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Impact of Climate Change on Agriculture and Other Livelihood Options in Costal Odisha

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ABSTRACT

Climate change affects agriculture in many ways through crop loss, poor soil conditions, and pest attacks. In addition, agriculture also faces natural disasters like droughts, floods, cyclones, and the late monsoon caused by climatic variations. In Odisha over 60 per cent of the population depends on agriculture for their livelihood and due to nature's extremes like cyclones and floods, agriculture shows a negative growth for the last decade, from 2004-05 to 2014-15 (Odisha Economic Survey, 2014-15). In addition to the unpredictable happening of nature, the difficulty in getting weather-related information also hamper agriculture and, many of the farmers were shifted to other unconventional and unsustainable livelihood options. The agronomic model of climate sensitivity indicates that higher temperatures are likely to be harmful to many crops, but in the contrary, some of other studies are in view that, climate change may not always produce a negative impact on crop yield. In this paper author has tried to provide a theoretical base for the cost of climate change in the form of crop modification, livestock and transition in livelihood options to the productivity of agriculture and livelihood across ten agro ecological zones, specifically in the coastal belt of Odisha and their climate resilience potentiality.

Keywords: *climate change, livelihood, ecosystem, agriculture, global warming*
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I. INTRODUCTION

Climate change is any significant long term change in the expected patterns of average weather of region (or the whole Earth) over a significant period of time. It is about non-normal variations to the climate, and the effects of these variations on other part of the Earth. These changes may take more than tens or perhaps millions of years (Mahato, 2014). The Fourth Assessment report of the Intergovernmental panel on Climate change (IPCC) has reconfirmed that the global atmospheric concentration of carbon dioxide (CO_2), Methane and Nitrous Oxide, Greenhouse Gases (GHGs), have increased markedly as a result of Human activities since 1750. The greenhouse effect is a natural process that plays a major part in shaping the earth's climate. It produces the relatively warm and hospitable environment near the earth's surface where humans and other life forms have been able to develop and prosper, but increased in anthropogenic activities such as industrialization, urbanization, deforestation, agriculture, change in land use pattern etc. are contributing at a faster rate for global

