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Coping with Floods: Does Rural-Urban Migration Play any Role for Survival in rural Bangladesh?

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Abstract. At the time of flooding, rural people in Bangladesh cannot manage the lingering effects of labor market disruptions, price fluctuations, and consumption deficiency. As a consequence, kin groups, lineages or even entire villages shift from their home to nearby big urban areas. To assess the efficacy of migration, a cross sectional household survey was carried out two weeks after a flood in four districts of Bangladesh in the year 2005. In total, 595 rural households were interviewed based on fully structured questionnaires. The results show that the decision to migrate is often guided by the aspiration to replenish asset values damaged by the flood. Thus, rural-urban migration emerges as a source of credit. Inclusion of social networks plays an important role during flood crisis to get information about the host areas. In financing livelihoods during floods, landless or poor people incur informal debts from the money lenders; this in turn accumulated by the consecutive years of flooding, leave a shadow of default and liquidation over many vulnerable households. The rural-urban migration allows potentially vulnerable households to avoid a debt cycle.

Keywords: *Bangladesh, Flood, Coping, Migration, Vulnerability*

1. Introduction

Bangladesh consists mostly of a low-lying river delta with over 230 rivers and tributaries, situated between the foothills of the Himalayas and the Bay of Bengal. With a population of almost 124 million people and an area of roughly 148,000 square km, Bangladesh is one of the world's most densely populated countries (839 persons per square km)[27].

The combination of its geography, population density, and extreme poverty makes Bangladeshi people very vulnerable to risks and disasters. Flood is a frequent catastrophe for Bangladeshi people. In the year 1987, about 40 percent of the country was flooded, affecting 30 million people and

[27]Bangladesh Bureau of Statistics, Population Census 2001, published July 2003.

causing about 1,800 deaths. The floods in 1988 were even more serious, covering about 60 percent of the land area, affecting about 45 million people, and causing more than 2,300 deaths[28]. In 1998, over 68 percent of the country was inundated[29] and caused about 2,380 deaths. In 2000 and 2002, floods affected approximately 20 million people. In the year 2004, a devastating monsoon flood submerged two-thirds of the country; close to 36 million people were affected, 726 died, and millions of people were made homeless[30]. Also in 2005, floods occurred again in some areas of Bangladesh, affecting people's livelihood, assets and activities. The frequent cases of floods and river-bank erosions are found as significant causes for homelessness, landlessness and consequent migration for many thousand people every year[31].

Migration is denoted as a component of people's livelihood strategies and in shaping the national economy in Bangladesh. Natural disasters play a part in forcing people to migrate and cope with vulnerability. Rural-urban migration is playing a significant role in this process. The net migration (migrants/1000 population) increased dramatically from 1.2 to 16.4 in urban areas between 1984 and 1998[32]. A study by Rahman et al., accumulating the information from 62 randomly selected villages in Bangladesh, shows that nearly two-thirds of the emigration from rural areas was to urban areas[33].

This study thus is set forth to examine whether rural-urban migration, which involves both permanent and temporary moves in search for better livelihoods, mitigate the vulnerability of flooded households. In addition, the role of social networks for rural-urban migration is analyzed.

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[28] Irrigation Support Project for Asia and the Near East, "Flood response and guidelines on planning flood proofing", *Bangladesh Flood Action Plan* (1993: FAP 14/ FAP 23).

[29] Carlo del Ninno, Paul Dorosh, L.C. Smith, and D.K. Roy, "The 1998 floods in Bangladesh: disaster impacts, household coping strategies, and response", *Research Report, International Food Policy Research Institute,* (Washington, D.C: 2001).

[30] http://www.adb.org/Documents/Economic_Updates/BAN/2004/eco-update-ban.pdf (last accessed 11.10.2007).

[31] James Lewis, *Development in Disaster-prone Places*, Studies of Vulnerability, Intermediate Technology Publications, London: 1999).

