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## The Moroccan Association of Agricultural Economics (AMAECO)

in partnership with

International Association of Agricultural  
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&

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Climatic constraints play a predominant role in the performance of national agricultures and their capacity to support economic growth and assure food security for the population. With the climate changes and projected inter and intra annual fluctuations, management of the agricultural sector takes a particular dimension including management of risks inherent in the sector and searching for sustainable growth for the sector. Agricultural policies must permit a continual adaption of the processes of agricultural production and a reduction of negative effects of climate change in order to assure food security for the population.

In the face of climate change, the adaptation strategies can generate important development opportunities. Also, governments have need for pertinent evaluations of the impacts of climate change.

Considering the importance of this problem; to permit an exchange of ideas among professional staff, researchers, and specialists in the domain of development; to contribute to a richer understanding of methods and analytical tools ; and to contribute to better preparation of decision making in this domain – the Moroccan Association of Agricultural Economics (AMAECO) in collaboration with the International Association of Agricultural Economics (IAAE) and the World Institute For Development Economics Research of the United Nations University (UNU-WIDER) are organizing an international conference 6-7 December in Rabat, Morocco under the theme:

### ***« Impacts of climate change on agriculture »***

Rabat, Morocco December 6-7, 2011

The principal themes proposed are the following::

1. Analysis of the impacts of climate change on agriculture: simulations and projections
2. Climate change and sustainability of agricultural production systems
3. Adaption strategies for agriculture in the face of climate change: systems of production, risks in agriculture, and policies for food security
4. Water management in the context of climate change

[http://www.wider.unu.edu/events/past-conferences/2011-conferences-/en\\_GB/06-12-2011/](http://www.wider.unu.edu/events/past-conferences/2011-conferences-/en_GB/06-12-2011/)

# **Vulnerability and Adaptation to Natural Disasters and Climate Change: Evidences from Rural Odisha, India**

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## **ABSTRACT**

With respect to developing countries, it is observed that climate change poses a serious threat to economic growth and impediment to the poverty reduction programmes undertaken in these countries for the upliftment of the vulnerable households. It can also have a major impact on issue of food security which is highly dependent on climate sensitive parameters. Evidences from preliminary assessments also reveal that the severity of droughts and intensity of floods in various parts of India might increase due to climate change. The present paper attempts to study the vulnerability of rural households in a disaster prone region of India and study the mechanisms undertaken by these household to adapt to the risks faced to their consumption pattern. We use random effects panel data model to understand the risks to the consumption practices of households and the adaptation mechanism followed by them. The results suggest that income from livestock assets emerged as major adaptation strategy with respect to reducing the fluctuations in consumption by the household in the study area.

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## 1. Introduction

Climate change refers to change in climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural variability observed over comparable time periods (IPCC, 2001). People in developing countries are subject to a variety of risks concerning their livelihoods. The risks arise mostly because of the dependence of the majority of the population in these countries on climate sensitive factors for their livelihoods. With respect to these countries, climate change poses a serious threat to economic growth and impediment to the poverty reduction programmes undertaken in these countries for the upliftment of the vulnerable households. It can also have a major impact on issue of food security which is highly dependent on climate sensitive parameters and evidences from preliminary assessments also reveal that the severity of droughts and intensity of floods in various parts of India might increase due to climate change. The vulnerability of the households residing in these hot spots is aggravated due to their limited capacities to cope with the impacts. In this context the present paper aims to analyze the vulnerability of the households in the state of Odisha, India to climate related disasters, the impact of climate change on the food security of the region and the effectiveness of coping and adaptation mechanisms followed by the households in achieving the overarching objectives of livelihood stability and poverty reduction.

Findings of Intergovernmental Panel on Climate Change indicate that climate change is going to impose significant stress on resources throughout the Asian region. With regards to India, preliminary assessments reveal that the severity of droughts and intensity of floods in various parts of the country might increase. Most of the river basins in India may experience constant water scarcity and shortage. Sea level rise would submerge mangroves and increase the salinity of wetlands. The rise in sea level is likely to have a significant impact on the coastal population and agricultural performance of India (NATCOM, 2004). Further, the predicted consequences of climate change indicate the possibility of an increase in the intensity of climate extremes (floods, droughts, hailstorms, hot and cold waves etc.) which in turn will have its impact on agricultural production, crop growth and also would have social, economic and environmental implications. Studies on India also point out that the inter-annual variability in rainfall will have major impact on food grain production in India and also on the economy as a whole.

