

# Climate Variability, Local Environmental Changes and Rural Livelihood Systems: A Case Study of Three Coastal Villages in India

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## Abstract

The paper examined the trends of climate variability and local environmental changes and their implications on livelihood of the people at local level in two Coastal districts in the state of Odisha in India. A trend analysis of the climatic variables has been made based on Indian Meteorological Department database and the perception of local communities on implications of these as well as other local environmental changes on livelihood has been discussed through a case study in three coastal villages. The trend analysis has been conducted at district and regional level where as the perception analysis has been done at village level. The perception study is based on a survey of 210 households in 3 villages, extensive discussion with key informants in the local community, focused group discussions, and direct observation of the researchers. The analysis of time series meteorological data shows that there is a moderate change in climatic variables. Interestingly, the analysis of community perception at local level found some conformity between local perceptions and scientific claims about the trends of climate variability and local environmental changes. The results show that climatic variation impacts the livelihood systems of rural communities through its interaction with local natural environmental resources and other socio-economic characteristics of the communities. Local people also have considerable knowledge about the changes happening in the natural resources around them and trying to adapt to the change.

## 1. Introduction

Current climatic variability and change is predicted to cause increasing global temperature and subsequently impact the global hydrological system, crop production and other natural ecosystems functions adversely (Sathaye *et al*, 2006; Siva Kumar *et al*, 2005). There is increasing evidence that these changes will strongly affect the livelihood of millions of people in the world. The projected magnitude of such changes and its impacts are diverse (Stern, 2007) and expected to be more in case of tropical and sub-tropical regions (UNFCCC, 2009; Parry *et al*, 2007). The developing countries in south are more vulnerable for the adverse impact as they are predominately located in tropics and have limited capacity to adapt to the changes for various inherent socio-economic, demographic, institutional and policy trends (Chambwera and Stage, 2010; UNFCCC, 2009; Assan *et al*, 2009, Mertz *et al*, 2009, Adger *et al*, 2003). The extensive dependence of the rural communities on climate sensitive livelihood options in these developing countries makes them the most vulnerable to any adverse impacts.

There are several studies that has projected the long-term patterns of climate change and estimated the probability and intensity of the impact of these changes both at national and regional scales (Ghosh *et al*, 2010; Parry *et al*, 2007; Sathaye *et al*, 2006; Grothmann and Patt, 2005). However, there are few studies examining the impacts on the livelihood systems and adaptations to such changes at local levels (Petheram *et al*, 2010; Mertz *et al*, 2009; Stringer *et al*, 2009; Paavola, 2008). The uncertainty over the patterns of changes in climatic variables (Brown and Crawford, 2008) and the very presence of an array of non-climatic stressors (Nielson and Reenberg, 2010; Mertz *et al*, 2009) complicates the understanding of these changes and its impact on rural

livelihood systems and the adaptation capabilities of the affected communities. The understanding of these complexities at micro level is essential in designing appropriate strategies to deal with future uncertainties and building a low carbon society. This paper makes an attempt to explore how climate change is impacting the rural livelihood systems by analyzing the trends of change in climatic variables at micro level, perception of the people about such changes and the adaptation strategies of the households.

## 2. Climate Variability and Rural Livelihood Systems: Review of Literature and the Analytical Framework

The word 'livelihood' connotes means, activities, entitlements and assets by which people make a living (Elasha *et al.*, 2005). The assets could be natural/biological (i.e., land, water, forest), physical infrastructures (i.e., roads, markets, hospitals, schools, bridges), and social (i.e., community, family, social networks). These assets are merely the means and need to be complemented by capabilities to enable people to earn their livelihood (Scoones, 1998). The activities that earn a livelihood are critically dependent on assets, capabilities and entitlements which in turn are influenced by the governing economic, social and political institutions. So a livelihood system constitutes the assets, activities and the related socio-economic and ecological factors that enable people to make a living. The recent research has documented the complex interactions among different factors affecting the livelihood systems in the context of rural areas and contributed to the emergence of the discourses on sustainable rural livelihood. The notion of sustainable livelihood has been introduced by The Brundtland Commission in 1987 in terms of its reference to the resource ownership pattern and its impact on access to basic needs and livelihood security. The livelihood systems could be termed sustainable 'when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base' (Chambers and Conway, 1992 pp. 4). Singh and Titi (1994) defined sustainable livelihood as 'people's capacities to generate and maintain their means of living, enhance their well-being, and that of future generations'.

There has been significant change in the rural livelihood systems in different parts of the world for the changes in the socio-ecological systems in which they live due to a variety of factors. These changes in socio-ecological systems could be instant or slow and could be driven by a single factor like the natural calamities, collapse of the political and economic systems in a country etc., or due to the interaction of a host of factors. The impact of such changes on livelihood could be beneficial or adverse or mixed. The response of the local community to these changes in livelihood systems implies the coping and adaptive capacity of the community. The literature often differentiates between coping and adaptation strategies based on the timescale of these response actions. The short term actions are termed as coping whereas longer term actions are called adaptation (Osbaht *et al.*, 2008). Both the coping and adaptation responses vary across the communities (also among the individuals within a community) and are influenced by a host of factors affecting the livelihood systems. The coping or adaptation responses could be anticipatory where adjustments are planned before the impacts of change are realized or compulsive on the onset of impacts (Elasha *et al.* 2005).

Among the different factors climatic variability is perceived to be one of the important factors affecting the livelihood systems. It's more so in the context of rural areas given the climate sensitive nature of livelihood systems. The ways in which climate change would impact the rural livelihood systems in tropical and sub-tropical regions are through agricultural production and food security due to extreme water supply situations which would increase the likelihood of crop failure and productivity loss, increased diseases and mortality of livestock, degraded fisheries systems, changes in the forest quality and increased forest fire risk (Parry *et al.*, 2007; Morton, 2007; Naylor *et al.*, 2007; Tubiello *et al.*, 2007; Kirilenko and Sedjo, 2007, Sathaye *et al.*, 2006). Further the variability of the climatic factors would induce increased frequency of natural calamities, changes in the sea level, increased vector borne diseases and so on (Parry *et al.*, 2007, Sathaye *et al.*, 2006). These changes would squeeze the existing livelihood options of the rural communities that may result in large-scale out-migration, indebtedness of the rural households and increased dependency on the relief and aid (Assan *et al.*, 2009; Parry *et al.*, 2007, Desinghkar and Anderson, 2004) which has a spiraling impact on the vulnerability of the affected communities.

For the very fact that climate change is happening and continues well into the future with considerable adverse impacts on humans as well as on natural ecosystem (Parry, 2007, Sathaye *et al.*, 2006), there has been consensus among various stakeholders to initiate appropriate mitigation and adaptation measures at different levels to deal with these adverse impacts. The earlier studies on adaptation aims at measuring the relative vulnerability of regions or communities (Brook *et al.*, 2005) and are based on the premise that human vulnerability is a function of physical characteristics of climate events (Petheram *et al.*, 2010). However, the recent studies have emphasized on social, economic and institutional aspects of human vulnerability (Smit and Wandel, 2006; Grothmann and Pat, 2005) as these factors influence the adaptive capabilities of the individuals in a community or the community in a region. IPCC (2001) has defined adaptive capacity as the 'ability of a community to withstand environmental changes'. In the current discourses of adaptation strategies, some scholars views adaptation as a matter of management and creation of adequate physical infrastructures to minimize the adverse impacts where as another group of scholars are emphasizing on poverty alleviation as a

more effective adaptation measure (Paavola, 2010) as it enhances the capability of the community to cope and adapt to the changing environment. However, it is imperative to have synergy between both these strategies as people who are vulnerable to adverse impacts of climate variability also face multiple stressors such as droughts, plant disease, inadequate and unequal access to enabling infrastructures, market fluctuations, and institutional changes (Stringer *et al.*, 2009; Misselhorn, 2005; Grothmann and Pat, 2005; Richards, 2003). The adaptation strategies are often informal and initiated by the local communities as a spontaneous response to any changes/stresses (Peetheram *et al.*, 2010; Mertz *et al.*, 2009; Stringer *et al.*, 2009; Osbahr *et al.*, 2008; Saldana-Zorrilla, 2008).

