieu. Only a limited number of studies exist that investigate quantitatively the relationship between household-specific characteristics and the effectiveness of risk-coping mechanisms adopted based on household-level data. The study area is chosen from the state of Uttar Pradesh (UP), India, which is one of the largest and underdeveloped states in India. In terms of the Human Development Index, the state ranks 13 among the other Indian states with a value of 0.38 (reference year 2006). The eastern part of the state is one of the most vulnerable regions in India to climate-related disasters like floods. Major floods occur every 10 years and smaller ones every 1–2 years. The

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3 Data from the EM-DAT (International Disasters Database, Centre for Research on the Epidemiology of Disasters – CRED) suggest that the scale of people affected due to floods in Uttar Pradesh ranges from a high of 3 lakhs (1 lakh = 0.1 million) during the 1987 floods to a low of 0.35 lakhs during the 1971 floods. 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. Around nine districts of the eastern UP were severely affected due to the floods in 2007 with over 95,000 hectares being exposed in the two study districts. Around 600 villages were affected and around 53,730 hectares of sown area was destroyed due to these floods.
flood-affected area in eastern UP accounts for around 29% of the area of the state. The Rohini River, a part
of the Gangetic Basin, which has its headwaters in the Nepal Terai region, is primarily responsible for
floods in this region due to cloudbursts and intense rainfall events in the Nepal region. The chosen area
of the present study, Gorakhpur and Maharajganj districts, witnessed around 25 flood events during the
period 1950–2007 (Moench et al., 2008)4. In a recent study of this region, Patnaik & Narayanan
(2010) report reduction in income of the households due to recurring floods. Figure 1 shows the basin
location and its features.

3. Data source

The present study is based on household responses to natural disaster related shocks in the state of
UP. The data are drawn from primary household surveys undertaken in the study area for flood-affected
households (spread over a radius of 5–6 km)5. The region witnessed a major flood during the year 2007
due to which some households lost nearly all their productive assets, while few others were left rela-
tively unscathed. Following the theoretical framework developed by Carter et al. (2007) and Carter
& Barrett (2006) for studying the longer-term economic impacts of environmental shocks, the data col-
lection was undertaken after 6 months after the event to enable exploration of questions regarding
resilience, the speed of recovery, and to examine the effectiveness of coping mechanisms adopted by
the households. Also, waterlogging and inundation of flood water were reported for around
45–60 days of the flood and subsequently cropping activity picked up. For the household surveys,
pre-tested questionnaires in local language (Hindi) were used and a two-stage stratified sampling pro-
cedure was adopted. The complete list of villages in the two districts was compiled from the Census
of India, and the ones vulnerable to floods were arrived at in consultation with Gram Panchayat,
Secretary, Block Development Officer and disaster management officials.

The first level of stratification was at the basin level and the next on the distance of a village from river
and embankments. In the first step, villages in the entire study area were demarcated into three parts: those
in the upper basin, the ones in the middle basin, and the ones in the tail end. The level of impact due to the
flood varies across these three parts. The households residing in the upper and middle basins witness the
more instantaneous impacts of the flood whereas these impacts subside by the time water reaches the tail

4 Villages located close to the river or the embankments are vulnerable to erosion, river flooding and waterlogging. Thirteen
villages are trapped between the river and the embankment, suffering increased flooding and sand-casting. People in these
villages tend to shift their houses over the embankments, living in temporary shelters. These villages lack the most basic
infrastructure and due to waterlogging and/or regular deep flooding most of their lands have become unfit for cultivation.
There are 48 villages located within 1 km behind the embankments. Here large tracts of land remain waterlogged due to
embankment-caused flow and drainage obstructions. An additional 75 villages 1–3 km from the embankments also suffer in
years of high floods, especially when embankments are breached in the vicinity or inundation is caused by water backing
up from blocked drains. Siphons are either closed during high floods or have become useless due to silting and clogging.
About 136 out of 837 villages in the basin are directly affected by flooding often exacerbated by embankments. Another
267 villages lie unprotected within 2 km of the river, mostly in the upper reaches of the basin. Here numerous hill streams
and drainage channels cause much flooding and sand-casting (Moench et al., 2008).