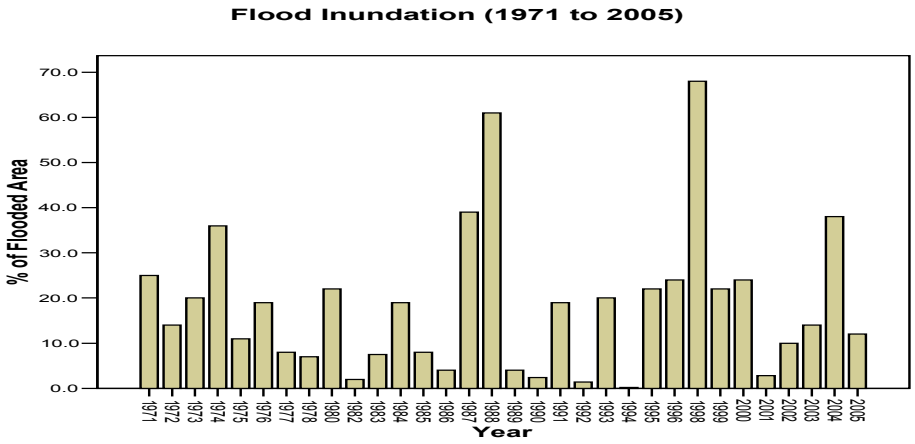
[32] Rita Afsar, "Internal Migration and the Development Nexus: The case of Bangladesh", in *Migration and Development: Pro-Poor Policy Choices*, ed. Tasneem Siddiqui (The University Press Limited, Dhaka, Bangladesh, 2005). 39-63.

[33] H. Z. Rahman, M. Hossain, and B. Sen, "1987-94 Dynamics of Rural Poverty in Bangladesh", *Report in Bangladesh Institute of Development Studies* (1996).

2. Flood as a Frequent Disaster in Bangladesh

Flood is a natural calamity which occurs by huge rainfalls followed by the overflow of riverbanks. Usually floods occur at the bottom of a valley and in coastal areas. There are numerous causes of floods but the basic one is climatologic. The south-western monsoon causes heavy rainfall in mid-June to mid-September in Bangladesh. The average annual rainfall ranges from 1,693 mm to 3,801 mm, and more than 80 percent of rainfall occurs during the monsoon season[34]. There are also backwater effects of the tides of the Bay of Bengal as those slow down the drainage of the flood water that inundates the low-lying areas and river basins in the southern and north-eastern parts of the country. In addition, the high water level of the major rivers slows down the discharge flow of the tributaries and distributaries. The average water level of the sea rises during the monsoon season and slows down the discharge flow of the rivers, which in turn causes floods in the adjacent coastal areas. There are some other climatologic reasons for devastating floods in Bangladesh, such as tsunamis, earthquakes and high rate of sedimentation. The figure below shows the frequency of floods and the percentage of inundation area of Bangladesh since independence in 1971.

Figure 1: Flood inundation in Bangladesh, 1971-2005



Source: Bangladesh disaster management bureau

[34] Bangladesh Bureau of Statistics, *Statistical Pocketbook of Bangladesh 2003*, (January 2005).

The topography of the country is also one of the major causes of flooding. The height above the mean sea level ranges from 60 m at the northern tip to less than 3 m at the southern coast[35] and 50 percent of the country is situated within the 8 m contour line with respect to the mean sea level[36]. Moreover, deforestation in the upstream, mainly in India and Nepal, worsens the floods downstream, namely in Bangladesh.

The frequent floods severely disrupt the livelihoods of millions of people. Aftermath flood disease causes severe health hazards. Wage laborers often suffer during floods, because the scopes of work and wage rates shrink at that time. It is estimated that real wages fall by more than 10 percent during the floods[37]. The most direct disastrous impact of flooding in Bangladesh arise from damage to standing crops, affecting the small farm holders significantly. As a consequence, poorer households fall into debt and lastly choose to migrate in nearby cities to enhance their livelihoods. In an empirical study on the impact of floods in the year 1988, researchers found that widespread increase of family migration was high for landless households who could not manage the lingering effects of labor market disruptions, price fluctuations and increased competition for formal and informal credit[38].

