Global Journal of Environmental Research 18 (1): 01-07, 2024
ISSN 1990-925X

DOI: 10.5829/idosi.gjer.2024.01.07

Assessment of Climate Vulnerability, Variability and Their Adaptation Strategies: in Selected Areas of Horo and Abe Dongoro Districts of Horo Guduru Wollega Zone, Ethiopia

[1]Rusha Yadeta, [2]Temesgen Kebede and [3]Mijena Leta

[1]Wollega University College of Management and Economics,
P.O. Box 395, Shambu, Ethiopia
[2]Debrebrehan University College of Management and Economics,
P.O.Box 295, Debrebrehan, Ethiopia
[3]Haramaya University College of Management and Economics,
P.O.Box 300, Haramaya, Ethiopia

Abstract: Rural communities have always been adjusting their livelihood against the vagaries of climate variability. This research assesses climate vulnerability, variability and their adaptation strategies in Horo Guduru Wollega Zone with sample of 127 rural households. The estimated head count vulnerability among the households shows that three fourth of rural households have 50 percent or more probability to become vulnerable next year using the recommended daily kilo calorie available per household per day. Rural households know temperature is changing and affecting their agricultural operation. They also perceive that land moist is decreasing from time to time leading to land slide, degradation, soil erosion and drought and becoming pertinent every year. Erratic rainfall and high temperature imposes major environmental hazard to study area. The feasible generalized least square model output show indicates that those female headed disproportionately vulnerable to climate variability than male headed. The family size increases vulnerability of household to climate variability also increases. Land size, livestock and nonfarm income and different sources of income are found to be important determinants of vulnerability to climate variability of the household. Use of agricultural inputs such as fertilizer increases productivity and thus reduces downward fluctuation of its production that in turn reduces vulnerability to climate variability. Credit facilities available to farmers increase their economic competitive by increasing to purchase farm input on time and exposure to labor and land augment technologies. To analysis adaptation strategies pursued by households, was employed. The results show that most of the explanatory variables are statistically significant. As for analysis purpose, we use the base category of cutting down on the number or size of the meal for no adaptation and evaluates the other alternatives choices. Age, education level and extension contacts of households increase, they switch to use of purcase than cutting down on the size or number of meal. Better access to extension contacts seems to have a strong positive influence on the probability of adopting all adaptation measures and abandoning the relatively risky of cutting down on the number or size of the meal.

Key words: Adaptation · Climate · Horo · Strategies Vulnerability · Variability

INTRODUCTION

Climate change is a complex biophysical process. It is difficult to demonstrate the climatic events attributed to the change. The dynamics of climate change exacerbate desertification, deforestation, erosion, land degradation and depletion of natural resources [1]. The case is different in developing countries, which are highly affected by the variability of climate than its long-term change. This climate variability becomes a serious concern over agriculture and the food systems as agriculture in less developed countries (LDCs) depends on rain fed agriculture [2].

Corresponding Author: Rusha Yadata, Wollega University, College of Management and Economics, P.O. Box 395, Shambu Ethiopia.

This poses a challenge of innovative technologies to improve rural livelihoods and environmental conservation and ensuring adoption of such technologies. Negative impacts of extreme events such as floods and droughts are expected to be high in developing countries especially, in rural areas [3].Scientific evidences suggest that higher temperatures and changing precipitation levels as a result of the changing climate will further depress agricultural crop yields in many arid-and semi-arid parts of Ethiopia over the coming decades [4]. As a result farmers in many arid- and semi-arid areas of the CRV will be more vulnerable to climate variability for their economies largely depends on climate-sensitive agricultural production systems [5]. In effect, ongoing national development efforts that are aimed at increasing food production through the expanding irrigation, flood protection and modern agricultural technologies to achieve food self-sufficiency will be at risk. Therefore, scientific investigations and applied researches on climate variability and its economic impact on the production levels and productivity of agriculture is critical to develop effective and locally adaptive agricultural production systems in the face of the increasing climate change and variability [6].

The change in climate is foreseeable; farmers are now faced more with variability to climate, which is inevitable [7]. The interviewed farmers vulnerability to climate shocks in the Nile Basin of Ethiopia based on diverse socio-economic and environmental settings and found that farmers living in low land zones are relatively more vulnerable to extreme climate events than farmers living in the other agro-ecological zones. However there exist gap in different parts of Oromia, particularly at my study area, Horo and Abe Dongoro, which part of HGW Zone of Oromia Regional State, Ethiopia.