Around 69 percent of India's population (2011 census) lives in rural areas and dependent on climate sensitive livelihood options like agriculture, animal husbandry, both inland and inshore fisheries and various non-timber forest products. The high resolution climate change scenarios and projections for India predicted an increase in annual mean temperature (3° to 5° C under A2 scenario and 2.5° to 4° C under B2 scenario) by end of the century, increase in maximum (2 percent warmer) and minimum (5 percent warmer) temperatures and 20 percent rise in all India summer monsoon (Sathaye *et al.*, 2006, Kumar *et al.*, 2006). The studies have also predicted a sea level rise and increase in the intensity of tropical cyclones in the Bay of Bengal (Sathaye *et al.*, 2006). These variations in climatic conditions is likely to alter the hydrological cycle, affect the agricultural productivity, spread of malaria and other vector borne diseases, intensify the desertification process, and a shift in the forest types (Sathaye *et al.*, 2006, Ghosh *et al.*, 2006). In the context of these predicted changes it is important to understand the trends of localized change and its impact on rural livelihood systems at micro level in rural India.

The analytical framework of the paper is based on the notion of five critical livelihood assets - human capital, natural capital, financial capital, physical capital and social capital as discussed in DFID Sustainable Livelihoods Framework (DFID, 1999) and presented in Figure 1. The vulnerability context is the external environment that affects the livelihood options significantly but people have 'limited or no control' over these and here in the analytical framework this has been grouped into broad categories i.e., climate and non-climate stressors. The DFID framework identified this vulnerability context as the trends, shocks and seasonality (DFID, 1999). The vulnerability contexts affect some or all the livelihood assets and also livelihood opportunities in the locality in different ways. In response to these changes the households-both as individual units and as community choose different adaptation strategies. The asset endowment of the households, along with several other socio-economic conditions as well the characteristics of the community in which the household lives determines the vulnerability and influence the choice of the adaptation strategies both at household and community level. The community characteristics here imply the group behavior of the households living in a village or hamlet and the kind of collective activities they engage in. These local adaptation strategies coupled with national or state level formal mitigation strategies by the government in turn impact the household assets and hence determines the livelihood strategies too. So the right mix of assets and the adaptation strategies minimize the vulnerability of the community and results to sustainable livelihood outcomes.

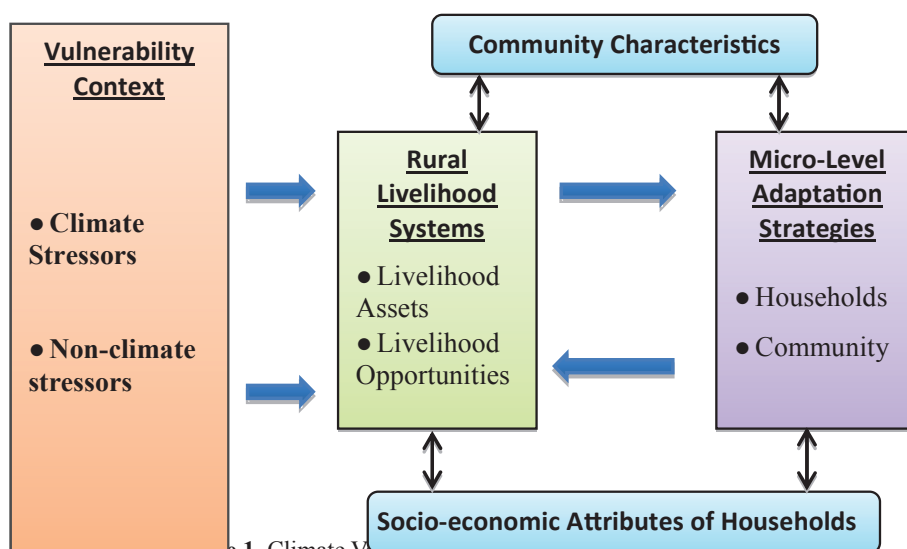
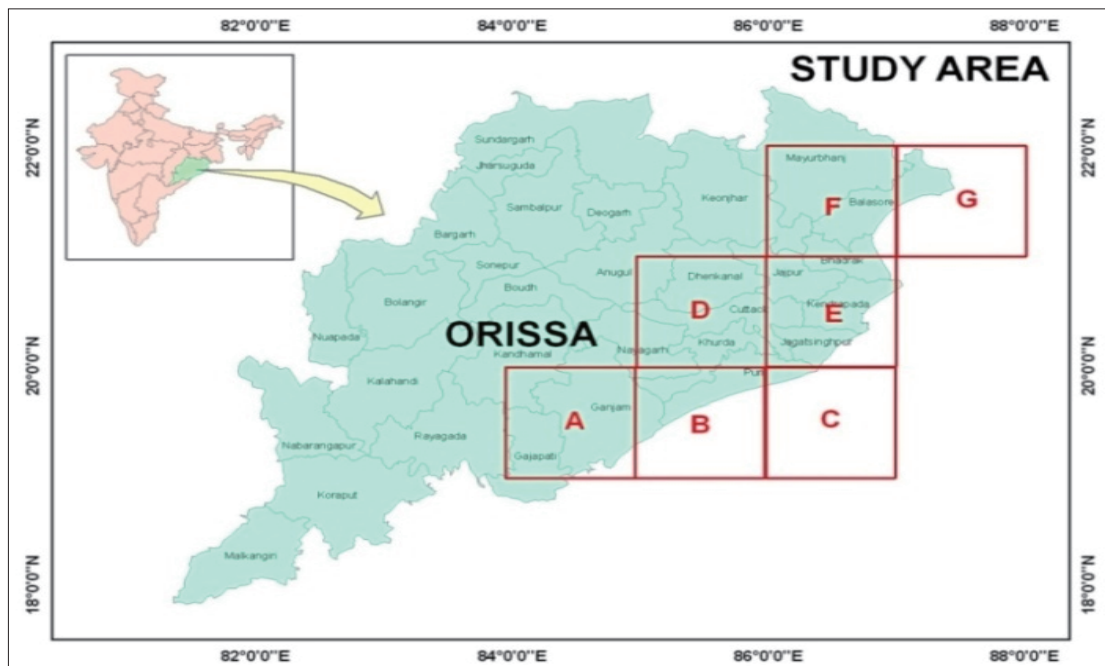


Figure 1. Climate Variability and Rural Livelihood Systems

### 3. The Methodology and Study Area

**The study approach and Methodology:** The approach of the study is analytical and the study is based on multiple data collection methodologies. The study has been conducted at two levels. First, the trends of the climatic variables like rainfall, temperature, frequency and intensity of cyclones are analyzed for the grid on which the study districts are located based on the grid level data from Indian Metrological Department. The data on other climatic variables like drought years, incidence of floods and other natural calamities are collected from the concerned government departments. Secondly, three coastal villages are selected from two of the coastal districts (Jagatsinghpur and Kendrapara) intensive field survey and localized investigation.