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climate change. For Indian region (South Asia), the IPCC has projected 0.5^0-1.2^0C rise in temperature by 2020, 0.88^0-3.16^0C by 2080 depending on the scenarios of future development (Table 1, IPCC 2007b). Climate change is likely to impact all the natural ecosystems as well as socio-economic system in India as shown by the National Communication report of India to the United Nations Framework Convention on Climate Change (UNFCCC). The climate is changing in a faster rate due to mushrooming of industries and population explosion and to meet the demand of the growing population the natural resources such as forest are being exploited at a faster rate.in spite of the rising demand for food and fodder, the climate change will further worsen the condition by reducing the yield of dry land crops (K. V. et al., 2012). Different sectors like water resources, forests, agriculture and coastal zones are projected to have several potential impacts. It will bring change in hydrological cycles, rainfall as well as the magnitude and the timing of its run-off. However, the distribution of the incidences of climate change will also vary with in the geography encompassed by India. Some sectors and regions in India are considered highly susceptible to current climate variability and the projected impacts of climate change. Climate is the primary determinant of agricultural productivity (Adams et al., 1998). Climate change is likely to have both positive and negative impact on agriculture, depending on the physiological characteristics of the region and the crops being produced (Antle, 2008). There are three ways in which the greenhouse effect may be important for agriculture. First increased atmospheric CO_2 concentrations have a direct effect on the growth rate of crop plants and weeds. Secondly CO_2 induced changes of climate may alter levels of temperature, rainfall and sunshine that can influence plant and animal productivity. Finally rises in sea level may lead to loss of farm land by inundation and increasing salinity of ground water in coastal areas. Scientists who are engaged in predictions of changing climatic impact predict that rising temperatures will have a significant impact upon crop yields, most noticeably on the tropics and subtropics by 2100. (IPCC, 2001) regard to this India as a developing and agrarian country is coming under tropical zone is more acute to climate change. Climate change is likely to increase the variability and uncertainty in monsoon patterns. Agriculture continues to be fundamentally dependent on weather which makes it sensitive to climate-induced effects. Any change in the climatic factors like temperature, precipitation, carbon dioxide concentration, changes in the soil moisture will affect Indian agriculture. The productivity of different crops will be affected. Rice and wheat yields could decline considerably due to climate change (IPCC 1996: 2001: Kumar & Parikh, 1998). Climate change induced increases in temperatures, rain fall variation and the frequency and intensity of extreme weather events are adding to pressure on the global agricultural system (OECD, 2015). Changes in sowing and harvesting dates, water availability, and evapotranspiration and land suitability, all these factors can change yield and agricultural productivity (Harry et al., 1993). The impact of climate change on agriculture is many folds including diminishing of agricultural output and shortening of growth periods for crops. (Janjua et al.2010). 2^0 C rise in mean temperature and a seven per cent increase in mean precipitation would reduce net revenues by 12.3 per cent for the country as a whole which implies that low production will be affected and food security will be adversely impacted. Particularly among small farmers and rural population. Besides agriculture the available evidence on climate change shows that it will also affect the occurrences of climate extremes like cyclones, drought and floods. The IPCC 2007 have projected a mean sea level rise of 0.18 to 0.59m by 2090, relative to the 1980-99 level. If these predictions are proved correct, it can hamper India's coastal population through increased flooding of low lying areas and loss of crop yields from inundation and salinization of fresh water sources. Under a range of climate change scenarios, the frequency and intensity of extreme precipitation events are expected to increase. This will put many more millions of people at risk due to flooding associated with extreme precipitation impacting both their lives and livelihoods. It will also put millions more at the risk of vector borne diseases, which indirectly hampered the livelihood of the poor due to heavy medical expenses. About 12 per cent of the total land mass of India is flood prone and 68 per cent of arable land is vulnerable to drought (GoI, 2015). Climate variability along India's Coast and resultant sea-level rise would eventually have a tremendous socio-economic impact on local communities and their livelihood.