Predicted increase in frequent and intensive floods and droughts are likely to have unfavorable impacts on the occupational structure, food security, health, social infrastructure etc. and the adaptive capacity of households go beyond just income and access to regular infrastructure (Roy et. al. 2005). Other studies try to measure the exposure of a region to specific events like cyclones, sea level rise, changes in temperature, and rainfall (Kavikumar, 2002). These studies examining the issue of vulnerability to disasters adopt a disasters / disaster management / climate change framework. The focus is on measuring the vulnerability of regions (states, coastal areas etc.). Further, the focus of the previous studies was on mapping out the vulnerability of regions (geographical / physical vulnerability) to external stressors like a disaster event (a flood or drought or cyclone) and the subsequent impact on the economy of the region. The studies fail to track down the impacts of disasters to a micro level (for example the impact of disasters on the people living in the vulnerable regions). Therefore they fail to analyze the importance of ex-post coping strategies adopted by households. However, with respect to household responses to coping with extreme climatic events

in select hotspots in India, Roy et.al., (2005) observe that income and access to regular infrastructure are not the only factors determining the adaptive capacity of individuals.

With respect to impacts of disasters on rural households, Patnaik (2009), Patnaik and Narayanan, (2010) observe that consumption smoothening behavior is not exhibited. Changes in consumption experienced by the households are explained through the household's increase in expenditure, decrease in income and shocks to its asset base and household specific characteristics have no significant role to play with respect to the changes in consumption. Further in respect of effectiveness of coping mechanisms they find that the risk coping mechanisms adopted by the households do not help them to mitigate the damages suffered by them due to impacts of natural disasters. With respect to food security Das and Bedmatta (2010) state that in the absence of adequate institutional and non-institutional support, the coping strategies of households differed based upon their asset holdings.

The remainder of the paper is arranged as follows: the next section describes the objectives of the study followed by the description of the methodology used for conducting the survey and primary data collection. Section two describes the study area and section three describes the data and the variables used in the analysis along with the econometric specification used for analysis. Finally section four elaborates the concluding observations that emerge from the analysis.

### **1.1 Objective of the Study**

The primary objective of the paper is study the livelihood security of households residing in disaster prone region. Secondly the paper also investigates the impacts of disasters on the consumption pattern of households during the post disaster phase. The paper will also focus on studying the role of the ongoing government programmes in enabling the vulnerable households to hedge against the impacts of climate change. Lastly the paper will also attempt to elucidate the probable theoretical and policy implications of the findings of analyses.

### **1.2 Methodology**

The data for the present study is drawn from detailed household surveys undertaken in districts of the state where Watershed Development Mission was in full swing. Under this mission watershed development projects under various schemes such as, Integrated Wasteland Development Projects (IWDP), and Drought Prone Area Programme (DPAP), National Watershed Development Project in Rain-fed Areas (NWDPR), River Valley Project (RVP) are in operation in the state of Odisha. Another externally aided project funded by DFID namely Western Orissa Rural Livelihoods Project (WORLP) is currently in operation in Bolangir and Nuapada districts which is aimed at the drought prone areas of these districts.

From a preliminary survey of literature and policy documents of the State government, we found that watershed activities have continued in full swing in only three districts of the KBK region. These are the districts Kalahandi, Balangir, and Nuapada. We have done two rounds of survey: first survey during the first *Kharif* agricultural season (2010) and a subsequent round immediately after the harvest of *Rabi* Crops (2010-11) and start of the second *Kharif* season (2011). The whole purpose of

the study was designed to carry out the study across two agricultural seasons were to understand changes in the pattern of landholdings, costs of cultivation, average farm business incomes accruing to a typical cultivator household of the region, total household incomes, access of the farmer to formal credit, availability of extension services, inputs and storage facilities etc.

Hence, at the first stage, the districts that were selected for the study were Kalahandi, Balangir and Nuapada. In the first round, we have completed survey of four villages in the districts of Kalahandi, Balangir and Nuapada districts. During the second stage, we carried out the repeat survey in the same villages in the three districts after harvesting of *Rabi* crops (2010-2011). It was decided to carry out the study in the blocks/villages nearer to the district headquarters; however, our focus was to survey one watershed and one non-watershed village from each of the districts. Accordingly, based on the list of villages divided on the basis of watershed and non-watershed we randomly selected two villages from each district. Thus villages where the survey was carried out during the first round were four in number.

First, a complete enumeration of all households was done in the two villages. Based on the census enumeration of all households we divided them into cultivator and non-cultivator households. A household was classified as a cultivator household if the main occupation of the head of household or adult male and female earning members was found to be cultivation. The cultivator households in each of the villages were taken as the sample for a detailed survey on various livelihood questions based on a structured close-ended questionnaire.