**Figure 2.** The Grids Covering Coastal Districts in Odisha

The analysis of trends of climatic variables is based on gridded data obtained from Indian Meteorological Department (IMD). IMD maintains a time series database of climatic variables and the following IMD data have been used for the trend analysis:

- Daily Rainfall: 1901-2004
- Daily Temperature: 1969-2005
- Cyclone Frequency 1891-2007

The time series data for rainfall and temperature for coastal Odisha has been generated by laying 1 Degree grids. Both the study districts are located in grid E (Figure 2). For temperature trends, Maximum, Minimum and average mean temperature were calculated from the daily maximum, daily minimum and daily mean temperature using C program and SPSS based on the arithmetic average of daily maximum, mean minimum and average mean temperature for 4 seasons, namely Winter (December to February), Pre monsoon (March to May), Monsoon (June to September) and post monsoon (October to November) as well as annual value were calculated for all grid for the period 1969-2005. The daily rainfall data of the grid are computed using C program and SPSS for four seasons, namely Winter (December to February), Pre monsoon (March to May), Monsoon (June to September) and post monsoon (October to November) as well as annual value were calculated for all grid for the period 1901-2004.

A detailed field survey has been conducted in study villages to understand the perception of the local community about the impact of climatic variables as well as the perceived impact of such changes on natural resource base and the livelihood options. Both qualitative and quantitative information are collected from study villages through structured questionnaire survey, semi-structured interviews and focused group discussions. The survey has been conducted both at household level and village level. For household survey, census survey method is used and 210 households (of the total 217 households in three villages) have been surveyed by using a structured questionnaire. Village level information has been collected by using multiple methods like

participatory rural appraisal (PRA), focused group discussion and key informant survey. At the household level, the respondents mostly constitute the head of the households or their spouses or both. The household questionnaire consisted information in various modules namely household particulars; household assets; social assets and access to common pool resources; changes in local climate, natural landscape, private land use, cropping pattern and food habits, social life, economic condition; losses due to natural disasters and compensation; and threat perception and adaptation.

**The Study Area:** The study has been conducted in two coastal districts namely Jagatsinghpur and Kendrapara in the Odisha (Figure 3), the state<sup>1</sup> located in eastern coast of India. Odisha<sup>2</sup>, comprising 4.74 percent of India's landmass and with 41.95 million people (2011 census) accounts for 3 percent of population of the country. It extends from 17° 49' N. to 22° 34' N. latitude and from 81° 39' E. to 87° 29' E. longitude with a geographical area about 155707 sq. km. The state has a coastline of 480 km that spread over six districts in the state i.e., Baleshwar (80 km.), Bhadrak (50 km.), Ganjam (60 km.), Jagatsinghpur (67 km.), Kendrapara (68 km.), and Puri (155 km.). There are 30 districts in the Odisha and these districts are further divided into 58 Sub-Divisions and again into 314 Tehsils<sup>3</sup>. There are 51349 villages in the state and these are grouped into 6234 Gram Panchayats (Village Councils). The state has 314 Community Development Blocks, 71 Notified Area Council and 32 municipalities.



**Figure 3.** The Map Showing Study Districts and Villages

Odisha, despite being a land of vast natural resources and human resources, has been wading through widespread poverty. After long decades of low per-capita income and low capital formation, the economy of the state is experiencing high growth in recent decades with huge inflow of investments in minerals based industries. The average annual growth rate in real terms for 10th Five Year plan (2002-2007) was 9.51 percent against the target of 6.21 percent. The quick estimates for 2009-10 also estimated the growth figure for the state at 10.45 percent in real terms at 2004-05 prices (GoO, 2011). The state of Odisha has a significant percentage population living in rural areas i.e. 83.32 percent against the national average of 68.84 (2011 census). This shows the dependence of a huge population in climate sensitive activities like agriculture, animal husbandry, fisheries etc. to earn livelihood. Agriculture continues to be the mainstay of the state's economy with contribution of 28.37 percent to GSDP during 2009-10 though

the share has declined gradually from 48.16 during 1950-51. However, agriculture is characterized with low productivity due to subsistence agricultural practices, inadequate capital formation and low investment, inadequate irrigation facilities and uneconomic size of holdings. The net area sown (NAS) in the state during 2009-10 was 5574 thousand hectares and is on decline since mid-eighties. The gross cropped area (GCA) has increased from 2848 thousand ha in 1936-37 to 9074 thousand ha in 2009-10 with a declining trend in last few decades (Figure 4).

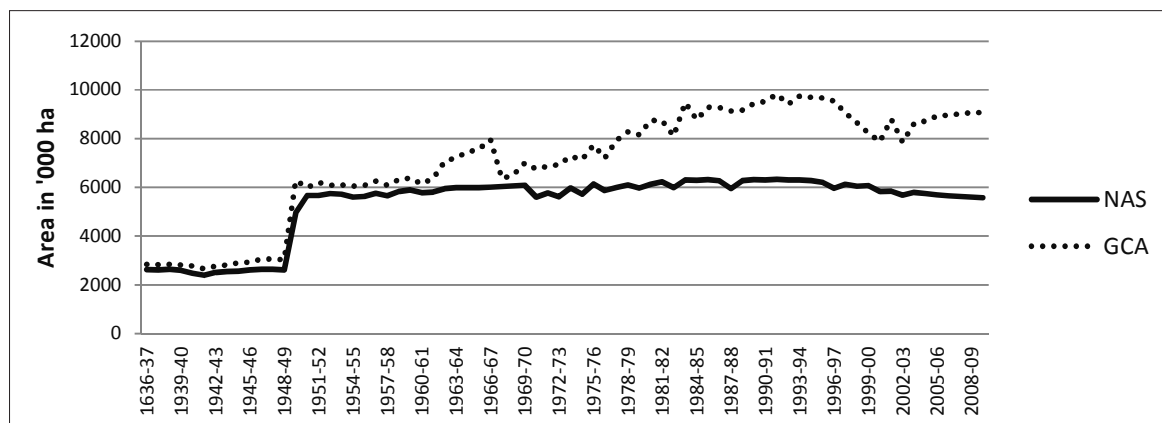


Figure 4. Gross Cropped Area and Net Area Sown in Odisha

Source: Statistical Abstracts of Odisha, various issues

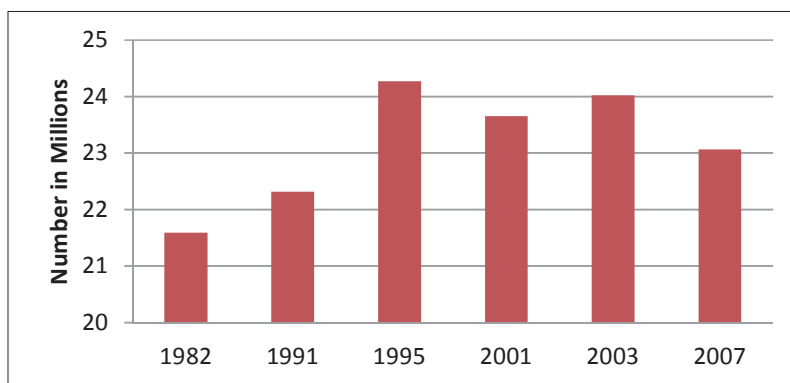
The irrigated area constitutes only 45 percent of the total cultivable area of 6165 thousand hectares (GoO, 2009). In the absence of adequate irrigation facilities, agriculture is critically dependent upon monsoon. As the cropping pattern is concerned, the area under paddy is increasing over the years with area under other crops are shrinking (Pattanayak and Nayak, 2006). Paddy being a water intensive crop with high vulnerability towards climatic factors has serious consequences for the livelihood of the farmers in rural areas in the context of different climate change scenarios. However, factors like preference of rice over other cereals as staple food in the region and other factors like minimum support price by the government for rice, provision of high yielding varieties and other technical support for rice cultivation by the government has resulted in increased area under paddy. As the result of the erratic behavior of the monsoon as well the changes in temperatures and rainfall pattern, agriculture production fluctuates widely from year to year. The yield rate for most of the food grain in the state is also lower than the average yield of other major states in India.