5 The primary household data used for analysis in this paper were collected as a part of the United Kingdom’s Department for
International Development (DFID) sponsored project ‘From Risk to Resilience: Assessing the cost and benefits of pro-active
disaster risk management to meet the needs of vulnerable communities in South Asia’. 
Fig. 1. Location and features of Rohini basin (Source: Moench et al., 2008).
end. Those residing in the tail end are subject to more of the indirect impacts as the flood water stays in the farming fields for a longer time as compared to the upper and middle basins. In the second step, sample villages for survey were chosen from the above-demarcated regions based on their distance from river and embankments, which was classified into six categories\(^6\). Following these criteria, 17 flood-prone villages were identified across the two districts, for undertaking the survey, where around 2,000 households reside in total. Of the identified 17 villages, six were from the upper basin, another six from the middle basin, and the remaining five from the tail end. Ten percent of the total households residing in each of these villages were surveyed randomly depending on their availability and willingness to participate. Accordingly data were collected from 95 households in the upper basin, 64 households in the middle basin, and 59 households in the tail end. The data collection was done during the months January–March during the year 2008 and around 200 households are used in the analysis\(^7\). This period was chosen for data collection for two reasons: firstly, the villagers are not involved much in cultivation during this period in the study area. The primary cropping season (Kharif season in local language) ends by late October, and the next season (Rabi season) starts by October/November and lasts until March. Therefore, during the survey period the initial phase of cropping (planting of saplings) is over and households are waiting for the crop to grow before harvesting the crop in March. Secondly, the winter crop is also not the primary cropping season and hence many households do not undertake cultivation during this time.

4. Methodology and econometric issues

The vulnerability faced by the households and the effectiveness of coping mechanisms are examined using a consumption insurance and risk-sharing self-insurance framework. The risk-coping mechanisms are identified based on the relative practice of these in the study area. The empirical analysis is carried out based on probit and multivariate probit models. The empirical estimation strategy involves two stages. Firstly, we examine the changes in the consumption pattern of the households due to floods, and secondly, we identify the effectiveness of the ex-post coping behavior adopted by the households to hedge against the shocks. The first-stage estimation is based on the full consumption insurance model. As outlined by Cochrane (1991), Ravallion & Chaudhuri (1997), Saito (1999) and Sawada & Shimizutani (2007), the changes in the consumption pattern of the households are estimated using the following equation:

\[
\Delta c_i = \sum_{k=1}^{K} \delta_k R^d_k + X_i \gamma + Z_i \beta + u_i
\]

The dependent variable \(c\) in Equation (1) measures the changes in consumption of the households. \(k\) is a regional identifier and \(R^d\) is a dummy variable, which is equal to one if the \(i\)th household is located

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\(6\) The six major categories for the selection of the villages based on their distance from river and embankments are: (i) villages located between the river and the embankments; (ii) villages located between 0 and 1 km from the embankment; (iii) villages located between 1 and 3 km from the embankment; (iv) villages located between 3 and 5 km from the embankment; (v) villages located more than 5 km from the embankment; and (vi) villages not protected by any embankments.

\(7\) Although data were collected from 218 households during the survey, the data for 200 households were found to be usable after cleaning of the data.
in the region, \( k \). For the estimation purpose, area dummies are used as a proxy for \( R^d \) and control for average. The matrix, \( X \), comprises indicators capturing the changes in household income, damages to housing and assets, and crop loss. The matrix, \( Z \), represents the household-specific characteristics. The null hypothesis of the full consumption insurance market is that all the coefficients for the matrix \( X \) are jointly equal to zero. The final term on the right-hand side of the equation is a well-behaved error term. To capture changes in consumption a dummy variable, \( I_c \), is constructed, which takes the value of one if the household consumption has decreased due to the floods as compared to the average consumption level before the floods, and takes the value of zero otherwise\(^8\). Accordingly, the following binary-dependent variable model is estimated as

\[
I^c_i = \begin{cases} 
1 & \text{if } \Delta c_i \neq 0 \\
0 & \text{otherwise}
\end{cases}
\]  

(2)

The analysis is based on the assumption that the error term in Equation (1) follows normal distribution, and estimation of the models of Equations (1) and (2) is done by using the probit model. With respect to the hypothesis, it is important to note that the rejection of the null hypothesis coincides with the rejection of the necessary condition for the full insurance model. On the other hand, the failure to reject the null hypothesis does not necessarily support the full insurance model.

Secondly, we identify the effectiveness of the ex-post coping behavior adopted by the households after the incidence of floods. The econometric model is based on the self-insurance model following Zeldes (1989), Deaton (1991), Sawada (2006) and Sawada & Shimizutani (2007). The estimation involves comparing four different coping strategies using a multivariate probit framework, which allows for testing the separability of coping strategies. We identified the following coping mechanisms in the study area that households resort to: (i) receiving monetary transfers from friends and relatives (mt), (ii) relief from government agencies (rel), (iii) selling of livestock (lvs), and (iv) borrowing (bor). A number of household-specific characteristics are also considered in the model. The econometric model used for estimation is based on Flavin (1999) and Sawada & Shimizutani (2007).

\[
\Delta \text{mt}_i = S_i \theta_1 + H_i \beta_1 + \varepsilon_{1i}
\]