Objectives of the study are to assess vulnerability of smallholder farmers to climate variability and their adaptation strategies in the study area.

MATERIALS AND METHODS

Description of the Study Area: The study areas consisted of two districts this are:-Horo and Abe Dongoro. Horo district is located in Horo Guduru Wollega Zone of Oromia Regional State at about 314 km west of Addis Ababa capital city of Ethiopia. Geographically, Horo is situated between 9°34'N latitudes and 37° 06'E longitudes bordered by Jarte Jardaga district in the north, Jimma Ganati district in the south and southeast and Abe Dongoro district in the west and Abayi Choman district in the east.

According to HWAO of 2012 the total population of Horo district is 76,162 of these 73,983 and 2,179 are rural and urban dwellers, respectively. Similarly, 38,256 are female and 37,906 are male in the district. From the rural dwellers, 36,811 are male and 37,172 are female. Among the urban dwellers, 1,095 are male and 1,084 are female. There are mixed agriculture practices. Both livestock rearing and crop production is the main livelihood of the community. Coffee and honey production is also practiced in the forest area. A major crop grown includes cereal crops. The livestock populations in the district are 362,507 cattle, 118,389 sheep, 29,214 goats, 85,557 poultry, 38,523 horses, 4,007 mules and 18,545 donkeys.

The distribution of rainfall is seasonal and characterized by a prolonged wet season from June to September and a short dry spell showers from mid-January to April. There is a long dry period from October to the end of February. Based on the recent data obtained from Shambu Meteorological Station, the mean annual rainfall in the study area is about 1566 mm. The mean annual temperature is about 16.6°C and the mean minimum temperature is 10.78°C whereas the mean maximum temperature is 22.32°C. There is slight temperature difference throughout the year. The hottest months are from February to May maximum temperature recorded is about 24.6°C (in April/May) and the coldest months are from July to December with the mean minimum temperature 9.8°C (in December). Based on altitudinal variations, Horo District has three Agro-Climatic Zones, which correspond to the traditional classification systems: 43% Dega (2500-3500 m) 55.56% Woina Dega (1500 - 2500 m) and 1.24% Kola (500-1500 m).

Sampling Design

Sampling Techniques: The study was used two stages of sampling procedure. In the first stage, Horo and Abe Dongoro districts were selected purposively. In the second stage through simple random sampling techniques; 4 kebeles were selected from the district based on agro ecology classifications.

Sample Size Determination: In this study a formula provided by [8] to determine the required sample size at 95% confidence level, degree of variability = 0.5 and level of precision (accuracy) = 5% will be used, which are recommended in order to get a sample size which is supposed to represent a true population.

$$n = \frac{Z^2 pq}{e^2} \Rightarrow n = \frac{(1.96^2)(0.91)(0.09)}{(0.05)^2} \Leftrightarrow = \frac{0.314627}{0.0025} = 125.8 \approx 126 \quad (1)$$