Table 1. Fisheries and Livelihood Systems in Study Area (2001)

Particulars	Jagatsinghpur	Kendrapara	Odisha
<b>Inland Fisheries</b>			
Number of Fisherman Villages	250	-	3678
Number of Fisherman Households	3622	-	135934
Fishermen Population	20926	51272	751356
<b>Marine Fisheries</b>			
Number of Fisherman Villages	75	85	589
Number of Fisherman Households	9615	6216	53020
Fishermen Population	37925	40373	332772

Source: The Economic Survey 2009-10, Government of Odisha

Fisheries, Forestry and Animal Husbandry also play an important role in providing and supplementing income of rural household. The study districts do not have much of forest cover though the state has around one third of its geographical area under forest. However, being coastal districts, fisheries provides livelihood for a significant size of the population (Table 1). Livestock is part and parcel of agro-based rural livelihood systems and provides an array of direct and indirect benefits. However, there has been a steady decline in the livestock population in the state in last two decades (Figure 5) due to different factors like lack of adequate grazing land, demise of traditional community grazing institutions, rural out migration, mechanization of agriculture, increased dependence on chemical fertilizers and so on. The total livestock population of state was 23.06 million as per 2007 livestock census of which about 60 percent are cattle, 32 percent are small ruminants and 2.5 percent are pigs.



**Figure 5.** Livestock Population of Odisha in different Livestock Censuses  
**Source:** Statistical Abstracts of Odisha, various issues

Odisha has the history of frequent occurrence of natural calamities like floods, droughts, coastal erosion, cyclone, tornadoes, heat wave, lightning etc., causing huge damage to the life and livelihoods. During last 12 years, there was some or other disaster almost every year in different parts of the state affecting the livelihood of people (Table 2). The whole of coastal Odisha is also prone to cyclone and coming under the Very High Damage Risk Zone – B, and the entire region was affected by 1999 super cyclone.

**Table 2.** Natural Calamities in Odisha since 1999

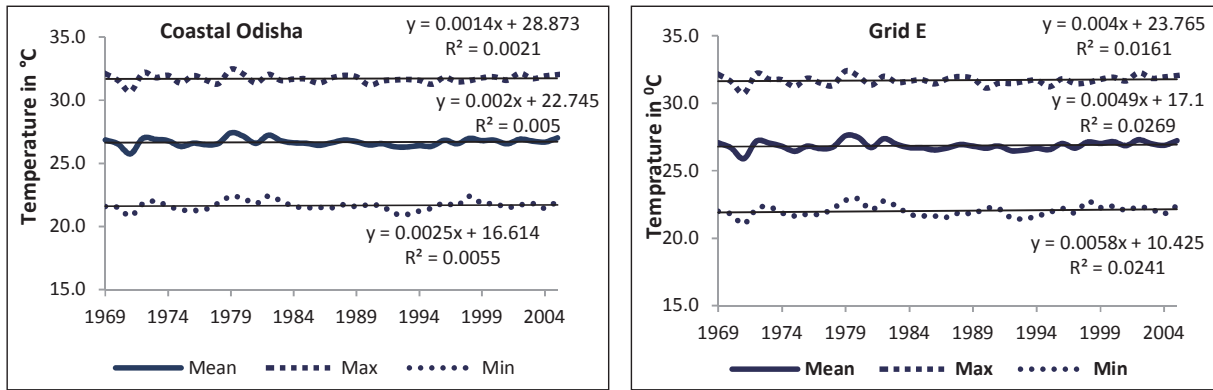
Year	No of Districts Affected
1999	Super Cyclone (All Coastal Districts)
2000	Drought in 29 Districts
2002	Drought in 29 Districts
2003	Flood in 11 Districts
2004	Drought in 10 Districts
2005	Drought in 30 Districts
2006	Flood in 10 Districts
2007	Flood in 06 Districts
2008	Flood in 19 Districts
2009	Flood in 17 Districts
2010	Crop losses in 30 districts due to unusual Rain during December
2011*	Flood in 19 districts and Drought in 11 districts

**Note:** \*based on newspaper reports

**Source:** Agricultural Statistics, Government of Odisha, *various issues*

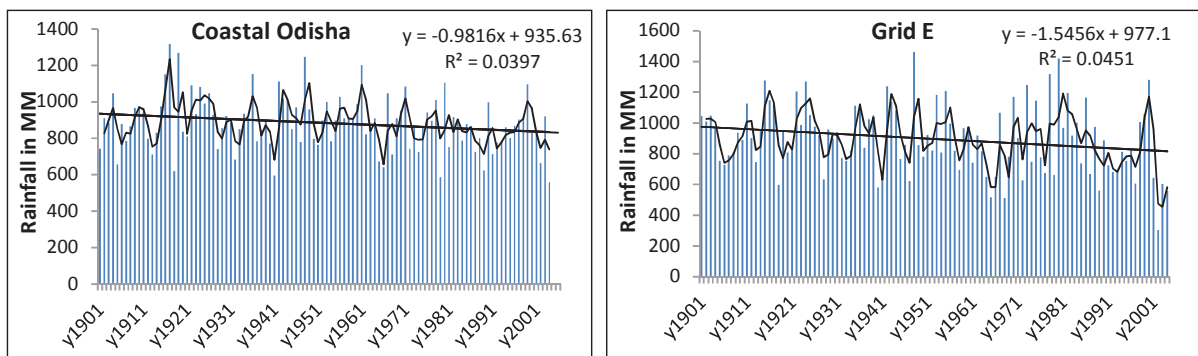
#### 4. Trends of Climatic Variables-Temperature, Rainfall and Cyclonic Storms

There has not been much variation in the trends of temperature in study districts as well as all the coastal districts of Odisha during 1969 to 2005. The trends of daily maximum, minimum and average temperature have been plotted in the Figure 6. As the trends of rainfall are concerned it has experienced decline for both Coastal Odisha as well as the study districts over the years. The annual rainfall data from 1901 to 2004 has been plotted to examine the trend for all the grids covering all the coastal districts as well as the grid E covering the study districts (Figure 6).



**Figure 6.** Trends in Temperature for all Coastal Districts and the Study Districts Grid

As the trend line in the graph indicates there is a declining trend in rainfall and it's statistically significant for both the plots. The rainfall has declined by 3.81 percent for coastal districts as a whole and for the grid covering the study districts (grid E) it has declined by 14.77 percent in compared to the base decade (Figure 7). It's not just the rainfall volume that declined; the number of rainy days has also declined for all districts in Coastal Odisha. The average number of rainy days for grid E is 86 whereas for the coastal districts as a whole it is 84 for the current decade. However, some of the coastal districts located in others grids like B, C and D experience increasing trends as number of rainy days are concerned. The seasonal trends of rainfall indicates declining trends of monsoon rainfall and increasing trends of post-monsoon rainfall both for all the coastal districts as well as the study districts. The pre-monsoon and winter rainfall has also declined for all the coastal districts.