(3)

\[
\Delta \text{rel}_i = S_i \theta_2 + H_i \beta_2 + \varepsilon_{2i}
\]

(4)

\[
\Delta \text{lvs}_i = S_i \theta_3 + H_i \beta_3 + \varepsilon_{3i}
\]

(5)

\[
\Delta \text{bor}_i = S_i \theta_4 + H_i \beta_4 + \varepsilon_{4i}
\]

(6)

where

\[
p_{li} = 1, \quad \text{if } \Delta \text{mt}_i > 0; \text{ and } 0 \text{ otherwise}
\]

(7)

\(^8\) The household was asked about their consumption of different goods 6 months prior to the flood event and this was compared with the consumption level of the same goods after the floods.
\[ p_{2i} = 1, \quad \text{if } \Delta \text{rel}_i > 0; \quad \text{and } 0 \text{ otherwise} \]  
(8)

\[ p_{3i} = 1, \quad \text{if } \Delta \text{lvs}_i > 0; \quad \text{and } 0 \text{ otherwise} \]  
(9)

\[ p_{4i} = 1, \quad \text{if } \Delta \text{bor}_i > 0; \quad \text{and } 0 \text{ otherwise} \]  
(10)

In Equations (3)–(6), \( S \) represents a matrix of household-specific shocks generated by the flood and \( H \) is a matrix of household characteristics and other control variables. The variance-covariance matrix of \( \varepsilon_{mi} \) is symmetric and the covariances are assumed to be non-zero with the restriction condition \( \text{var}(\varepsilon_{li}) = \ldots = \text{var}(\varepsilon_{ni}) = 1 \) for identification. Under the assumption of joint normality of the error terms, a four-variable multivariate probit model is estimated. Since the intensity of risk-coping strategies cannot be observed from the present data, i.e. \( \Delta \text{mt}, \Delta \text{rel}, \Delta \text{lvs} \) and \( \Delta \text{bor} \), the dependent variables in the above equations indicate whether a household adopted a particular risk-coping device against the disasters. The independent variables in the above equations are a matrix of household-specific shock variables generated by the disaster and 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, i.e. dependent variable models. The analysis utilizes the estimation process outlined by Cappellari & Jenkins (2003) to estimate the multivariate probit model using the method of simulated maximum likelihood, also known as the Geweke-Hajivassiliou-Keane (GHK) estimator\(^9\) using STATA 9 software.

5. Results and discussion

Floods result in more direct damage, such as damage to housing structures, and wash away the standing crops. The land used for cropping also remains inundated with flood water. This leads to a shortfall in income of the households and, as a result, the occupation of the households may tend to change. For example, households employed in agriculture may seek other employment as their land may not be suitable for cultivating. Carter et al. (2007) report similar impacts after Hurricane Mitch, which resulted in losses to plantations and land in Honduras. Table 1 provides the definition of the variables used in the empirical analysis and the descriptive statistics. The majority of households in the study area depend on agriculture as their primary source of income though a few report agricultural labor and non-farm wage labor as a supplementary source of income. It is observed that 61% of the households report that their consumption has decreased post-floods as compared to earlier periods. With regard to changes in income, around 73% report a decrease in their income, which is higher than the percentage of people reporting changes in consumption. This implies that income is more volatile than consumption in the

\(^9\) 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 it is more efficient in terms of variance of the estimator of probabilities than other simulators such as the acceptance-rejection or stern simulator. It is consistent as the number of draws and the number of observations tend to infinity and thus satisfy the asymptotic property of a maximum likelihood estimator (Cappellari & Jenkins, 2003).
study area, as was also observed by Morduch (1999) and Dercon (2002) for Africa. Further, 21% of the households reported to have suffered damage to their housing structures. A majority of the households (more than 65%) have also suffered crop damage.