3. Data and Methodology

This study uses primary data from a sample survey conducted in rural Bangladesh just after the flood in 2005. During that year, Bangladesh was affected by two types of floods: a monsoon flood which occurred during mid August to September in the east and west parts of the country and a flash flood which occurred in the northern areas during November. Monsoon floods in Bangladesh

[35] M. Hossain, A.T.M.A. Islam and A.K. Saha, "Flood in Bangladesh: Recurrent Disasters and People's Survival", (University Research Centre, Dhaka, Bangladesh, 1987).

[36] M. Ahmad, "Deluge in the Delta", in *Flood in Bangladesh*, ed. Ahmed M., (Community Development Library, Dhaka, Bangladesh, 1989).

[37] Jean-Paul Azam, "The impact of floods on rural real wages in Bangladesh", *The Bangladesh Development Studies*, XXI 1 (1993):1-14.

[38] Randall Kuhn, "The Logic of Letting Go: Family and Individual Migration from Rural Bangladesh". *Working paper at Institute of Behavioral Science*, (2002: University of Colorado at Boulder).

are caused by heavy monsoon rains over the Himalayas and overflow of the Ganges-Brahmaputra rivers and their tributaries. Flash floods often occur in hill streams over the Meghna-river basin.

A cross-sectional household survey was carried out two weeks after the floods. Four districts were randomly chosen according to the flood proneness and damage. A three stage stratified random sampling technique was applied to the survey, where the first stage was the district, the second one the mouza (the smallest administrative unit in the rural area) and the third stage the household level. Flooded households were detected if at least the home or homestead was submerged by flood water. The sample size was determined by the estimated proportion formula[39]. The total number of surveyed households from different rural areas amounted to 595. The survey include some questions about fixed household's characteristics such as age, gender, education, occupation; related to household variables such as monthly income, or expenditure; and information about temporary migration during flood periods, as well as permanent migration.

To analyze the poverty and vulnerability of households in the context of migration, the following concepts have been used:

Poverty can be defined in multidimensional ways. It is an ex-post measure of household's wellbeing. Poverty refers to being deprived of basic levels of economic wellbeing (absolute income poverty) and human development including universal primary education, girl's access to primary and secondary education, infant, child and maternal mortality[40]. It is also characterized as the deprivation of capabilities[41].

Vulnerability, on the other hand, is an ex-ante measure of household's wellbeing and concerning the future poor. Vulnerability is always defined relative to some benchmark. Vulnerability may be the product of risk, household condition and actions. The term that distinguishes or relates poverty and vulnerability is risk[42]. The risk of a household relates to events possibly occurring, but with less than certainty. Households may have a priori sense of the likelihood of some events occurring, without overall knowledge of this likelihood. Completeness of the

[39] William G. Cochran, *Sampling Techniques*, (3rd Edition, John Wiley, 1977): 75.
[40] Stefan Dercon, "Assessing vulnerability to poverty", *working paper at Centre for the Study of African Economies*, (2001: University of Oxford).
[41] Amartya K. Sen, *The Standard of Living*, (Cambridge University Press, Cambridge, 1987).
[42] Shubham Chaudhuri, "Assessing Vulnerability to Poverty: concepts, empirical methods, and illustrative examples", (2003: Columbia University, New York, mimeo).

distribution distinguishes risk from the concept of uncertainty, where the probability of an event occurring is assumed to be unknown. Risky events may relate to the environment or climate, to the death of a person, or to any action taken by households. Such kinds of risks may be upside or downside. This study is focusing more on the downside risk effect on the households of rural Bangladesh, albeit some fishermen or boatmen may increase their income from flooded season. Downside risk is defined here as the estimate of the potential that a security, income, expenditure or overall livelihoods might decline in real value if the area is flooded.