## 2. The Study Area

The present paper is with reference to Odisha state in the eastern coast of India which is highly vulnerable to multiple climate related natural disasters. Around 85 percent of state's 37 million people reside in rural areas and depend largely on an undiversified agricultural economy. A significant proportion of them are facing the impacts of multiple disasters which include perennial droughts, floods and cyclones. It is one of the poorest states of the country and it. It is observed that there is a limited diversification of the agriculture and low penetration in the non-farm sector aggravated the situation further. It may be mentioned here that the entire State of Orissa is divided into four agro-ecological zones. They are (a) Northern Plateau region (b) Coastal Plains region (c) Central Table Land Region and (d) Eastern Ghats region. The districts Kalahandi, Balangir and Nuapada fall in the Eastern Ghats agro-ecological zone of the State which is characterized by warm humid climate and red soil with low organic matter content. Dry land farming is practiced in these districts mainly due to lack of irrigation facilities. Following the methodology outline in the above section, we carried out the study in revenue villages *Malgaon* and *Rojanaguda* in Kalahandi district, *Randa* and *Mehermunda* villages in Balangir district and *Kodamari* and *Chuhuri* villages in Nuapada district of the state of Orissa, India.

Geographically, district Kalahandi is located in the western part of the State, which has dry soil conditions and is a low rain intensity area. The ratio of average rainfall to average annual temperature is 50.8. The topography of Kalahandi comprises of rolling upland with height varying between 153 to 305 metres. The predominant soil type is moderately acidic red soil with patches of black soil. The ground water potential of Kalahandi is low and the yield prospects are less than 5

cubic metres per hour. The total geographical area of Malgaon village is 361.79 hectares, of which, the cultivable area is 299.29 hectares. Forest area of the village is 21.37 hectares. District Balangir is also located in the western part of the State and is surrounded by districts Sonepur in the east, Nuapada in the west, Kalahandi in the south, and Baragarh in the north. The district is situated in the valley of rivers *Ang* and *Tel*. The important tributaries of *Tel* are *Lanth*, *Sonegarh*, and *Suktel*. The dominant tribes residing in the district of Balangir are *Kutia*, *Khonds*, *Binjhals*, and *Gonds*. Nuapada district is located in western part of Orissa, whose boundaries extend in the north, west and south to Raipur district in Madhya Pradesh and in the east to Bargarh, Balangir and Kalahandi districts. This district is spread over an area of 3407.5 square kilometers and the administrative headquarters is located at Nuapada. *Jonk* is the principal river of the district, which is often subjected to floods. *Silda*, *Sundar*, *Khohjhar*, *Indra* and *Udanti* are the hill streams found in the district. These are perennial in nature and reduced to almost tiny streams in their lower reaches; particularly in the months between February and June.

### 3. Data and Variables

To understand the livelihood security of the households in the disaster prone region we use certain indicators which intend to capture the risks associated with the livelihood practices of the households in the study area. These indicators reflect the farming, consumption and income diversification aspects of the households. In the context of the present study the consumption of the households is proxied by the monetary value of food grains that is retained by the households for their self consumption. Similarly the farming practices of the surveyed households are captured by indicators related to the use of inputs in the farming process and value of the final produce that is harvested by them. The diversification aspect is reflected by the number of livestock that is reared by these households and the corresponding earnings from these. The risk faced by them due to a natural disaster is captured by a dummy showing the percentage of households reporting a crop loss due a disaster.

As described in the previous section the data used for analysis was drawn from household surveys undertaken in the study areas during the years 2010 and 2011. Table No. 1 given below shows the descriptive statistics of the variables for which data was drawn from the surveys.

Table No. 1: Descriptive Statistics of the Sample

Indicators	Round 1		Round 2	
	Mean	Standard Deviation	Mean	Standard Deviation
Total no of household members	5.47	2.35	5.47	2.35
Total land in acres	4.93	3.50	5.12	3.70
Total owned land in acres	4.28	3.11	4.49	3.39
Total leased land in acres	0.66	2.47	0.65	2.44
Production of main crop (Rs.)	18302.98	13614.45	11817.02	14357.55
Consumption of Household (Rs.)	10523.40	7867.27	7322.34	7768.55
Manures used (Rs.)	431.82	524.64	859.57	780.09
Chemicals used (Rs.)	671.82	829.43	766.06	776.87
Seed used (Rs.)	1118.33	1436.57	1284.04	1455.96
Cost of Irrigation (Rs.)	134.78	439.17	141.63	605.75
Total number of livestock	2.83	3.57	6.70	10.08
Livestock Output used for household consumption (Rs.)	536.49	1077.12	751.06	1360.45
Livestock output sold (Rs.)	1128.94	3638.74	1665.81	3344.48
Percentage of Crop Damage	0.47	0.50	0.15	0.36