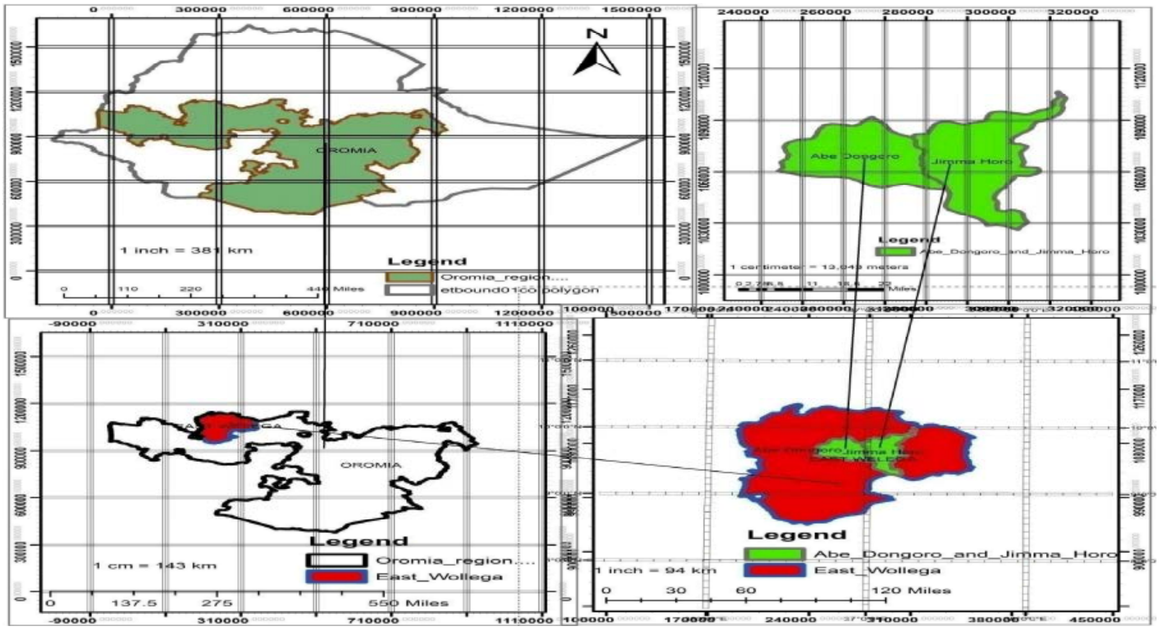
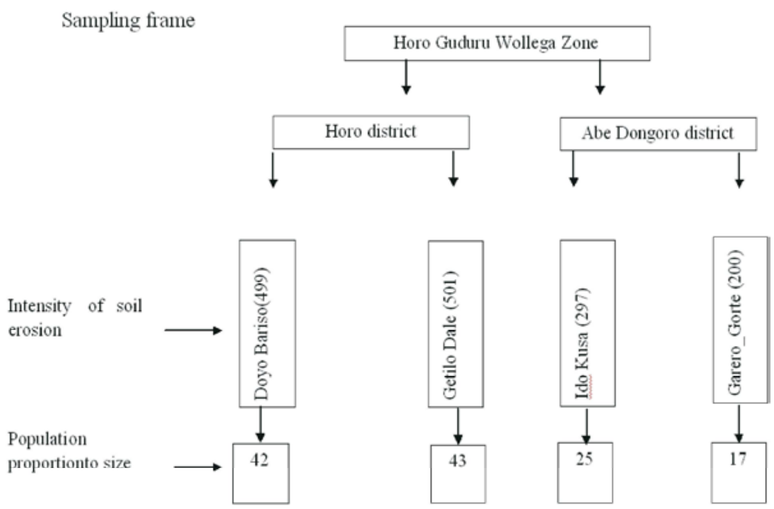


Fig. 1: Geographical location of the study area Source: GIS, 2015 (Drawn by Temesgen Kebede PhD)



Source: Horo and Abe Dongoro district (HWAO and OARD, 2015)

Fig. 2: Sampling frame of district and peasant association

127 sample respondents were selected for this study randomly. Proportionate to sampling size was employed to select 127 households' for interview, 85 of the House hold in Horo and 42 of the house hold of them are in Abe Dongoro district. Moreover, informal interview was conducted with the most intelligent household heads. Officials and development agricultural extension workers were also being interviewed.

Types, Sources and Methods of Data Collection

Types and Sources of Data Collection: Both primary and secondary data sources were used for this study. The primary data was collected by using structured questionnaires. The data collected on socio-economic aspects of the household such as farmer's age, educational level, family size, access to credit, crop sale, livestock sale, off farm income, on farm income, drought, rainfall perceptions, temperature, water shortage, market, agricultural production and other biophysical and institutional factors. Secondary data was collected from relevant sources such as Metrological Station of Shambu, Agriculture and Rural Development Bureau, Horo and Abe Dongoro District Offices.

Data Collection: For data collection, enumerators' was recruited who fluently speak the local language, Afan Oromo and have good knowledge of the area. Training was given to the enumerators, on methods of data collection, how to approach the household heads and the content of the questionnaire before commencing the work.

The questionnaire was administered by 4 (four) enumerators. The questionnaire was first were pre-tested and improved based on result obtained from pre-test. In order to generate a wide range of primary information and capture better socio-economic context in the study area discussion was made with key informants, focus groups discussions, community leaders and government officials. On the other hand, secondary data were collected from seasonal and annual reports of Horo and Abe Dongoro District Offices of Agriculture and Natural Resource Department Office and Shambu Metrological Station.

Analysis of Data: Both descriptive statistics and econometric models were employed to study the relationship between the dependent and explanatory variables. Using descriptive statistics the mean, range, minimum as well as maximum values of variables were indicated. In addition, an econometric multinomial logit model was used to study the relationship between variables empirically.