**Figure 7.** Trends in Annual Rainfall for all Coastal Districts and the Study Districts Grid

A majority of such cyclones and depressions occurred in Bay of Bengal during 1891 to 2007 have passed through Odisha (Figure 8, left hand side plot). The trends also reveal that the frequency of cyclonic storms (CS) and depressions (D) has increased over the years though the instances of severe cyclonic storms (SCS) have declined (Figure 8, right hand side plot).



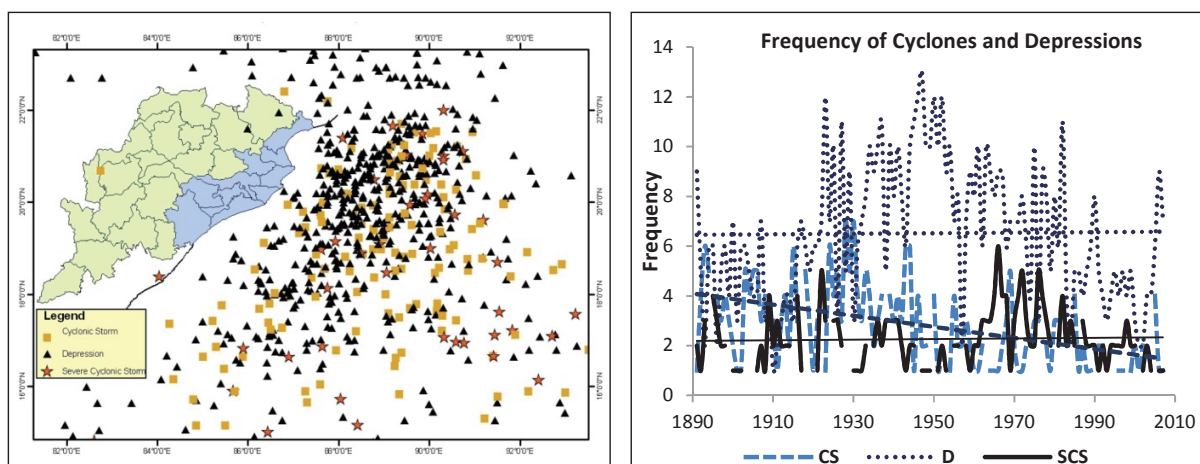


Figure 8. Cyclonic Storm, Depression and Severe Cyclonic Storms in Odisha Coast 1891-2007

## 5. Socio-Economic Characteristics and Livelihood Assets of Households in Study Villages

The field study has been conducted in three coastal villages namely Pentha and Prasannapur (neighboring villages) in Rajnagar block of Kendrapara district and Siali in Erasama block of Jagatsinghpur district. Rajnagar is one of the block most affected by sea erosion in the state and Erasama was one of the block most affected in super cyclone of 1999. Rajnagar was also affected in 1999 super cyclone. The socio-economic attributes of households are collected through census survey in these three villages are discussed below. There are 217 households in all 3 villages and the survey has covered 210 households<sup>4</sup> (Table 3).

Table 3. Social Composition of Households in Study Villages

Category	Pentha	Prasannapur	Siali	All Villages
Odia SC	2	0	1	3
Odia OBC	50	23	3	76
Odia Gen	1	35	0	36
Bengali OBC	1	8	75	84
Total HHs surveyed	54	66	79	199
Total HHs in the village	58	72	85	217

Source: Field Survey 2010-11

The major social stratum in any specific region or locality in India is the caste<sup>5</sup> and religion. All the households in all three study villages are Hindus by religion and though from caste and the linguistic groups<sup>6</sup>. There are several Bengali settlements/villages in coastal Odisha of which some of them are very old and some new ones. The old Bengali settlements date back to pre-independence British era when *Zamindaris*<sup>7</sup> in coastal Odisha are owned by the Bengali Zamindars (Patnaik, 1997; inputs from elderly persons in study villages). The Bengali landlord got agricultural laborers from Bengal who got settled subsequently (but with little socio-cultural interactions with Odia villagers due to linguistic differences). The new ones have emerged with the influx of illegal migrants (mostly through sea routes) during the war for the separation of Bangladesh from Pakistan in 1971 and afterwards<sup>8</sup>.

Table 4. Demographic Composition of the Households Surveyed

Name of the Village	Male	Female	Total Population	No. of Households
Pentha	202	172	374	54
Prasannapur	175	176	351	66
Siali	210	211	421	79
Total	587	559	1146	199

Source: Field Survey 2010-11

It's evident from Table 4 that the sex ratio is more or less similar to state averages except Pentha and varies across villages. Around 60 percent of the population is children and youth in all the villages showing a significant young as well as dependent population (Table 5).

**Table 5.** Age wise Distribution of Population (%)

Age Group	Pentha	Prasannapur	Siali	All Villages
0-15	29.95	29.63	29.69	29.76
16-30	27.81	32.19	31.12	30.37
31-45	19.25	16.52	20.43	18.85
46-60	10.7	9.12	11.64	10.56
61+	12.3	12.54	7.13	10.47

Source: Field Survey 2010-11

The average household size for all the households in study villages is 6 though it varies across the social groups in each of these villages. The average household size is higher in Pentha than other two villages (Table 6).

**Table 6.** Average Household Size across Social Categories

Social Group	Pentha	Prasannapur	Siali	All Villages
Odia SC	9	-	5	7
Odia OBC	7	6	6	6
Odia Gen	10	5	-	5
Bengali OBC	9	4	5	5
Total	7	5	5	6

Source: Field Survey 2010-11

The literacy rate in all the study villages (92 percent) is higher than the state average and varies across villages with lowest literacy in Prasannapur (86 percent). As the educational attainment is concerned significant portions of the population have studied up to secondary and less (Table 7). This level of education though enables people read and write, does not fetch a livelihood based on their educational qualifications.

**Table 7.** Educational Level (% of population)

Educational Level	Pentha	Prasannapur	Siali	All Villages
Illiterate	5.61	13.39	5.7	8.03
Primary	39.57	27.92	37.05	35.08
Middle	10.96	15.38	14.01	13.44
Secondary	26.47	29.91	27.32	27.84
Higher Secondary	3.74	3.42	5.23	4.19
Graduate & above	6.68	5.41	4.75	5.58
Infants	6.95	4.56	5.94	5.85

Source: Field Survey 2010-11

As the activity status of the population is concerned, around 30 percent of the households are workers. Most of the women don't work as wage laborers or even in agricultural fields though helps the male members several activities related to cultivations. The women are mostly assigned with activities like child care, cooking and all other household work. Agriculture and unorganized rural non-farm sector provides major employment opportunities. The occupational pattern of the working population in study villages reveals that for all the villages together around 55 percent are engaged in agriculture and other non-agricultural activities though it varies across the villages. The occupational patterns are determined by a host of local conditions that include the livelihood asset endowments and proximity of the village too any centers of economic activity. As it's evident from the Table 8, occupational pattern varies across the village with the dependence on agriculture lowest in Pentha and highest in Siali. The

proximity of Pentha and Prasannapur to the port city of Paradeep has created opportunities for salaried or casual employment.