From table 1 it can be seen that the average size of the households from the sample is around five members. The maximum number was reported to be around thirteen members for a household while the minimum stood at around two members. The size of the households remains same across the two periods of survey. The average land holdings for the sample households is around 4.9 acres during the first round of survey which increased to around 5.12 acres by the time the second round was completed. From the table it can be seen that although the average size of leased land has not changed much, the size of owned land has marginally increased. The households retain a part of their primary crop for self consumption during the rest of the year. The average earnings of the households from the farming activity was Rs. 18,302 during the first round of survey while it dropped to around Rs. 11817 during the second round. The monetary value of crops retained for own consumption was Rs. 10523 and Rs. 7322 during the first and second round of survey respectively. With respect to the inputs used in the farming process it can be seen from the above table that there was been a marginal increase in the average cost of inputs used in the farming process between the two rounds of survey.

As a means of diversification of income the households in the study area resort to rearing of livestock. It can be seen from table 1 that average number of livestock owned by the households has substantially increased across the two survey periods. While during the first round of surveys the average number of livestock owned by the sample households was around 2, it increased to around 6 during the second round of surveys. Similar pattern of increase is also observed for the value of livestock output sold and used for self consumption by the households. With respect to the crop damage due to drought it is observed that around 47 percent of the households in the study area report of having suffered a loss to their primary crops due to drought. Similarly during the second



round of survey it is observed that around 15 percent of the households report crop damage due to drought.

### 3. Results and Discussion

To understand the impacts of disasters on the consumption pattern of households and coping means adopted by them during the post disaster phase we use a random effects panel data model. The responses collected from the households during the two rounds of surveys are used to construct a cross sectional time series data set. Panel data analysis is a method of studying a particular subject within multiple sites, periodically observed over a defined time frame. With repeated observations of enough cross-sections, panel analysis permits to study the dynamics of change with short time series. The combination of time series with cross-sections also enhances the quality and quantity of data in ways that would be impossible using only one of these two dimensions. The rationale behind random effects model is that, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model. If you have reason to believe that differences across entities have some influence on your dependent variable then you should use random effects. An advantage of random effects is that you can include time invariant variables which in the fixed effects model these variables are absorbed by the intercept (Greene, 2008). Equation 1 shows a random effects model used for analysis in the present study

$$Y_{it} = \beta X_{it} + \alpha + u_{it} + \varepsilon_{it} \quad (1)$$

Here the random error term  $e_{it}$  is heterogeneity specific to a cross-sectional unit and in this case specific to a village. This random error  $u_{it}$  is constant over time. The random error  $e_{it}$  is specific to a particular observation. For  $v_i$  to be properly specified, it must be orthogonal to the individual effects. Because of the separate cross-sectional error term, these models are sometimes called one-way random effects models. Owing to this intra-panel variation, the random effects model has the distinct advantage of allowing for time-invariant variables to be included among the regressors. Further, random effects assume that the entity's error term is not correlated with the predictors which allow for time-invariant variables to play a role as explanatory variables thereby it also allows in generalizing the inferences beyond the sample used in the model (Greene, 2008). Table 2 shows the results of the estimation carried out using a random effects model.

Table No. 2: Estimation results of the random effects model

Variable	Description of the Variable	Coefficients	z values
village	Village Specific Indicator	0.086	2.19***
hh_mem	Number of adult members in the household	0.076	2.26***
lit_head	Literacy level of the head of the household	0.006	0.12
land	Total land owned by the household in acres	-0.038	-2.00***

In_prod	Value of the primary crop produced by the household (Rs.)	0.681	13.64***
irri_1	Primary Source of Irrigation for farming	0.004	0.09
In_manure	Value of the manure used by the household in the farming (Rs.)	-0.015	-0.49
In_chemical	Value of the chemicals and pesticides used by the household in the farming (Rs.)	-0.003	-0.09
In_seed	Value of the seeds used by the household in the farming (Rs.)	-0.01	-0.38
In_irri	Cost of irrigation (Rs.)	0.008	0.28
In_lvstk_ear	Earnings from rearing of livestock (Rs.)	0.024	1.56*
cropdam	Damage to primary Crops: Dummy	-0.39	-3.12***
cons	Constant Term	2.228	3.74***
sigma_u	0.313	R-sq: within	0.763
sigma_e	0.405	between	0.683
rho	0.373 (fraction of variance due to u <sub>i</sub> )	overall	0.714
Wald chi2(13): 24014.85***			
Note: The variables In_prod, In_manure, In_chemical, In_seed, In_irri and In_lvstk_ear are used as natural log form in the regression equation; *** denotes significance at 1%, ** indicates significance at 5% and 8 represents significance at 10% level respectively			