Measuring and Estimation of Vulnerability: Vulnerability is the likelihood that at a given time in the future, an individual or households will face shocks. It is a probability of a household falling below a given consumption requirement level was considered vulnerable.

$$V_{it} = P(C_{i,t+1} \leq Z) \quad \text{[EQ1]}$$

where V_{it} is vulnerability of household i to shocks at time t, $C_{i,t+1}$, is household's per capita

Consumption level at t+1, Z is consumption poverty line. Household consumption level depends on a factor of variables like household's characteristics, environmental factors and others. Consumption is specified as:

$$C_{i,t} = c(X_i, \beta_t, \alpha_i, e_{it})[\quad \text{EQ2]}$$

Where X_i - is the environmental and household characteristics, β - their respective vector of Parameters to be estimated, $^{\alpha}$- time invariant household level effect, e_{it} is the idiosyncratic factors. Therefore, vulnerability of household i at time t is expressed as:

$$V_{it} = P(C_{i,t+1} \leq Z) = P[C(X_i, \beta_t, \alpha_i, e_{it+1}) \leq Z / (X_i, \beta_t, \alpha_i, e_{i,t})] \quad \text{[EQ3]}$$

It makes clear that a household's vulnerability level derives from the stochastic properties of the inter-temporal consumption stream it faces and again depends on the environmental and household characteristics.

The probability of a household vulnerable depends not only on the probability that she/he is currently poor or remains poor in the future, but also on the volatility of consumptions (variance, from inter-temporal consumptions) of its stream. To estimate a household's vulnerability to poverty, therefore, a minimum estimate both its expected consumption and the variance of its consumption is needed. Following [9] the stochastic process generating the consumption of a household is given by:

$$\ln C_i = X_i \beta + e_i \quad \text{[EQ4]}$$

where C_i is per capita consumption expenditure, X_i represents a bundle of observable household characteristics and climatic shocks, β is a vector of parameters and e_i is a mean zero disturbance term and estimated using the help of OLS. The variance of $e_{i\ is}$ given by:

$$\delta^2 e,i = X \theta$$

The estimates β and θ using three step FGLS, the expected log of consumption and the variance of log consumption for each household i are, respectively, estimated as:

$$\hat{E}[\ln C_i / X_i = X_i \hat{\beta}] \quad \text{[EQ5]}$$

And the variance of log consumption is given as:

$$\hat{V}[\ln C / X = \delta\, 2e,i = X \hat{\theta}][\quad \text{[EQ6]}$$

By assuming that consumption is log-normally distributed (i.e. that ln C_i is normally distributed), the above equations allow us to estimate the probability that a household with characteristics X_i will be poor (the household's vulnerability level). If Φ denotes the cumulative density of the standard normal, the estimated probability will be given by:

$$\hat{I}_i = \hat{P}(\ln < \ln Z) / = \frac{\Phi[(\ln Z - X_i C_i X_i \hat{\beta})]}{\sqrt{X_i \hat{\theta}}} \quad \text{[EQ7]}$$

Where ln Z is the log of the minimum consumption level beyond which a household would be called vulnerable. This analysis is based on the assumption that experiencing climatic shocks such as drought, flood and/or rainfall and temperature variability will increase the probability of a household falling below a given consumption level, or force him/her to stay under such a level.

Estimate the Choices of Adaptation to Shocks: Climate variability adaptation refers to the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptive strategies differ from coping strategies. The latter are reactive, usually short term, strategies used by people to cope with hazards in the immediate term. Climate change adaptation relates to longer term, anticipatory strategies in which people adjust the ways in which they use their resources in order to explore new livelihood opportunities, which internalize climate variability or other types of changes. It is assumed that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of climate attributes, socioeconomic characteristics and other factors X. The MNL model for adaptation choice specifies the following relationship between the probabilities of choosing option A_i and the set of explanatory variables X as [10]:

$$p(A_i = j) = \frac{e^{\beta j} x_i}{\sum e^{\beta} x^{ki}} \quad \text{[EQ8]}$$

where β_j is a vector of coefficients on each of the independent variables, X. The equation above can be normalized to remove indeterminacy by assuming that β_0 =0 and the probabilities can be estimated as:

$$p(A_i = j \mid x_i) = \frac{e^{\beta j} x_i}{1 + \sum e^{\beta k} x_i} \quad \text{[EQ9]}$$

This gives to the odds of log ratio

$$\ln(p_{ik} p_{ij}) = \frac{x'(\beta - \beta) = x'\beta \quad if \quad k = 0}{i \quad j \quad k \quad i \quad j} \quad \text{[EQ10]}$$