II. REVIEW OF LITERATURE

Agriculture also contributes a significant share (9 %) of Greenhouse gas (GHG) emissions, more if related land use change (Particularly deforestation), and livestock are included (CAIT, 2010). At the same time, long term changes in average temperatures, precipitation, and increased climate variability threaten agricultural production, food security, and the livelihoods of the poor (Adger et al., 2003). Agronomic and economic impacts from climate change depend primarily on two factors: (1) the rate and magnitude of change in climatic variables and the biophysical effects of these changes and (2) the ability of agricultural systems to adapt to changing environmental conditions (Adams et al., 1998). Among, the most significant potential impact of climate change on India are changes in the monsoon pattern. Several studies have shown that in general the mean monsoon intensity and variability is expected to increase (Ashrit et al., 2001; Chung et al., 2006; Kumar et al., 2006; Panda, 2009). Climate change is likely to direct impact on food production across the globe. Increase in the mean seasonal temperature can reduce the duration of many crops and hence reduce final yield. In areas where temperature is already close to the physiological maxima for crops. Warming will impact yields more immediately (IPCC, 2007). Change in frequency and intensity of rainfall events, rise in mean temperatures, extreme events like floods, droughts, rise in sea level rise, increase in carbon dioxide concentrations etc. Rise in temperature can aggravate food security by increasing evapotranspiration, reducing soil moisture, reduction in germination and desiccation of seedling leading overall reduction crop productivity and yields. Increasing temperature also affects livestock health and human health due to heat stress. It also leads to losses in perishable produce in absence of proper poor harvesting system. The climatic phenomenological changes can result in changes in crop yield and water requirement due to changes in planting dates (Sacks & Kucharik, 2011; Tao et al., 2012). Erratic rainfall events lead to either plenty or little of water resources for irrigation. Excess water at the wrong time, for example before harvesting in the crop cycle can potentially reduce yields substantially. Similarly lack of adequate water resources for irrigation would also lead to reduction in yields. Events like sea level rise would lead to crop losses if not drained out in time. Floods can cause damage to infrastructures and directly damage standing crops. It can damage livestock and fisheries. Droughts have a huge impact and contribute to land degradation and desertification, crop losses, scarcity of water resources and increased cost of cultivation. Increased CO_2 concentrations can lead to increase in yields in C_3 and C_4 plants due to the carbon fertilization effect. Depending on the orientation of the driving factors of crop yield, a similar direction of change in climate parameters in different regions may lead to different directions of change in crop yields among the regions. While the Fourth Assessment Report of the Intergovernmental Panel on Climate change (IPCC, 2007) clearly mentioned the incremental impacts on crop and pasture yield in higher and mid-latitudes with moderate warming. Decline in crop yields in lower latitudes and reduction in food production due to extreme events was also projected. And the Fifth Assessment report (IPCC, 2014a), reveals that decline in major crop yields in the lower latitudes is demonstrated as yields of maize and wheat begin to decline in the tropics with 1^0-2^0 C increase in temperature whereas impacts of an increase in temperature are only evident in the temperate regions with a 3^0-5^0C increase in temperature. Contrary to AR4, AR5 reports more yield decrease than increases across the globe. Increase concentration of carbon dioxide also increase in crop yield due to the carbon fertilization effect. Research said that C_3 plants like Rice Wheat are highly impacted than c4 plants like sugarcane and sorghum.it has been documented in the third and fourth assessment reports that rain-fed crops would benefit more from elevated CO_2 than those that are irrigated. AR5 also suggested that in rain-fed regions, the yield gain is higher in dry years as compared to wet years, it can also possible that relationship between water stress and impact of elevated CO_2 concentrations may vary spatially. The degree of mineral uptake by plant is affected by change on CO_2 concentrations depending on the plant tissue, crops, soil and water status. It is reported that elevated CO_2 level can decrease nutritional quality of flour of grain cereals and lead to decrease in nitrogen content. This would led overall reduced mineral concentrations in crops like wheat, maize, rice, etc. Apart from this there are also different pests and insect species differently across regions and also affect their geographic spread. Each crop has a specific temperature range at which vegetative and reproductive growth will proceed at the optimal rate, and exposure to extremely high temperature during these phases can impact growth and yield. Higher temperature during the reproductive stage at development can affect pollen viability, fertilization and grain or fruit formation. Even a short period exposure of higher temperature during the pollination stage of initial grain or fruit set will reduce wild potential. For example, warming generally allow plants to grow faster, however for cereal crops faster growth means there is less time in the grain itself grow and mature which reduce yields. (Rosenzweig & Iglesias, 1994; Reilly et al.,1996; Adams et al., 1998; Pittock, 2003; Hitz & Smith, 2004; Field et al., 2007; Hennessy et al., 2007; Aydinalp & Cresser, 2008; Dermodt et al., 2008; Hatfield et al., 2008; Taub et al., 2008; Zavala et al., 2008; Karl et al., 2009; Thornton et al., 2009; Kulshreshtha, 2011). The grain filling period of wheat and other small grains shortens dramatically with rising temperatures. Even moderate increase in temperature will decrease yields of corn, wheat, sorghum, bean, rice, cotton, and peanut crops (Hatfield et al., 2008). An increase of 2^0C in temperature could decrease rice yield by about 0.75 tons/ha in the high yield areas and a 0.5^0C increase in winter temperature would reduce wheat yields by 0.45 ton/ha. (Sinha & Swaminathan, 1991). In a study, Saseendran et al. 2000 exhibited that, for every 1^0C rise in temperature the decline of rice yield would be about 6 per cent. In India farmers are basically dependent on rainfed agriculture. For the temperature rise of 2^0C in mean temperature and the 7 per cent increase in mean precipitation would create a 12 per cent reduction in net revenues for the country as a whole (Dinar et al., 1998).