**Table 1. Definition and descriptive statistics of the variables used in the analysis.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>Definition</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cst</td>
<td>Consumption stress</td>
<td>Dummy = 1, if household’s consumption level was decreased due to flood; 0, otherwise</td>
<td>0.61</td>
<td>0.48</td>
</tr>
<tr>
<td>Yrdn</td>
<td>Income shortfall</td>
<td>Dummy = 1, if decrease in income was reported by the household due to flood; 0, otherwise</td>
<td>0.73</td>
<td>0.44</td>
</tr>
<tr>
<td>Hdam</td>
<td>Damage to housing structure</td>
<td>Dummy = 1, if housing damage was caused due to flood; 0, otherwise</td>
<td>0.21</td>
<td>0.41</td>
</tr>
<tr>
<td>Adam</td>
<td>Damage to other assets</td>
<td>Dummy = 1, if damage to household assets was caused due to flood; 0, otherwise</td>
<td>0.03</td>
<td>0.17</td>
</tr>
<tr>
<td>Crdam</td>
<td>Crop damage</td>
<td>Dummy = 1, if crop damage was caused due to flood; 0, otherwise</td>
<td>0.68</td>
<td>0.47</td>
</tr>
<tr>
<td>Health</td>
<td>Health shock</td>
<td>Dummy = 1, if health-related shocks were caused to the family due to flood; 0, otherwise</td>
<td>0.69</td>
<td>0.46</td>
</tr>
<tr>
<td>Ocsf</td>
<td>Occupational stress</td>
<td>Dummy = 1, if the household reports a shift in occupation due to flood; 0, otherwise</td>
<td>0.34</td>
<td>0.47</td>
</tr>
<tr>
<td>Age</td>
<td>Age</td>
<td>Age in years of the head of the household</td>
<td>50.8</td>
<td>14.06</td>
</tr>
<tr>
<td>AgeSq</td>
<td>Square of age</td>
<td>Square of the age of the head of household</td>
<td>2,777.98</td>
<td>1,449.78</td>
</tr>
<tr>
<td>Mig</td>
<td>Migration</td>
<td>Dummy = 1, if there is an out-migrant in the household; 0, otherwise</td>
<td>0.35</td>
<td>0.47</td>
</tr>
<tr>
<td>Sec</td>
<td>Level of education secondary</td>
<td>Dummy = 1, if the head is educated up to secondary level; 0, otherwise</td>
<td>0.75</td>
<td>0.43</td>
</tr>
<tr>
<td>Hsdip</td>
<td>Level of education (Hig. secondary/degree)</td>
<td>Dummy = 1, if the head is educated up to higher secondary/degree; 0, otherwise</td>
<td>0.44</td>
<td>0.49</td>
</tr>
<tr>
<td>Grad</td>
<td>Level of education (graduation)</td>
<td>Dummy = 1, if the head is educated up to graduation; 0, otherwise</td>
<td>0.03</td>
<td>0.18</td>
</tr>
<tr>
<td>RD1</td>
<td>Regional dummy 1</td>
<td>Dummy = 1, if the household lived in upper basin; 0, otherwise</td>
<td>0.47</td>
<td>0.5</td>
</tr>
<tr>
<td>RD2</td>
<td>Regional dummy 2</td>
<td>Dummy = 1, if the household lived in lower basin; 0, otherwise</td>
<td>0.31</td>
<td>0.46</td>
</tr>
<tr>
<td>Child</td>
<td>Children</td>
<td>Dummy = 1, if the household has children; 0, otherwise</td>
<td>0.81</td>
<td>0.38</td>
</tr>
<tr>
<td>Mart</td>
<td>Marital status</td>
<td>Dummy = 1, if the head of the household is married; 0, otherwise</td>
<td>0.79</td>
<td>0.4</td>
</tr>
<tr>
<td>lnY</td>
<td>Income</td>
<td>Natural log of the income of the household</td>
<td>10.35</td>
<td>0.83</td>
</tr>
<tr>
<td>lnA</td>
<td>Assets</td>
<td>Natural log of the total value of the assets of the household</td>
<td>8.74</td>
<td>1.34</td>
</tr>
<tr>
<td>L</td>
<td>Land</td>
<td>Land in acres owned by the household</td>
<td>0.78</td>
<td>1.24</td>
</tr>
<tr>
<td>mt</td>
<td>Monetary transfers from different sources</td>
<td>Dummy = 1, if the household used monetary transfers as a means of coping after the flood; 0, otherwise</td>
<td>0.15</td>
<td>0.36</td>
</tr>
<tr>
<td>rel</td>
<td>Relief</td>
<td>Dummy = 1, if the household used relief as a means of coping after the flood; 0, otherwise</td>
<td>0.26</td>
<td>0.44</td>
</tr>
<tr>
<td>lvs</td>
<td>Selling of livestock</td>
<td>Dummy = 1, if the household used selling of livestock as a means of coping after the flood; 0, otherwise</td>
<td>0.08</td>
<td>0.27</td>
</tr>
<tr>
<td>bor</td>
<td>Borrowing</td>
<td>Dummy = 1, if the household used borrowing as a means of coping after the flood; 0, otherwise</td>
<td>0.16</td>
<td>0.36</td>
</tr>
</tbody>
</table>
In the study area, health-related shocks (outbreaks of jaundice, malaria and Japanese encephalitis) are also common due to the inundated water in addition to some fatalities. Around 70% of the households report an increase in health-related expenditure. With respect to household-specific characteristics it is observed that around 47% of the households reside in the upper basin, 31% live in the lower basin, and the remaining 22% are based in the middle basin. Approximately 35% of the sample report the presence of an out-migrant in the household and the average age of the sample is 51 years. A majority of the households (81%) also report the presence of children, and the average land holding is around 0.78 acres. A majority of the sample has been educated up to matriculation (10 years of schooling). With respect to coping variables, it is observed that households resort to a mix of coping options simultaneously. A large proportion (26%) depends on relief from governmental and non-governmental organizations\textsuperscript{10}. Around 16% depend on borrowing from informal sources as a means of coping\textsuperscript{11}. Households also use monetary transfers from friends and relatives to cope with the impacts of flood (15%), and a small fraction (8%) sell their livestock to augment their income and make up for the losses to consumption due to floods.