**Table 8.** Occupational Pattern (% population)

Occupation	Pentha	Prasannapur	Siali	All Villages
Agriculture worker	17.95	38.89	53.17	37.04
Non-agricultural labor	31.62	30.56	23.81	28.49
Business	3.42	1.85	11.9	5.98
Government employee	11.11	4.63	3.17	6.27
Private employee	35.9	24.07	7.94	22.22

Source: Field Survey 2010-11

Land is the most critical source of livelihood for rural masses. Land as a household asset has multiple socio-economic uses others than food production. The survey found that 74 percent of the households in study villages own less than 1 ha of land and hence are marginal farmers. This varies across villages with Prasannapur having 89 percent households owning less than 1 ha<sup>9</sup> of land (Table 9). None of the households owns land more than 10 ha. The average landholding size for the all the household is less than 2 acres indicating the predominance of marginal and small farmers in the study villages. The average land holding size of households constitutes 0.90 acres (0.36 ha) and 74 percent of the households are marginal landholders. These marginal land ownership patterns as well as small size of land holdings indicate the subsistence agriculture in study villages.

**Table 9.** Households by Agricultural Land Ownership (%)

Land Ownership	Pentha	Prasannapur	Siali	All Villages
Marginal (< 1 ha)	74.07	89.39	60.76	73.87
Small (1-2 ha)	18.52	3.03	32.91	19.1
Semi-medium (2-4 ha)	7.41	3.03	5.06	5.03
Medium (4 -10 ha)	0	4.55	1.27	2.01
Total	100	100	100	100

Source: Field Survey 2010-11

The survey findings also suggest abysmally small number of livestock in the study villages (Table 10). The bovine livestock in traditional Indian agricultural societies plays a crucial role in terms providing milk, bullock power for tilling the land and multiplying livestock wealth of the household. The declining number of bullock<sup>10</sup> does not imply increased mechanization of agriculture in the study villages but abandonment of cultivation by many households. This could be due to a variety of socio-economic factors like low returns from agriculture, high input cost, changing occupational preferences and so on. The number of ruminants is also less and in Siali none of the households owns these livestock.

**Table 10.** Livestock Population

Livestock	Pentha	Prasannapur	Siali	Total on villages
Cow	40	59	124	223
Bullock	24	24	37	85
Buffalo	0	0	2	2
Goat	31	69	0	100
Sheep	37	2	0	39

Source: Field Survey 2010-11

The livestock ownership also varies across social groups with OBCs (both Odia and Bengali) having more livestock. Table 11 presents the livestock population in cow units across social groups in the study villages. The scheduled caste population has least livestock ownerships. Given the importance of livestock in livelihood systems, this differential pattern of livestock ownership indicates disparity in the vulnerability and adaptability.

**Table 11.** Livestock Population across Social Groups (in Cow units\*)

Social Group	Pentha	Prasannapur	Siali	Total
Odia SC	1	-	0	1
Odia OBC	86	58	4	148
Odia Gen	1	47	-	48
Bengali OBC	2	8	180	189
Total	90	113	184	386

**Note:** \*1 bullock = 1.5 cow, 1 buffalo = 2 cow, 4 goat = 1 cow, 6 sheep = 1 cow. These conversion units are calculated on the basis of the market price of these livestock species in study region

**Source:** Field Survey 2010-11

The public as well as private infrastructure also influences the vulnerability of the communities and their adaptive capacities. There is no public irrigation infrastructure in these regions too and agriculture is rain fed. The farmers depend on ponds, wells and rivulets to source water for irrigation in other seasons. Another major factor affecting the vulnerability is the kind of houses people live in. As Table 12 indicates, a significant percentage of the households live in are the houses with thatched roof and mud wall which is very much susceptible to be washed or blown away in natural calamities like flood and cyclones. The discussion with the respondents suggests that mud wall houses with thatched roof are the traditional housing pattern in this region and people usually build houses on higher foundations to avoid submergence during floods. The thatched roofing pattern was also designed to resist low intense cyclones and this also takes into consideration the direction of wind from sea to have minimal impact of cyclones. However, the increased intensity of major floods<sup>11</sup> and severe cyclonic storms make these housing structures highly vulnerable and put the lives of people and livestock at risk.

**Table 12.** Building Materials of Living Houses (in %)

Building Materials	Pentha	Prasannapur	Siali	Total
Roof				
Thatched	87.04	98.48	56.96	78.89
Asbestos	3.7	1.52	7.59	4.52
Concrete	9.26	0.00	35.44	16.58
Wall				
Mud	83.33	100.00	54.43	77.39
Bricks	16.67	0.00	45.57	22.61
Floor				
Mud	85.19	100.00	53.16	77.39
Bricks	14.81	0.00	46.84	22.61

**Source:** Field Survey 2010-11

With these socio-economic attributes of the households in the study villages as discussed in preceding pages, the major sources of livelihood for non-salaried households are: farming (food crops, betel vine, cashew, shrimp farming), wage labour, petty business, leasing out land for shrimp farms, tertiary activities (masonry work, transportation, carpenter etc.) and remittances. Though commercial shrimp farming is widespread in coastal Odisha, it's mostly done by outside businessmen as it needs big investments. They purchase or lease in land from local farmers for this. Only 11 households in one of the study village (Siali) have shrimp farms though many households have leased out land for this purpose. In the absence of public irrigation infrastructure, agriculture is mostly rain-fed though few farmers have their own private tube wells for irrigation. Paddy is the only major food crop grown and the few farmers reported to cultivate pulses and vegetables. Field crop production meet 7.53 (std. dev.= 4.80403) months of household food demand.

## 6. Climate Variability, Natural Resource Base and Livelihood Assets of the Rural Communities: Perceptions and Adaptations

The trends of change in climatic variable discussed previously (in section 1.4) are based on the data from meteorological centers. However, the local communities too perceive these changes and adapt to such changes in diverse ways as their livelihood systems are very much integrated with local climatic conditions and also to the local natural resource base. The dominant perception of the local communities about the trends and timelines has been mapped during field survey and is presented in Figure 9. The dominant perception found to be decline in the volume of rainfall and such a declining trend is more pronounced since 1980s. As the rainfall pattern is concerned, there is a feeling that it's more erratic and there have been increased instances of untimely rainfall. Interestingly people have pointed out two different time periods for this erratic trend i.e., a decade during mid-fifties to mid-sixties and since 1990s. The temperature is also perceived to have increased and more pronounced since last two decades. There is uniform response about the increased temperature across all the respondents. This is probably due to increased incidences of deaths due to sun stroke<sup>12</sup> in the state. There is also a perception that the frequency of natural calamities have increased in recent years, particularly since late 1990s. This could be due to the devastating super cyclone of 1999 and several other calamities in subsequent years (Table 2). However, some elders also opined that this trend of increased cyclones and depressions is more felt since mid-eighties.

Figure 9. Climate Variability Perception Timelines

Climate Variables	Trends	1940	1950	1960	1970	1980	1990	2000
Rainfall Volume	↓					→	→	→
Rainfall Pattern	↔		→				→	→
Temperature	↑						→	→
Calamity frequency	↑					.....	→	→
Sea erosion	↑			→	→	→	→	→

Source: Group Discussion and Key Informant Interviews during Field Survey 2010-11

As discussed in earlier sections, all the study villages are exposed to sea erosion with one village already lost some of its forests and lands to the sea. People have been observing this trend of inward movement of sea since 1960s though this has become more intense in recent years. The elders viewed that 'sea was 3 to 4 hours of walk from their villages when they were children but it's now 10-20 minutes of walk and they could hardly see the sea water or hear the sea roar from the village as its now'. It evident from above discussion that the perception of people about changes in climatic variables matches the trends of change based on analysis of scientific data.