RESULTS AND DISCUSSION

The survey covers a total of 127 households that are engaged in crop production and rearing livestock as their primary activity. The result shows that out of 127 sample respondents considered, 108 (85.04%) of the respondents were male-headed. Female-headed households comprise 15 % (19) of the total sample. The ethnic composition of the sample respondents shows that the Oromo constitute 95% of the total while the 5% belong to other groups of which Amharas are the dominant ones. Almost half of the total respondents are Protestant religion followers and the remaining respondents are Orthodox, *Wakefeta* and Muslims (Table 1). The 97% of the respondents are full labor participants

Smallholder farmers were asked concerning their perception to climate variability. Their perceptions were presented in both tables and the following subsections. Temperature change, in particular, affects the life and livelihoods of smallholder farmers, especially in the last decades (2005 to 2015) resulting in decline of precipitation and rainfall in summer (kiremt) season below the long-term average rainfall. The land moist is also decreasing from time to time leading to land slide, degradation, soil erosion and drought and is becoming pertinent every year.

The estimated head count vulnerability among the households shows 74.80% of them have 50 percent or more probability to become poor next year using the recommended daily kilocalorie available per household per day. In terms of food security status, 68.5% of households are ex post food insecure.

By agro ecology classification, households living in rural areas of lowland are vulnerable. Whereas, farmers in midlands 29% of them are non-vulnerable as compared to 71% of them are vulnerable. There are more percentages of food insecure in lowland agro ecology than midland agro ecology. The notion that the head count vulnerability ratio of 0.748 and the incidence of food insecurity among the households is 68.5% using the same benchmark. These figures shows there are households that are regarded as being food secure but are vulnerable to food insecurity next year.

For a minimum 2200kcal threshold, a higher vulnerability to food insecurity ratio is observed in lowland agro ecology exposing the fact that more dispersed distribution of vulnerability exist whereas, in midland agro ecology the ratio is lower revealing that vulnerability is concentrated among a few.

The surveyed households have encountered many environmental shocks such as variability of rainfall and high temperature, land degradation, flooding and water-logging. The result revealed that most of the contacted households had recognized erratic rain fall and high temperature are the major environmental hazard that they have encountered in Horo and Abe Dongoro central Oromia, Ethiopia.

Table 1: Results of vulnerability and food security status of sample respondents

Vulnerability and food security status		Freq.	Percent	By agro ecology: Lowland Freq	%	Midlands Freq	%
Vulnerability status	non vulnerable	32	25.2	-	-	32	28.83
	Vulnerable	95	74.8	16	100	79	7117
Food security status	food insecure	87	68.5	13	81.25	74	66.67
	food secure	40	31.5	3	18.75	37	33.33

Table 2: Estimation of vulnerability to food insecurity (households with vulnerability > 0.5) by agro ecology

By agro ecology	Percentage of households	Vulnerable	Vulnerability to food insecure insecure ratio
Lowlands	1	0.813	1.23
Midlands	0.712	0.667	1.067
Total	0.748	0.685	1.09

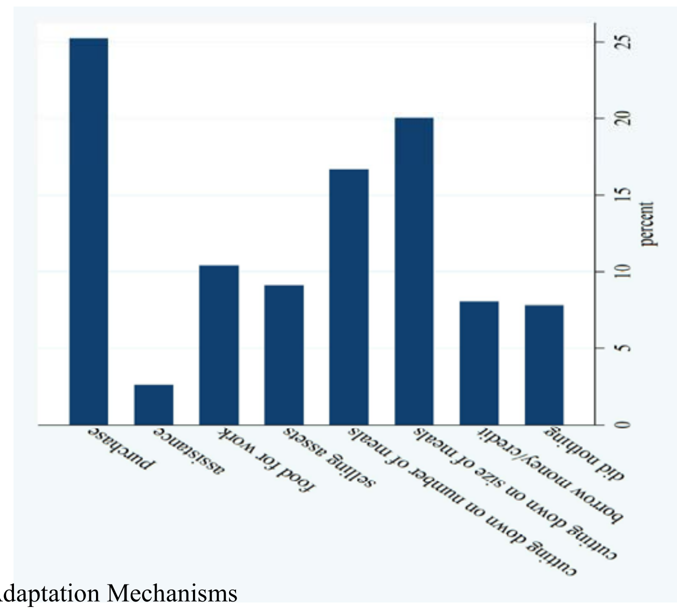


Fig. 3: Graphic show of Adaptation Mechanisms

Adaptation to climate variability is necessary both to reduce current vulnerability to climatic hazards and stresses as well as to prepare for future climate change. Although development cannot necessarily be made climate-proof, development strategies should acknowledge predicted climate change in order to minimize its impact. It is of paramount importance that research aimed at supporting adaptation to climate variability among such groups is well- grounded and based on the experience and needs of marginal groups. Not enough attention has been paid to the means which vulnerable people themselves use to respond to stresses [11].