5.1. Consumption behavior of households

The first part of the analysis corresponds to the estimation of a probit model to study the impact shocks generated by the floods on the households. The dependent variable used in the analysis is a dummy variable representing the changes in the consumption of households due to floods. Table 2 reports the results obtained from the estimation.

From Table 2, it can be observed that reduction of the consumption level of the households after the floods is explained by (i) reduction in the income of the households and (ii) the damage suffered by the household to its housing structure and crops. The magnitude of coefficients for the variables, reduction in income, and housing damage and crop loss, is quite high, as indicated by their marginal values suggesting lack of insurance for physical assets and it also elucidates that formal insurance schemes of the government are not successful in providing a stable income stream for households. This is in line with the findings of Alderman & Paxson (1992) about the absence of formal insurance markets in developing countries. With respect to the household-specific characteristics, it is observed that the households with presence of children and possessing land are less likely to change their consumption behavior. The presence of children may provide the households with income-supplementing options, as observed by Jacoby & Skoufias (1997) that in some villages in South India households send their children to work to supplement income after adverse shocks. Households with a higher value of assets are more likely to change their consumption patterns than those with a lower value of assets. The moderate value for the coefficient of variation is due to the cross-sectional nature of the data. However, the Wald statistic is quite high and significant, rejecting the null hypothesis of complete insurance.

\textsuperscript{10} The relief involves the distribution of food supplies, kitchen sets, blankets, mosquito nets, tarpaulins and safe and clean drinking water; however, the major constituent of relief is the distribution of food packets.

\textsuperscript{11} Borrowing included those from non-formal sources (in the present case, mostly moneylenders) where the borrower had to pay interest and the rate of interest was very high, in excess of 30%.
5.2. Effectiveness of coping mechanisms of households

The second stage in the estimation involves comparing the effectiveness of four coping mechanisms adopted by households based on a multivariate probit model. The results are exhibited in Table 3.

The results suggest that risk-coping strategies are specific to the nature of the loss caused by the disasters on the households. Different means of coping or a combination of coping measures are used by the households to compensate against the losses. Monetary transfers from friends, relatives and other sources are examples of informal risk-sharing arrangements. Although complete risk sharing through these instruments is rejected by many studies for countries like the USA, India and Ethiopia, evidence of partial risk sharing is found (Townsend, 1994; Hayashi et al., 1996; Dercon & Krishnan, 2000). In the present case, the results suggest a negative relationship between the health shocks and the monetary transfers, implying that households do not depend on transfers from friends and relatives as a means of coping to cover for health-related impacts post flood event. The positive sign of the occupational shock coefficient indicates that households use monetary transfers in meeting the occupational shifts required during the post-disaster phases. With respect to household-specific variables, it can be observed that migration and income are significant. The positive sign for both of these coefficients indicates that households reporting migrant members in the family use monetary transfers as a coping mechanism. The level of education (graduation) has a negative sign and is highly significant, indicating that educated people are not likely to depend on monetary transfers for coping with floods. The variable age and age square are also significant with the interactive term, age square, being added to check for cyclical effects. Age has a positive impact on the probability of adoption of monetary transfers as a coping mechanism, which also might be capturing the life-cycle effects. Older people who have fewer years to live