Working Concept of Household Vulnerability

A household is said to be vulnerable to future loss of welfare below some socially accepted norm(s) caused by risky events. The degree of vulnerability depends on the characteristics of the risk and the household's ability to respond to risk. Ability to respond to risk depends on household characteristics, notably their asset base. The expected future outcome is defined with respect to some specified benchmark—a socially accepted minimum reference level of welfare (poverty line, nutritional standards). Measurement of vulnerability also depends on the time horizon: a household may be vulnerable to risks over the next month, year, etc. Thus, households are vulnerable *to* suffering an undesirable outcome, and this vulnerability comes *from* exposure to risk[43].

Some general principles related to vulnerability as a concept include: (a) it is forward-looking and defined as the probability of experiencing a loss in the future relative to some benchmark of welfare, (b) a household can be said to be vulnerable to future loss of welfare and this vulnerability is caused by uncertain events, (c) the degree of vulnerability depends on the characteristics of the risk and the household's ability to respond to the risk, (d) vulnerability depends on the time horizon, in that a household may be vulnerable to risks over the next month, year, etc. and responses to risk take place over time, and e) the poor and near-poor tend

[43] Karin Heitzmann, R. Sudharshan Canagarajah, and Paul B. Siegel, "Guidelines for assessing the sources of risk and vulnerability", *Social Protection Discussion Paper* (2002: 0218. Washington, D.C.: World Bank).

to be vulnerable because of their exposure to risks and limited access to assets (broadly defined) and limited abilities to respond to risk[44].

4. Results of the Case Studies

The following part delineates the empirical results from the field survey and relates these to some literature review and theoretical point of views. It will be first investigated what types of migration occur in Bangladesh due to floods, and how these different types relate to poverty and vulnerability of households. Special attention will be put on the reasons for migration, and the role of social networks in the context of migration. What follows is a more detailed analysis of income sources and their relations to vulnerability, as well as an analysis to what extent migration impact on the household members who stayed behind.

4.1 Synopsis of Migrants

The interview was conducted by asking the respective household head or representative. All members sharing the same kitchen were defined as belonging to the household; any member who lives outside the residence but who contributes to the household's resources, is denoted as migrant. Out of 595 rural households, 168 (28%) households indicate that they have at least one migrant. 79 percent of these 168 households have only one migrant, others have more than one. The following Table 1 shows different types of migration of the flooded households.

Table 1: Types of migration

Type	Frequency	Percentage
From village to village	10	6
From village to nearby city	150	89
From village to outside country	8	5

Source: Own survey results, total households = 595, migrant households = 168.

[44] Jeffrey Alwang, P. B. Siegel, and S. L. Jørgensen, "Vulnerability: A view from different disciplines", *Social Protection Discussion Paper* (2001: 0115. Washington, D.C.: World Bank).

From the above it is depicted that most of the flooded households (89 percent) migrate from the rural area to the nearby city. Only 6 percent of the households move to another village, while 5 percent decide to move to another country. Now, the general question arises why 89 percent of migrant households choose a nearby city?

This study starts searching on the basis of the theoretical literature which offers two models in this context. The Harris-Todaro model is based on a neo-classical response to urban-rural wage differentials[45], while the Massey-Parrado model is from the new economic theory of migration which anticipates migration from areas with limited credit and capital markets[46]. The first neo-classical model only focuses on the migration's role in generating labor market equilibrium, return of remittance in origin areas and the migrants' knowledge of expected returns. The Harris-Todaro model predicts that migration is more likely if an individual's expected income in the destination area, arising from the expected wage times the probability of employment, is higher than income from the current origin area. Asking about reasons for migration, it is found from the empirical analysis that 83 percent of the migrants' households see unemployment and deficiency of capital market formation due to frequent floods as the main reasons for migration, 5 percent of the head of the households with emigrants gave wage differentials as a cause. Only 3 percent indicate education as a main reason for migrating, and the remaining 9 percent of households with migrants said better employment and high wage in nearby cities as well as loan repayment impelled the migrated members to move, despite they were employed in the rural areas with low wages.