It is possible to see from the figure below, the adaptation mechanisms widely practiced by households. Around 25% of the respondents' adaptation to climate variability is made through purchase of food. Participation in food for work and reducing household consumption are also widely practiced.

The model estimated to show the impact of various household and environmental factors on household vulnerability to climate variability. Assumptions were made based on linear relationship between household and environmental variables of more than 20 explanatory variables that are included in the model. Model information shows the model is suitable for the problem at hand. Table 2 below gives model information and the estimates of coefficients from the model. Most of the variables are significant with expected signs. Here it is important to reiterate them in some detail.

CONCLUSION AND RECOMMENDATIONS

The most significant number of households is vulnerable. Many are trapped and vulnerable to disproportionate climate variability. More aged and large sized land holding households are less vulnerable as age serves proxy for farming experience. By agro ecology classification, households living in rural areas of lowland are vulnerable. Mean family size in the study area was 5.05persons per household. The average household size was higher for the households who perceived climate variability (5.5 individuals per household) than their counter arte (5.05 persons per household). The difference in mean family size between households who perceived variability in climate did statistically significant. Households who perceive the existence of climate variability have more number of economically active family members, compared to the households who did not perceive climate variability. Based on the above conclusions the following ideas are recommended.

- Creating opportunities for non-farm income reduces the extensive dependence of the community on natural resource based livelihoods, thereby reducing their vulnerability to climate variability.
- Afforesting the forest and conserving the natural resources.
- Forest protection policy should be applied by the government and Communities.

REFERENCES

1. El-Beshary, D.M., S.M. Robaa, A. El-Motey, G. Gamil, Z. Salah and M.M. Abdel Wahab, 2019. The Extreme Climate Indices for Benghazi-Libya from Canadian Regional-Climate Model. Environment Asia, 12(1).
2. Arndt, C. and F. Tarp, 2017. Aid, environment and climate change. Review of Development Economics, 21(2): 285-303.
3. Bernstein, L., P. Bosch, O Canziani, Z Chen, R. Christ and K. Riahi, 2008. IPCC, 2007. climate change 2007. synthesis report.
4. Bezabih, E., G. Hadera and R. Nigatu, 2010. Impacts of Improved Seeds and Agrochemicals on Food Security and Environment in the Rift Valley of Ethiopia: Implications for the application of an African Green Revolution: Dry lands Coordination Group Report No. 5602, 2010, DCGc/o, Miljøhuset G9. Norway. Oslo.
5. Temesgen Deressa, R. Hassan and C. Ringler, 2008. Measuring Ethiopian Farmers Vulnerability to Climate Change across Regional States. IFPRID is cussion Paper 008.
6. Karim, Z., S. Mohamed, G. Hussain and Kh. B. Rashid, 1994. Impact of Climate Change in the Production of Modern Rice in Bangladesh. In Implications of Climate Change for International Agriculture: Crop Modeling Study, EPA 230-B-94-003.: Bangladesh 1-11.Washington D.C.USA.
7. Rockström, J., P. Kaumbutho, J. Mwalley, A.W. Nzabi, M. Temesgen, L. Mawenya, J. Barron, J. Mutua and S. Damgaard-Larsen, 2009. Conservation farming strategies in East and Southern Africa: Yields and rain water productivity from on-farm action research. Soil and Tillage Research, 103(1): 23-32.
8. Israel, G.D., 1992. Determining sample size
9. Chaudhuri, S., J Jalan and A Suryahadi, 2002. Assessing household vulnerability to poverty from cross-sectional data: A methodology and estimates from Indonesia.
10. Greene, W.H. and D.A. Hensher, 2003. A latent class model for discrete choice analysis: contrasts with mixed logit. Transportation Research Part B: Methodological, 37(8): 681-698.
11. Mercer, J., 2010. Disaster risk reduction or climate change adaptation: Are we reinventing the wheel?. Journal of International Development: The Journal of the Development Studies Association, 22(2): 247-264.