Table 2. Estimation results for the consumption insurance model.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Coefficients</th>
<th>Robust std. errors</th>
<th>Marginal effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yrdn</td>
<td>1.115***</td>
<td>0.227</td>
<td>0.421</td>
</tr>
<tr>
<td>Hdam</td>
<td>0.634**</td>
<td>0.253</td>
<td>0.218</td>
</tr>
<tr>
<td>Crdam</td>
<td>0.346*</td>
<td>0.215</td>
<td>0.132</td>
</tr>
<tr>
<td>Health</td>
<td>0.067</td>
<td>0.228</td>
<td>0.025</td>
</tr>
<tr>
<td>Age</td>
<td>0.04</td>
<td>0.042</td>
<td>0.015</td>
</tr>
<tr>
<td>AgeSq</td>
<td>-0.0004</td>
<td>0.0004</td>
<td>-0.0001</td>
</tr>
<tr>
<td>Mig</td>
<td>-0.131</td>
<td>0.221</td>
<td>-0.049</td>
</tr>
<tr>
<td>Child</td>
<td>-0.646***</td>
<td>0.276</td>
<td>-0.22</td>
</tr>
<tr>
<td>Mart</td>
<td>0.208</td>
<td>0.241</td>
<td>0.08</td>
</tr>
<tr>
<td>Sec</td>
<td>0.148</td>
<td>0.295</td>
<td>0.056</td>
</tr>
<tr>
<td>Hsdip</td>
<td>-0.055</td>
<td>0.226</td>
<td>-0.02</td>
</tr>
<tr>
<td>Grad</td>
<td>-0.154</td>
<td>0.549</td>
<td>-0.059</td>
</tr>
<tr>
<td>L</td>
<td>-0.232**</td>
<td>0.117</td>
<td>-0.087</td>
</tr>
<tr>
<td>lnA</td>
<td>0.248**</td>
<td>0.11</td>
<td>0.093</td>
</tr>
<tr>
<td>RD1</td>
<td>-0.154</td>
<td>0.293</td>
<td>-0.058</td>
</tr>
<tr>
<td>RD2</td>
<td>-0.75***</td>
<td>0.309</td>
<td>-0.287</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.986**</td>
<td>1.445</td>
<td></td>
</tr>
</tbody>
</table>

Wald chi²(20) = 45.49***.
Pseudo $R^2 = 0.207$; Efron’s $R^2 = 0.264$.
***, ** and * denote significance at 1, 5 and 10%, respectively; $N = 200$. 

5.2. Effectiveness of coping mechanisms of households

The second stage in the estimation involves comparing the effectiveness of four coping mechanisms adopted by households based on a multivariate probit model. The results are exhibited in Table 3.

The results suggest that risk-coping strategies are specific to the nature of the loss caused by the disasters on the households. Different means of coping or a combination of coping measures are used by the households to compensate against the losses. Monetary transfers from friends, relatives and other sources are examples of informal risk-sharing arrangements. Although complete risk sharing through these instruments is rejected by many studies for countries like the USA, India and Ethiopia, evidence of partial risk sharing is found (Townsend, 1994; Hayashi et al., 1996; Dercon & Krishnan, 2000). In the present case, the results suggest a negative relationship between the health shocks and the monetary transfers, implying that households do not depend on transfers from friends and relatives as a means of coping to cover for health-related impacts post flood event. The positive sign of the occupational shock coefficient indicates that households use monetary transfers in meeting the occupational shifts required during the post-disaster phases. With respect to household-specific variables, it can be observed that migration and income are significant. The positive sign for both of these coefficients indicates that households reporting migrant members in the family use monetary transfers as a coping mechanism. The level of education (graduation) has a negative sign and is highly significant, indicating that educated people are not likely to depend on monetary transfers for coping with floods. The variable age and age square are also significant with the interactive term, age square, being added to check for cyclical effects. Age has a positive impact on the probability of adoption of monetary transfers as a coping mechanism, which also might be capturing the life-cycle effects. Older people who have fewer years to live
are less willing to depend on monetary transfers from friends and relatives to cope with the floods as compared to the younger generation. Older people have limited access to employment and income-generating activities compared to younger people and hence may not be sure whether they will be able to repay the transfers over due course of time. A related finding was also arrived at by Sawada & Shimizutani (2007) with reference to Kobe earthquake in Japan where they found that older people are more likely not to save compared to younger people in order to cope with shocks.

Relief provided by the government agencies and non-governmental organizations during the post-flood phase is one of the major means of coping that is used by households reporting occupational loss due to floods. It is also used by households to cover for the loss in consumption and occupational stress. With respect to household-specific characteristics, education, marital status, level of income and the regional dummies turn out to be significant. The regional dummies and level of income exhibit a positive sign, highlighting that the households living in the upper and the lower basins and those with higher income use relief as a means of coping.