III. OBJECTIVES

1) To find out the impact of climate change on agriculture in Odisha.
2) To know about the other livelihood options of the coastal people of Odisha.

IV.DATA AND METHODS

This paper is basically a qualitative study. Bhadrak District of Odisha was selected which is near to Bay of Bengal and vulnerable with various disasters like cyclones, tidal surge, river bank erosion and frequent floods. Most of the people are dependent on Agriculture as their primary livelihood. But due to the frequent disasters the people are leaving the age old practices of agriculture and searching for other livelihood options. This paper is based on both primary as well as secondary data with intense literature review. Random sampling design was selected. Total sample size was 200. Data collected from both primary and secondary method. Primary data was collected from interview scheduled, FGD, Case analysis have supplemented a lot to get qualitative information. Participatory observation was a continuous process throughout the study. Secondary data was collected from various journals, Economic Survey of Odisha, Statistical Abstract, Climatological data of Orissa, census data. Added to that the available statistical data base have used to measure the degree of impact of climate change on Agriculture.

V. RESULT AND DISCUSSION

Climate Change in Odisha

Odisha due to its geographic location, is most prone to climate change. It has an extensive coastline measuring 480kms that is subjected to frequency of cyclones, storms, floods and coastal erosion which is regular feature of coastal area. (Odisha Economic Survey, 2014-15). Though the impact of global warming and climate change has not studied systematically in Odisha as well as its district context but some effects have already apparent for example the state and district have the evidence of very high temperature during 1999 and 2009.Annual rainfalls have fluctuated over the years and the period of rainfall appears to be shifting from June-September to July-October. Drought like situations have been witnessed with more frequency which has been affecting farmers and other poor whose livelihoods are adversely affected (District Human Development Report Sundargarh, 2015). Odisha is seriously affected to the climate change as mentioned in the disaster plan of government of Odisha. Odisha is vulnerable to various natural disasters which cannot be over looked as over the years these have been inflicting heavy damages on loss of the state economy. Almost all the 30 districts are affected by different disasters. The state has been declared disaster affected for 95 year out of the last 105 years. Floods have occurred for 50 years. Drought for 32 and cyclones have stuck the state almost every year. Since 1965 these calamities have not only became frequent but also they are striking areas that have never experienced such conditioned before. A heat wave in 1998 killed around 2200 people. Since 1998 almost 3000 people have died due to heat stroke. In 1999 super cyclone around 15 million people were affected, two million tons of rice crop was lost and 17000 agricultural land was devastated (Mahapatra, 2009). Rainfall patterns in Odisha have been more erratic since the 1960s, with below-normal rainfall across all districts being recorded for most years. The normal 120 days of monsoon rain has shrunk to 60-70 days, and unusual spikes in rainfall, with torrential rainfall of over 200-250 mm/day, are more frequent during the monsoon, especially during *Rabi* season, because of the reduced residual moisture. The temperature increases are likely to be much higher in winter (*rabi*) season than in Rainy *(Kharif*) season. Precipitation is likely to increase in all time in all month except during December February when it is likely to decrease. Analysis done by the Indian meteorology department and the Indian institute of tropical meteorology, Pune generally show the same trends for temperature, heat wave, glaciers, drought, floods and sea-level Rise as by the IPCC. Although the magnitude of the change varies. It is projected that by the end of the 21st century rainfall over India will increase by 15-40 per cent, and the mean annual temperature by 3^0-6^0C (NATCOM 2004; Aggarwal 2008). By 2100, the mean annual temperature globally is projected to increase by 1^0 to 5^0 degree Celsius (24.5^0 C in 1970 to 28.5^{0}C in 2080). According to the climate change experts temperature rise by 2 per cent have projected soil moisture regimes shall further worsen. This would impact the farming as well as the farmer's livelihood. Temperature data of the coastal region in the last three years shows wide fluctuations and average temperature have risen (Mahapatra, 2009).