As an agro-based country, majority of the households in Bangladesh depend on underwater cultivation of rice during the flood season (June-September) as a primary staple crop. Small landholders overcome flood-season deficits by taking loans in terms of high, pre-harvesting grain prices

[45] John R. Harris and Michael P. Todaro, "Migration, Unemployment and Development: A Two Sector Analysis", *American Economic Review* 60(1), (1970): 126-142.
[46] Douglas S. Massey and Emilio A. Parrado, "Migradollars: The Remittances and Savings of Mexican Migrants to the United States", *Population Research and Policy Review*, 13 (1994:3-30).

and repaying the loans with lower, post-harvest prices[47]. This type of yearly cycle of debt dependence often leads small landholders to default, land mortgage, and oreclosure[48]. Remittances sent by the emigrants to the places of origin, like rural areas, would reduce the need to incur debt. The results demonstrate inclination to the Massey-Parrado model of limited credit and capital markets. However, the two models are not mutually exclusive; some justifications for the wage differentials are also found from the data set, supporting the Harris-Todaro model.

4.2 Income Quartile and Migration Cost

Migration can take different modes by being either temporary or permanent, or by selecting different household members to migrate. The mode of migration also depends on to which income quartiles the households belong. Households from the richest quartile would send the most efficient member to a new destination area being located either within or outside the country. In fact, the 5 percent migrants from village to outward country in Table 1 are all from the richest income quartile, those who could also bear the migration cost. However, households from the poorest quartile would choose preferably temporary migration during the flood period and in the extreme case, landless households would undertake family migration for survival because their rural options would hold little value. All village to village migration in Table 1 occurred indeed from the poorest quartile households. The major proportion of rural-urban migration (about 70 percent) arises from the 2nd and 3rd quartiles income groups. It is an interesting finding that households in the poorest group are mostly vulnerable but migration rate is higher in middle income group. The reason might be that rural-urban migration is highly constrained by the migration cost.

[47] Eirik G. Jensen, "Rural Bangladesh: Competition for Scarce Resources", (1987: University Press Limited, Dhaka, Bangladesh).
[48] Randall Kuhn, "The Logic of Letting Go: Family and Individual Migration from Rural Bangladesh". *Working paper at Institute of Behavioral Science*, (2002: University of Colorado at Boulder).

4.3 Social Network and Migration

This study also focuses on the role of village-based social networks in perpetuating the flow of rural-urban migration. According to Kuhn[49],

> *"The decision to migrate is often guided by a desire to restore or replenish a family's agricultural tradition and resources, yet ironically the success of migration is often determined by the extent of a family's resources. And more often than not, the opportunity to migrate is determined by social linkages based in the village."*

About 79 percent of migrant households said they had known someone in the destination place. In the context of migration, networks function as a form of credit and information source for the potential migrants. This study examines the strength of weak ties for rural-urban linkage[50]. Weak ties are defined as acquaintances being less likely socially involved with one another compared with strong ties arising from close relatives or friends. According to the Granovetter[51],

> *"…individuals with few weak ties will be deprived of information from distant parts of the social system and will be confined to the provincial news and views of their close friends. … the weak ties have a special role in a person's opportunity for mobility."*

Empirical work also supports the above stated theory of networks and weak ties for enhancing rural-urban migration. About 72 percent of the households reported that rural-urban migration was motivated by friends already living in the destination places. Those who migrated received the information from former village friends or neighbors in urban areas, which indicates the strength of weak ties. 26 percent of households indicated that their migrated members shifted to urban places with the help of close relatives or friends (strong ties), and the remaining 2 percent was based on organizational links and networks.