From table 2 it can be seen that many variables turn up significant in the estimation using a random effects model. Five independent variables are significant at one percent level while one variable is significant at ten percent level. The first significant variable is the village specific indicator which says that there is a difference between the consumption practices across different sets of villages. Households belonging to different villages adopt different consumption strategies to mitigate the risks to their consumption pattern due to the droughts. Some of the villages are more affected by the droughts as compared to others and hence the household residing in these villages adopt a different mechanism for consumption than others. The number of members is also significantly related to the amount of consumption. Any increase in the number of members of the household results in higher consumption for the household.

Production and harvest of crops is also significantly related to the consumption practice of that household. The estimation results show that this variable is highly significant and a unit change in this variable across time and space will lead to a change in the amount of consumption by around sixty five percent. Although the variable land (measured as total acres of land owned by the household) is significant at one percent it comes in the model with a negative sign, thereby implying that changes in the ownership pattern may not always lead to a positive impact for the households. Since the study area is a perennial drought prone region the productivity of the land is questionable. Hence households having larger ownership of land may not necessarily enjoy the benefits of a higher produce and in turn a higher production. From the results it can be observed that the variable measuring the crop loss suffered by the households in the study region is highly significant and also has a negative sign. Therefore it can be said that the incidence of droughts and the resulting crop

failures have a negative impact on the consumption pattern of the households. The households reduce their level of consumption of primary grains due to these droughts.

The variable capturing the impact of livestock earnings on the level of consumption of households is also significant though at ten percent level of significance. Any unit increase in this variable will result in the consumption of the households by two percent. This result of significance in the present case as we have seen from table 1 also that the households are gradually diversifying their income generation streams by resorting to rearing of livestock as a means of secondary source of income. The average number of livestock owned by the households is almost double during the second phase of survey as compared to the first phase. The average income of the households from selling livestock produce is around Rs. 1100 which increased to around Rs. 1600 by the second round of survey. This increased income of the households during the second phase of survey points out that gradually the households may be diversifying their income through this and in the process targeting to overcome the risks to consumption faced by them due to their continuous exposure to droughts.

#### **4. Conclusion**

From the analysis undertaken in the paper it is seen that the impacts of natural disasters on households/population are complex in nature and there are multiple ways in which the two can be related to each other. The channels of transfer of the impacts of disasters are difficult to quantify. The direct impacts of disasters are on infrastructure, loss of physical capital, impact on agriculture, damage to environment and human capital. The indirect ones include loss of production of goods and services, loss of future harvests and income etc. are difficult to quantify. Given the uncertainties about possible impacts of disasters on households, the analysis, undertaken in this study provided insights about the vulnerability of households and their coping mechanisms. It is observed that while agricultural productivity has been very low in the study area, inaccessibility to water has further aggravated conditions of food insecurity. Considering that the survey period 2010-11 coincided with a major drought year, earnings from agriculture was deeply affected in the study area. Loss of household income was compounded due to crop losses resulting from lack of irrigation water. In consequence, the dependence of the households was mostly from earnings from wage labour in agriculture and non-agriculture activities. In this context our results are also in line with the observations of Bedamatta and Das (2011) whereby they state that households owning bigger livestock (cows and bullocks) suffered major losses in total income earnings, they also could not move out of their villages in search of hired work in non-farm activities. On the other hand, households that owned smaller livestock, such as sheep, goat, and poultry either sold off their livestock or lived through the drought months depending upon meat and eggs. Moreover, the cost of maintenance of the smaller livestock was much less compared to the latter group. Larger costs of maintenance of bigger livestock during the drought months compounded the problems of income earning opportunities for such households leading towards negative incomes.

It is observed that the nature of vulnerability faced by the households in the study area is prone to disasters like drought varies across space with specific pockets of vulnerability existing in the region. Some villages are more vulnerable with respect to agriculture and farming than the others and accordingly the consumption practices of households also differ across villages. Further, due to continuous exposure to these disasters households are gradually resorting to diversification of

income to adapt with the risks faced to their consumption. There is evidence that the households have undertaken the rearing of livestock to stabilize their consumption streams and to meet the shortfall in consumption due to crop failures and ensuring household food security during the study period. To conclude it can be said that although agriculture continues to be the primary source of income for the households in the study area and also is the target of major policy interventions of the state, income from livestock assets emerged as major adaptation strategy with respect to reducing the fluctuations in consumption in particular and food security in general and needs due policy attention.

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