Along with the changes in climatic variables, people also reported changes in the local natural resource base. These changes could be due to ecological or socio-economic factors or interaction of both. However, this paper focuses in assessing the perception of people about the trends of such changes and its timelines (Figure 10) rather than the reasons of such changes. It has been pointed out that the rivulets and creeks in the region have changed directions, silted and become more saline in last three decades. These water bodies have been the sources of water, fish and crabs for the local community and provided an array of ecosystem services which has declined significantly in recent years. Other water bodies like community pond, community well have also become dilapidated and this trend has been observed since 1990s. Coastal Odisha had a vast tract of mangrove forest which acted as a natural barrier for cyclones, tidal waves and also sea erosion. Mangrove forests was instrumental in saving thousands of people in the areas where these forests still stands during 1999 cyclone (Das and Vincent, 2009). The mangrove forests also support livelihoods of the local communities in different ways ranging from the provision of food, fodder, fuel wood and so on. There were mangrove forests in sea coast close to these villages which no more exists. The degradation of mangrove forest started around late 1950s and early 1960s and was all over by 1990s. Whatever little left near village Penthath got washed away in sea erosion and we couldn't see even a single bush in all three villages during our field visit. The tree cover has also declined significantly in the region more specifically in post 1999 cyclone. It has also been pointed out by the people that village commons like pastures and open land

has also declined during last 2-3 decades. Some of these lands were distributed among the landless during land reform and land consolidation and also encroached upon. Some of the village pastures got saline with sea water during high tides.

**Figure 10.** Perception about Changes in Common Pool Natural Resource Base

Resources	Trends	1960	1970	1980	1990	2000
Rivulets/Creeks	Salinity increased, change in the direction, silted					→
Other water bodies	Silted, dilapidated					→
Mangrove Forest	Declined	→				
Tree Cover	Declined					→
Community land	Declined					→
Pasture	Declined, Salination					→

**Source:** Group Discussion and Key Informant Interviews during Field Survey 2010-11

These changes have important implications on livelihood assets of the households and hence their livelihood security. Climate change literature discusses extensively the impact of such variability in the context of coupled human-natural resource interactions. However, the focus of this study is not intended to infer any causality but to explore the changes as perceived by the people and their adaptation responses to such changes. The study has explored the changes in the some components of the livelihood assets i.e., livestock, land use, cropping pattern and occupational pattern in the study villages.

The changes in livestock population in the study villages during survey and before 2009 (super cyclone year) has been presented in Table 13. The table indicates that except the goat population in Prasannapur all other livestock has declined considerably during these two periods in all the villages. The significant declines have been observed in cow and bullock that were predominant livestock in the region. The last row of the table presents the livestock in cow units where the numbers of other livestock have been converted to number of cows based on the conversion units as specified in note below the table. It has been pointed out by the villagers in Siali that all most all livestock were washed away by the tidal wave during super cyclone in 1999 in this village.

**Table 13.** Changes in Livestock Population

Livestock	Pentha		Prasannapur		Siali	
	2011	Before 2009	2011	Before 2009	2011	Before 2009
Cow	40	100	59	140	124	1370
Bullock	24	63	24	41	37	146
Buffalo	0	12	0	1	2	0
Goat	31	64	69	47	0	67
Sheep	37	80	2	10	0	0
Total Livestock in Cow units*	90	248	113	217	184	1606

**Note:** \*1 bullock = 1.5 cows, 1 buffalo = 2 cows, 4 goats = 1 cow, 6 sheep = 1 cow

**Source:** Source: Field Survey 2010-11

As the distributions of livestock across different social groups in the village are concerned, livestock populations are mostly concentrated with OBC (both Odia and Bengali) households (Table 14). The OBCs in these villagers mostly belongs to cultivator caste group and this shows the how livestock are very much integrated with agro-based livelihood options. So the changes in livestock population would affect the livelihood systems considerably.

**Table 14.** Changes in Livestock Population (in Cow Units) across Social Groups

Social Groups	Pentha		Prasannapur		Siali		All Villages	
	2011	Before 2009	2011	Before 2009	2011	Before 2009	2011	Before 2009
Odia SC	1	0			0	22	1	22
Odia OBC	86	245	58	60	4	17	148	322
Odia Gen	1	1	47	148			48	149
Bengali OBC	2	2	8	10	180	1567	189	1578
All Groups	90	248	113	217	184	1606	386	2070

**Note:** \*1 bullock = 1.5 cow, 1 buffalo = 2 cow, 4 goat = 1 cow, 6 sheep = 1 cow

**Source:** Field Survey 2010-11

The discussion with villagers during field survey also revealed that there have been significant changes in private land use pattern in last few decades (Figure 11). It has been pointed out that the land under cultivation has declined with increase in fallow period and diversion of land use for purposes other than crop cultivation like shrimp farm, brick kilns, betel vines, cashew plantations, residential uses and so on. These changes are more observed since mid-1980s. Declined crop productivity, increased instances of crop failure due to frequent natural calamities and salination has resulted in leasing out of land for brick kilns<sup>13</sup>, shrimp farms etc., as these fetches better return to farmers. It has been reported that these conversions are more rampant after 1999 super cyclone. This finding also substantiates the declining trends of gross cropped area and net sown area in the state as a whole.

**Figure 11.** Perception about Changes in Private Land Use

Land use: Pentha and Prasannapur	1960	1970	1980	1990	2000
Less land under cultivation					
More fallow period					
Leasing out land for brick kilns					
Land use: Siali	1960	1970	1980	1990	2000
Less land under cultivation					
More fallow period					
More land under shrimp farming					
More betel vines					
More cashew plantations					

**Source:** Group Discussion and Key Informant Interviews during Field Survey 2010-11

The study also made an attempt to collect information about the changes in cropping pattern and it has been found that there has been a significant shift in the crop mix during last five decades (Table 15). The farmers were not only growing different crops that include cereals, pulses, oilseeds, tobacco and vegetables but also grow different breed varieties of each of these crops<sup>14</sup>. With passing decades the crop breeds as well as crop varieties have. Farmers have opined that their land is no more suitable to grow pulses and many other crops. This change towards mono cropping also makes farmers vulnerable to changes in climatic conditions and resultant crop failures. The market dependence of households for food other than rice has also increased in recent years for these changes.

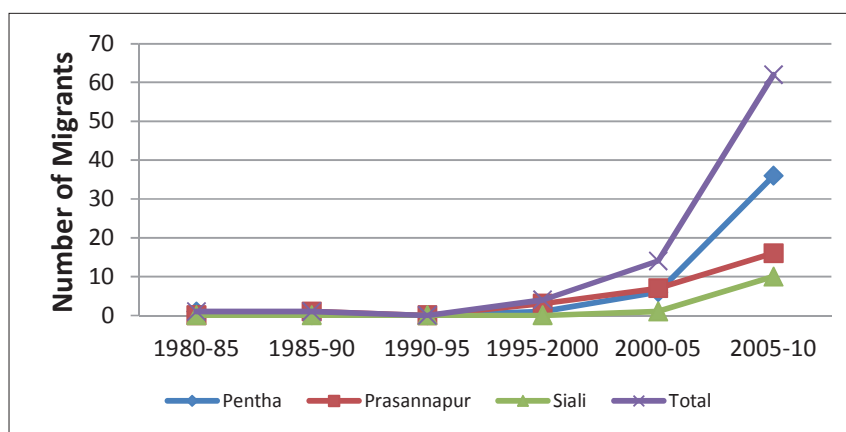
**Table 15.** Changes in Cropping Pattern

Villages	1960s	1970s	1980s	1990s	2000
Pentha and Prasannapur	Paddy, Pulses (4), Oilseed (3)	Paddy, Pulses (3), Oilseed (1)	Paddy, Pulses (2), vegetables	Paddy, pulses (1), vegetables	Paddy
Siali	Paddy, Pulses (4), Oilseed (2), Vegetables	Paddy, Pulses (4), Vegetables	Paddy, Pulses (2), betel leave,	Paddy, Pulses (1), betel leave	Paddy, betel leave, shrimp farms

**Note:** numbers in parenthesis shows the number of crop breed varieties grown by the farmers. The figures collected for paddy has not been reported due to some data discrepancies.