Table 3. Estimation results for the multivariate probit model.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coping mechanisms</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cst</td>
<td>mt</td>
<td>rel</td>
<td>lvs</td>
<td>bor</td>
</tr>
<tr>
<td>−0.012 (0.262)</td>
<td>0.527*** (0.22)</td>
<td>0.396 (0.341)</td>
<td>−0.106 (0.309)</td>
<td></td>
</tr>
<tr>
<td>Hdam</td>
<td>−0.198 (0.286)</td>
<td>−0.148 (0.245)</td>
<td>0.095 (0.31)</td>
<td>−0.528* (0.311)</td>
</tr>
<tr>
<td>Adam</td>
<td>0.288 (0.601)</td>
<td>0.236 (0.653)</td>
<td>0.259 (0.708)</td>
<td>−3.738*** (0.419)</td>
</tr>
<tr>
<td>Crdam</td>
<td>0.209 (0.279)</td>
<td>0.117 (0.232)</td>
<td>0.432 (0.325)</td>
<td>0.159 (0.298)</td>
</tr>
<tr>
<td>Health</td>
<td>−0.524** (0.24)</td>
<td>0.182 (0.214)</td>
<td>0.226 (0.309)</td>
<td>−0.19 (0.303)</td>
</tr>
<tr>
<td>Ocst</td>
<td>0.801*** (0.238)</td>
<td>0.75*** (0.213)</td>
<td>0.519* (0.285)</td>
<td>0.189 (0.289)</td>
</tr>
<tr>
<td>Age</td>
<td>0.114** (0.063)</td>
<td>0.04 (0.05)</td>
<td>0.61 (0.078)</td>
<td>−0.012 (0.034)</td>
</tr>
<tr>
<td>AgeSq</td>
<td>−0.001* (0.0005)</td>
<td>−0.0003 (0.0004)</td>
<td>−0.0006 (0.0007)</td>
<td>0.0002 (0.0003)</td>
</tr>
<tr>
<td>Mig</td>
<td>0.503** (0.242)</td>
<td>−0.169 (0.228)</td>
<td>0.358 (0.317)</td>
<td>0.377* (0.231)</td>
</tr>
<tr>
<td>Sec</td>
<td>−0.286 (0.306)</td>
<td>0.265 (0.288)</td>
<td>−0.116 (0.32)</td>
<td>−0.018 (0.495)</td>
</tr>
<tr>
<td>Hsdip</td>
<td>0.238 (0.253)</td>
<td>0.206 (0.236)</td>
<td>−0.462* (0.274)</td>
<td>0.441 (0.312)</td>
</tr>
<tr>
<td>Grad</td>
<td>−6.266*** (0.683)</td>
<td>−0.894* (0.559)</td>
<td>−4.484*** (0.477)</td>
<td>1.079* (0.676)</td>
</tr>
<tr>
<td>Child</td>
<td>0.068 (0.301)</td>
<td>−0.181 (0.254)</td>
<td>0.192 (0.362)</td>
<td>−0.018 (0.352)</td>
</tr>
<tr>
<td>RD1</td>
<td>0.245 (0.332)</td>
<td>0.701*** (0.302)</td>
<td>0.148 (0.369)</td>
<td>−0.241 (0.325)</td>
</tr>
<tr>
<td>RD2</td>
<td>0.436 (0.358)</td>
<td>0.749*** (0.305)</td>
<td>−0.35 (0.442)</td>
<td>−0.567 (0.417)</td>
</tr>
<tr>
<td>Mart</td>
<td>0.26 (0.317)</td>
<td>−0.747*** (0.245)</td>
<td>−0.012 (0.401)</td>
<td>−0.374 (0.309)</td>
</tr>
<tr>
<td>L</td>
<td>0.11 (0.13)</td>
<td>−0.103 (0.137)</td>
<td>0.096 (0.225)</td>
<td>0.233*** (0.125)</td>
</tr>
<tr>
<td>lnY</td>
<td>0.33* (0.192)</td>
<td>0.525*** (0.218)</td>
<td>−0.24 (0.263)</td>
<td>−0.103 (0.194)</td>
</tr>
<tr>
<td>Constant</td>
<td>−8. 236*** (2.278)</td>
<td>−7.923*** (2.173)</td>
<td>−1.492** (2.698)</td>
<td>−0.432 (1.984)</td>
</tr>
</tbody>
</table>

Wald $\chi^2(76) = 2810.50***.$
Likelihood ratio test: $\chi^2(6) = 42.657***.$
Huber White consistent robust standard errors are shown in parentheses.
***Indicates statistical significance at 1% level.
**Indicates significance at 5% level.
*Indicates statistical significance at 10% level; $N = 200.$
significant, indicating that households resort to selling of livestock as a means to cover for the occupational damage. The dummy variable showing the level of education (graduation) is also significant along with the level of education (higher, secondary/diploma) with the negative sign implying that households where the head is educated up to these levels are not likely to resort to selling of livestock as a means of coping against floods in the study area. This could be because with higher education people have access to greater employment opportunities and hence want to maintain the level of livestock.