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[49] Randall Kuhn, "Identities in Motion: Social Exchange Networks and Rural-Urban Migration in Bangladesh", *Working paper at Institute of Behavioral Science*, (2002: University of Colorado at Boulder).
[50] Mark Granovetter, "The Strength of Weak Ties: A Network Theory Revised", *Sociological Theory*, 1 (1983): 201-233.
[51] Ibid

4.4 Income Sources and Vulnerability

A more detailed analysis aims at finding out which groups of households are more vulnerable to floods depending on the source of income, including remittances. As it can be seen from Table 2, most households derive their income from agriculture and from day labor. These households also belong to the poorest and most vulnerable households after a flood event. Less poor and vulnerable households are either employed in the services sector, or they have their own business.

Table 2: Sources of income and vulnerability after flood

Source of income of main earner	Distribution of households in frequency	After flood	
		Poverty	Vulnerability
Agriculture	29.4	67.23	93.79
Service	7.7	35	39.5
Business	13.8	37.35	45.78
Day labor	26.5	77.5	90
Dairy & Poultry	5.3	28.57	50
Fishing & Boating	5.55	64.71	61.53
Remittances from migration (urban)	8.8	24.15	25.44
Remittances from migration (other villages and foreign countries)	2.95	18.63	29.66

Note: methodology and sensitivity analyses are shown in the appendix
Source: Own survey results.

The least vulnerable households are those whose major source of income is remittances from urban migrants. However, their poverty level due to flood is

slightly higher than in the household group receiving remittances from urban migrants.

4.5 Consequences of Migration

If households suffer from a shock like a flood, they utilize the resources and options they have to survive. The actions for survival strategies are considered as coping strategies. The coping strategies are fallback mechanisms for when habitual means of meeting needs are disrupted[52]. Initially, households try to minimize risks and maintain some minimal level of sustenance. Gradually, the households start the disposal of assets as a coping strategy. Several phases can be distinguished: first, the liquid assets are disposed of, then jewelry, and finally, the productive assets. After the disposal of assets, individual or family migration is chosen as a survival strategy.

The household heads were asked about the effects of migration in origin places. The following Table 3 shows the consequences if any member of household has migrated.

Table 3: Impacts of migration

Category	Frequency	Percentage
Financial help from migrants	100	60
Improvement of social value (without any financial help)	21	12
Financial help and social value	33	20
Financial loss due to migrants	14	8

As an illustration from the above Table 3, it is apparent that 80 percent of the households with migrants receive financial help. 12 percent of the migrants' households respond not to get any remittances but their social prestige increases; inhabitants from surrounding places come and ask them about the way how and where to migrate and give them importance in social gatherings. Only 8 percent of

[52] T. Frankenberger, "Indicators and data collection methods for assessing household food security", in *Household food security: Concepts, indicators, measurements. A technical review*, ed. S. Maxwell and T. Frankenverger. (New York and Rome, 1992: UNICEF and IFAD).

the households responded that they had spent migration cost for migrants which are higher than the remittances they are getting back. Therefore, the households from the places of origin in the rural areas who are left behind are denoting the investment costs as financial loss for migrants.

Households were also asked about the utilization of remittances from emigrants. The analyses from data show that the highest amount of the remittances was used for buying food items in both before and during flood periods. Remittances are also used for repairing houses after floods.

5. Conclusions

Rural-urban migration acts as a form of credit. The results from the empirical study show inclination to the Massey-Parrado model of credit market deficits due to flood and unemployment. Some results, however, also support the Harris-Todaro model of the rural-urban wage differentials. About 70 percent of rural-urban migration was held from 2nd and 3rd quartiles income groups, which indicates that migration cost has an important effect on the migration choice. It is depicted from the cross-sectional vulnerability estimates that households whose major source of income are remittances from urban migrants were the least vulnerable from the flood 2005 in surveyed areas. Empirical works also justify the strength of weak ties; about 72 percent of the households reported that rural-urban migration was motivated by acquaintances and lose friends living in destination places, which indicate that weak ties were more effective for the surveyed households.