Impact of climate change on Odisha agriculture

Agriculture is the backbone of Odisha's economy. It remains the main source of livelihoods for the rural population. Odisha's agriculture is more dependent on monsoon. Any change in monsoon trend drastically affects agriculture. Even the increasing temperature is affecting the agriculture. One of the most challenging and direct impacts of climate change would be on agriculture and food system (Erickson, 2008). Agricultural contribution remains as the crucial sector in Odisha's economy in terms of its arresting contribution to state domestic product, employment and income generating activities, environmental sustainability, livelihood of dependency of rural people etc. there is a structural change in the state economy with share of agricultural sector. The share of this sector in the GSDP, which has more than 70% in the early 1950s has come down to 15.39 % as per the estimates for the year 2014-15. (Odisha Economic Survey, 2014-15), and the share of agriculture is NSDP shows a declining trend over the years that is 29.7 (200-01 to 2004-2005), 22.4 (2005-06 to 2009-10), 20.6 in 2010-11. This declined trend is due to frequent natural shocks like cyclones, droughts and flash floods affecting the growth trend and also the growth in other sector of the economy. Because of the susceptibility of the state to natural calamities the food grain production fluctuates from year to year. The food grain production was 83.60 lakh tones in 2013-14 as compared to 102.10 lakh tones in 2012-13 and 63.16 lakh tones in 2011-12. And improving agricultural productivity and increasing profits from agricultural production are critical to achieving food security as well as most of the largest specified under the Millennium Development Goals (Rosegrant et al. 2006). The climate change is a major threat to the existing agricultural practice in many developing countries and the crop production vary significantly based on rainfall, temperature and humidity pattern of that particular area (Alam et al., 2013; Challinor & Wheeler, 2008; Mimi & Jamous, 2010). Most of the coastal people live in rural areas relying on the agriculture sector for their livelihood. Impacts of climate change on agriculture suggests that in future, productivity and production stability will be reduced in areas which are already food insecure. (FAO, 2010). Climate change vulnerability in terms of exposure, sensitivity and adaptive capacity of the coastal community, particularly those engaged in agricultural and fishing activities have been assessed.

Odisha is situated at the Bay of Bengal has experienced a large number of cyclonic storms, floods etc. intensity of cyclonic storms has been increasing particularly during the second half of the last century. (Mohanty, 2008; Pasupalak, 2010). The agriculture crop year in Odisha is classified into two season *Rabi* (October-April) and *Khariff* (July-October). In the *Khariff* season the planting, growing and harvesting stage occur in April, July and October Respectively. The *Rabi* season starts with the onset of North-East monsoon in October. The planting, growing and harvesting season starts with October, January and April. (Kumar, 2001). With reference to the monsoon and month wise occurrence of cyclonic storms occurred during the monsoon period. And it is proved that an increasing trend for the occurrence of cyclones during the late monsoon season (i.e. August- September). Major portion of the agricultural land is cultivated during August- October which is devastated during the cyclones or floods. Which affects the livelihood of a large percentage of a house hold in the district. During rainy season the coastal district are damaged more with floods than cyclones.it is proved that the trends, frequency and intensity of extreme rainfall events are increasing during the last century in Odisha. (Guhathakurta, 2012; Roy, 2002). Due to frequent loss in agriculture 68 per cent farmers have not get benefited out of the crop production whereas 54 per cent have the opinion that they are not able to repay the loans which they have taken from co-operative societies and banks. 33% respondents agreed that they depend on local money lenders to take loans, for which they have to repay a heavy amount and to repay the loans almost 70 per cent people in the are migrating in the off season to Paradip port, Surat, Dubai. And rest the people are depending on MGNREGA, and other livelihood options like started their own business. About 75 per cent of the respondents said that they got benefited more in *Rabi* season instead of *Khariff*. They got benefited from *Khariff* season when there is no flood. And, 89 per cent said that cyclone never hampered their crop but with cyclone due to low pressure heave rain fall occurred which ultimately taken floods. Of these 98 per cent people said that flood is a major problem in their locality, the flood not only devastated the crop but also their *Kachha* houses are Washed away. They had to repair their houses every year. Where 99 per cent people have the opinion that the government is helping every one after post disaster in terms of relief. But, 59 per cent people said that they lose the income of a year but got the assistance for seven days relief. They need a permanent solution for this. Those who are not in BPL list said that they are losing the same thing but only because they don't have any BPL card they are not getting the Govt. assistance properly. 47 per cent of the respondents said that, the intensity of flood and cyclones are increasing in their locality. Due to the loss of production people are shifting from agriculture to other livelihood options. 42 per cent respondents said that agriculture which has become the primary source of livelihood are becoming secondary options. Most of the people are giving their land to others for cultivation and during the time of getting any govt. assistance the land owner is getting the benefit. 56 per cent respondents reply that community gathering is happening to cook food and eat together which create example of community we feeling ness. All the roads and communication facilities are stopped during the flood. Most of the respondents started boating during the flood to take people from one place to other. Though there are only three tube wells but people are well known about the diseases so they take utmost care for their drinking water.