With respect to borrowing as a means of coping, Eswaran & Kotwal (1989) suggest that credit serves as a substitute for formal and informal insurance. In the present case three shock variables (capturing damage to housing structure and assets) are significant. This suggests that households are not likely to use this option for repairing and reconstruction of their houses and other assets. The dummy variable showing the level of education is also significant, implying that households where the head is educated up to graduate level are likely to resort to borrowing as a coping mechanism. Households having land are likely to use borrowing as a coping strategy, suggesting collateralized lending. Similarly households having migrant members are like to use borrowing as a means of coping, highlighting the role of remittances.

The correlation between the errors assumes importance because of the assumption of separation of coping strategies as outlined in the previous section. The high value of likelihood test statistics rejects the null hypothesis that the correlations are jointly equal to zero. The value of the log-likelihood function is quite high and rejects the null hypothesis of independent error terms, a finding that supports the adoption of the multivariate probit model. Table 4 shows the correlation coefficients between the error terms of the multivariate probit regression.

The positive relationship between the error terms of the transfers and relief equations suggests that households who get transfers also benefit from the relief activity undertaken after the floods. Another important finding that emerges is that households resort to a mix of coping strategies, for example, households who gain from monetary transfers from friends and relatives might resort to relief as a means of coping. However, no such supplementary relationship exists between selling of livestock and borrowing. Further, households who report to have suffered an occupational shock resort to a combination of coping options, such as monetary transfers, relief and selling of livestock, as a means of coping against the shock.

6. Conclusion

The paper analyzed the impact of floods on the households and effectiveness of coping mechanisms adopted by them based on a rural Indian setting. The main objective was to study the impact of floods on

<table>
<thead>
<tr>
<th>Correlation between</th>
<th>Coefficient</th>
<th>Robust S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e_2$ and $e_1$</td>
<td>0.808***</td>
<td>0.083</td>
</tr>
<tr>
<td>$e_3$ and $e_1$</td>
<td>-0.029</td>
<td>0.163</td>
</tr>
<tr>
<td>$e_4$ and $e_1$</td>
<td>-0.263</td>
<td>0.257</td>
</tr>
<tr>
<td>$e_3$ and $e_2$</td>
<td>-0.11</td>
<td>0.153</td>
</tr>
<tr>
<td>$e_4$ and $e_2$</td>
<td>0.04</td>
<td>0.16</td>
</tr>
<tr>
<td>$e_4$ and $e_3$</td>
<td>-0.294*</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Huber White consistent robust standard errors are shown; *** indicates statistical significance at 1% level; * indicates statistical significance at 10% level.
the consumption behavior of the households and analyze the effectiveness of various coping options used by the households. The hypothesis of full consumption insurance implies that households do not have access to formal or informal insurance mechanisms to cover the shortfall in consumption due to floods. Household-specific characteristics have a limited role to play with respect to the observed consumption shortfall. Location of the households (upper basin or lower basin) is found to be a significant factor influencing the consumption changes exhibited by the households after the floods.

With respect to the effectiveness of coping mechanisms, the options chosen for consideration were based on the relative practices in the affected area. We do not find evidence of full risk sharing, as also reported by Alderman & Garcia (1993), Deaton (1992) and Morduch (2002). Households adopt a wide variety of risk-coping measures but the means of coping are specific to the nature of the shocks created by the disasters. A comprehensive response to risk should focus on strengthening the asset base of the poor and combine it with an effective and credible ex post support system, as also observed by Dercon (2002). While monetary transfers are used by households to cope with occupational shocks they are not likely to be used to cope with health shocks. Relief is primarily used by households to cope with the shortfall in consumption. There is evidence that households resort to selling of livestock to cover for the occupational loss due to floods; however, households with a higher level of education of the household head are not likely to choose selling of livestock as a coping strategy. The higher level of education may provide the household with options to diversify income or to enter into activities with low entry costs such as non-agricultural employment, as also observed by Dercon & Krishnan (1996) in Ethiopia and Tanzania.

Policy-makers in developing countries face multiple development challenges and hence concentration should be on increasing the adaptive capacity to deal with climatic extremes like floods. It can be achieved at a meso-level by empowering groups of households by providing them with adequate employment opportunities and at a macro-level by introducing water-related disaster countermeasures as advocated by Dercon (2002), Dercon & Krishnan (2002) and Adikari et al. (2013). The analysis carried out in this study suggests that disaster mitigation policies need to be integrated with poverty alleviation measures in particular, in line with Hosterman et al. (2012). A number of interventions for income enhancement and livelihood diversification are undertaken by developing countries (e.g. Mahatma Gandhi National Rural Employment Guarantee Act, Backward Regions Grant Fund, Indira Awas Yojana, etc. in the case of India). The key is to undertake activities under the above-named interventions that enhance disaster risk reduction, reduce fluctuations in income and target introducing effective flood and water management systems, which in turn will be helpful in raising the adaptive capacity of households.

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