Migrants who are successful are pivoted not just only from social networks, but also from a direct and significant connection with the places of origin and having something to offer in return. The success of migration really depends on whether a member of the household can earn a steady income from migrant labor and can share the earnings with his or her family. Many of the migrants also move to nearby urban places to diminish health hazards and insecurity caused by floods; their aims are not matched by economic gains. Some households from the poorest quartiles are found to migrate to other villages or cities without knowing anything about the destination place, but as an ultimate coping strategy for survival. In sum, it can be concluded that migration plays a major role for survival after floods in Bangladesh.

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APPENDIX

Vulnerability estimate[53]

This study incorporates some variables to estimate vulnerability to floods with sensitivity analyses at 95 percent confidence level. The variables are classified into several factors, such as: *demographic factors*: household size, age of the household head, year of schooling of working members, gender and district dummies; *economic factors*: per capita land holding, value of durable assets, distance to nearest market place, ownership of dwelling place and membership in cooperatives; *coping factors*: amount coped from loan, savings, and selling items; *shock factors*: flood height and duration in homestead, value of crop and asset loss for flood.

Vulnerability level of a household i at time t is defined as the probability that the household will be in income poverty at time $t+1$:

$$v_{it} = \Pr(y_{i,t+1} \le z) \text{ .....[1]}$$

where, $y_{i,t+1}$ is the household's per capita income level (welfare indicator) at time $t+1$ and z is the income poverty line. Therefore, the level of vulnerability at time t is detected by the future income of the household at time $t+1$. The assumptions begin with the stochastic process, generating the income of a household i:

$$\ln y_i = X_i\beta + e_i \text{ .....[2]}$$

Where, y_i represents the per capita income before flood, X_i is a set of observable household characteristics, β is a vector of parameters and e_i is a disturbance term with mean zero. Applying the three-step Feasible Generalized Least Squares (FGLS)[54], we get,

$$\hat{E}\{\ln y_i \,|\, X_i\} = X_i\hat{\beta}_{FGLS} \text{ ... [3]}$$

[53] Shubham Chaudhuri, J. Jalan, and A. Suryahadi, "Assessing household vulnerability to poverty: A methodology and estimates for Indonesia", *Department of Economics Discussion Paper* (2002: No. 0102-52, New York, Columbia University).

[54] Takeshi Amemiya, "The maximum likelihood estimator and the non-linear three stage least square estimator in the general nonlinear simultaneous equation model", *Econometrica*, 45 (1977): 955-968.

and the variance of log per capita income for each household i as given below:

$$Var\left\{\ln y_i \middle| X_i\right\} = \hat{\sigma}^2_{e,i} = X_i \hat{\theta}_{FGLS} \text{ .....[4]}$$

By assuming that income y_i is log-normally distributed (that is, $\ln y_i$ is normally distributed) and using the above estimates, it is possible to form an estimate of the probability that a household with characteristics X_i will be poor after flood or vulnerable due to flood shock. Letting $\Phi(.)$ denote the cumulative density of the standard normal distribution, the estimated probability can be expressed as follows:

$$\hat{v}_i = \hat{\Pr}\left(\ln y_i < \ln z \middle| X_i\right) = \Phi\left[\frac{\ln z - \left\{\ln y_i \middle| X_i\right\}}{\sqrt{Var\left\{\ln y_i \middle| X_i\right\}}}\right]$$

$$= \Phi\left\{\frac{\ln z - X_i \hat{\beta}}{\sqrt{X_i \hat{\theta}}}\right\} \text{ .....[5]}$$

The value of $\hat{v}_i$ varies from 0 to 1. The estimate $\hat{v}_i$ thus denotes the vulnerability of i th household with the characteristics X_i. The vulnerability threshold is assumed 0.50.