**Source:** Group Discussion and Key Informant Interviews during Field Survey 2010-11

These changes are also accompanied by changes in occupational pattern in study villages. There have been increased instances of out-migration in these villages as people move to cities within the states as well as far away cities in other states for employment. These migration ranges from seasonal to all the months of the year. The data about migrants (year migrated, destination and remittances) have been collected from their respective households during the survey.

**Figure 12.** Trends of Out-Migration in Study Villages

**Source:** Field Survey 2010-11

It has been found that people started moving to other cities from 1980s onwards and there has been a spurt in during last one decade, particularly after the 1999 super cyclone (Figure 12). However, the cyclone can't be the only (push) factor for out-migration from the region though it could have triggered the same.

**Table 16.** Educational Qualification of Migrants

Educational Qualification	Pentha	Prasannapur	Siali	Total
Primary & Below Primary	13.04	3.7	18.18	10.71
Middle	26.09	14.81	9.09	20.24
Secondary	32.61	62.96	54.55	45.24
Higher Secondary	13.04	3.7	9.09	9.52
Graduate & above	15.22	14.81	9.09	14.29

**Source:** Field Survey 2010-11



**Table 17.** Landownership pattern of Migrant Households

Land Ownership	Pentha	Prasannapur	Siali	Total
Marginal	67.74	90.91	60	74.6
Small	22.58	0	40	17.46
Semi-medium	9.68	4.55	0	6.35
Medium	0	4.55	0	1.59

Source: Field Survey 2010-11

As the educational profile of these migrant members shows (Table 16) majority of them are not skilled or trained to move to other cities to find employment of their choice. So migration could be one of the adaptation strategies of these rural households to cope with the series of changes that affected the livelihood systems in the region. The landownership pattern of migrant households indicates (Table 17) that a significant percentage of migrants are from household owning less land.

## 7. Conclusions

The paper discussed the climate variability and the perception of the rural communities at micro level in two coastal districts in the state of Odisha in India. The analysis of time series meteorological data shows that there is moderate change in climatic variables. A case study has been conducted in three coastal villages to examine the perception of the local communities on climate variability and its impact on their livelihood. The study analyzed the perceptions of the local community about the trends of change on various aspects livelihood and it has been found that there is conformity between local perceptions and scientific claims about the trends and impacts of climate change. The rural livelihood systems are intricately related with climatic conditions for critical climate-natural resource-livelihood system interactions and are significantly influenced by the local/global changes. Local people also have considerable knowledge about the changes happening in the natural resources around them and trying to adapt to the change. Interestingly there is a great deal of consistency in local perception about the changes and the scientific data. Along with the climatic variations, there have been significant changes in the local natural resource base. Such changes in natural resource base may not be climate induced, but has significant bearings on the rural communities for the critical support that these resources have been providing since ages. The paper has analyzed how these changes are also complemented with changes in different components of livelihood assets at local level like livestock, private land use, cropping pattern and occupational pattern over the years. Given the differential socio-economic attributes of the households within any rural community, the vulnerability as well as the adaptation strategies also varies across the household. The poor and the marginal groups within the communities are more vulnerable. The analysis also suggests that the changes in climatic variables and natural resource base impact the livelihood assets as well as the livelihood opportunities of the rural communities. Though the study has refrained from inferring any causality between climate variability and rural livelihood systems for the methodological difficulties in singling out climatic factor for the changes, the findings have suggested critical interaction between the climate and livelihood. The coastal communities in general are highly vulnerable to any future climate variability given their livelihood asset endowments and socio-economic attributes.

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## Endnotes

<sup>1</sup> The states are subnational administrative territories in India, similar to prefectures in Japan. Each state is further subdivided in to districts for administrative convenience.

<sup>2</sup> The name of the state has been changed from its Anglicized version 'Orissa' to 'Odisha' through constitutional amendment and became effective since 1<sup>st</sup> November 2011. However, the authors have used Odisha indiscriminately throughout though many of the documents referred in the text were published before this.

<sup>3</sup> Tehsil is the lowest revenue administrative territory within the districts in states. The developmental administrative units are called community

- development blocks (CD Blocks) for villages, notified area councils (NACs) for small towns and municipalities for urban areas.
- <sup>4</sup> Though 210 households are covered under the survey, only data pertaining to 199 households are tabulated and analyzed. The remaining 11 household's data were dropped for inconsistency and incomplete information for some variables.
- <sup>5</sup> The caste system in India is a traditional institution of social stratification in which communities are defined by thousands of endogamous hereditary groups. It started as an institution of division of labor in ancient India and the caste of person was decided on the basis of activity that the person chooses to earn livelihood. Subsequently, the caste became hereditary and decided by the family to which the person born and this formed the basis of social and economic exploitation by the upper caste and dominant caste groups.
- <sup>6</sup> Usually in Indian villages most people within a state speak same language and most of the states are formed on the basis of linguistic identities of the different regions after independence. For example, Odia is the dominant language in Odisha, Bengali in West Bengal, Telugu in Andhra Pradesh, and Tamil in Tamil Nadu and so on.
- <sup>7</sup> Zamindari is a system of land governance where vast tracts of land in a region are assigned to a zamindar (land lord) for tax collection and administration.
- <sup>8</sup> [http://articles.timesofindia.indiatimes.com/2001-11-26/kolkata/27242953\\_1\\_Odisha-government-bangladeshi-super-cyclone](http://articles.timesofindia.indiatimes.com/2001-11-26/kolkata/27242953_1_Odisha-government-bangladeshi-super-cyclone)
- <sup>9</sup> 1 ha=2.47 acres
- <sup>10</sup> Each farming household used to own at least 2 bullocks making it a pair to plough the land. Households with more land had multiples of 2.
- <sup>11</sup> Government has initiated several flood control measures like flood management through big dams, barrages, embankments in both sides of rivers. It has been pointed out by the villagers that though these measures successfully controlled minor floods, major floods are more frequent in recent years and have devastating impacts.
- <sup>12</sup> A major heat wave in 1998 summer killed 2042 people across the state which alarmed the state administration to take a series of proactive measures and create awareness among the people not to be exposed to severe heat conditions in summer. As per the government records 846 people have died in sun stroke from 1999-2010 (Das and Smith, 2012).
- <sup>13</sup> Brick kilns use the top soil to make mud bricks which are in huge demand in constructions both in rural as well as urban areas.
- <sup>14</sup> Individual farmers have reported to grow 7-8 varieties of paddy, 5-6 varieties of pulses, 3-4 varieties of oilseeds

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