Adaptation Mechanism

Developing countries are highly vulnerable and have less capacity for coping with the impacts of climate change (IFRC, 2005, UNFCCC, 2007). Based on the extent of vulnerability, India is one of the most vulnerable countries to the projected climate change impacts in south Asia. (IFRC, 2006). Adaptation strategies varies from region to region and depends both on the magnitude and range of climate change or the exposure of the region to climate change and the socio-economic background of the people. The adaptive capacity mainly coming from the awareness about the impact of climate change. While mitigation of GHG emissions can lessen the extent of climate change, adaptation is essential to reduce the impact of climate change on food security and to protect the livelihoods of the poor farmers. (Bryan et al., 2013). Use of new and advanced technologies such as use of tractors, power tillers, hybrid seeds, fertilizers etc., to reduce the fertilizer the farmers check the soil timely. They are adopting the changes to some extent by shifting the dates of plantation, choosing varieties with different growth duration, or changing crop rotation. By double seeding, shifting from farm to nonfarm activities. Most of them are depending on irrigation facility. And migration is the important source of their livelihood. Level of education of the farmers, family size and income of the family have influenced positively to adopt in a better way. Sometimes poor economic condition and non-availability of enough land for agriculture put barriers to adapt new technology. Government help a lot to the poor farmers in the region to enhance their capability to cope with the changing climate which would help them a lot to reduce the vulnerability.

VI.CONCLUSION

Climate change is the outcome of the global warming has now started showing its impact worldwide as well as the food production, which is the primary determinant of agricultural productivity. Though considerable progress has been made in evaluating the potential effects of climate change on global agriculture, but significant uncertainties still remain. Existing evidence indicates that global effect is manageable, concern has shifted to regional level. Research regarding climate change is still underdeveloped. Further research is urgently required in several areas to properly understand the problem with more accuracy. Coping with the impact of climate change on agriculture will require careful management of resources like soil, water and biodiversity. To cope with the impact on agriculture and food production work will act at the global, regional, national and local level. Early warning system should be put in place to monitor changes in pest and disease outbreaks. The overall pest control strategy should be based on integrated pest management because it takes care of multiple pest in a given climatic scenario. Crops should be climate resilient. Which could tolerate higher temperatures, drought and salinity. Seasonal weather forecasts could be used as a supportive measure to optimize planting and irrigation patterns. Greater coverage should be provided to weather linked agriculture insurance. And provide intensive to farmers for resource conservation and efficiency by providing credit to farmers for transition to adaptation technologies. Provide technical, institutional and financial support for establishment of community banks of food, forage and seed. Provide more funds to strengthen research for enhancing adaptation and mitigation capacity of agriculture.

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