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Socio-economic Impacts of Climate Change in Odisha: Issues, Challenges and Policy Options

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Abstract: Climate change has been affecting people around the world, threatening the basic elements of life – access to water, food, health and use of land, and the basic environment. In the case of a developing country like India and her states, climate change is an additional burden because ecological and socio-economic systems are already facing pressures from rapid population, industrialization and economic development. It is in this context, this study is an overview of the climate change scenario in Odisha, its impacts, policy options available so far, and the road ahead. In view of the 1999 super cyclone that broke the economic backbone of the State, and floods, droughts and heat waves being the constant visitors to State, the State has been relatively more vulnerable to climate change over the years. These issues have the potential to derail the growth strategy and deepen poverty in the State. Climate change has the potential to exacerbate inequality and prevent economic growth. Thus, it is essential that the private sector units, civil society and government should work together to improve environmental performance while pursuing goals of sustainable economic development in Odisha. This would certainly foster a carbon-conscious, and climate resilient development path in the State.

Keywords: Climate change; Agriculture; Industry; Mining; Water resources; Forestry; Odisha.

Introduction

In recent years, climate change has become a major global environmental challenge. It has become a serious threat, not just to our environment but also to the growth and development of nations. Further, it is a potential threat to the generations coming ahead. Its impact could create difficulties for people to access basic necessities like drinking water, food and energy in times to come. Thus, the real challenge is to integrate the management of climate related risks into the policies and programmes of socio-economic development. For this purpose, the issue is required to be addressed not only at global and/or national levels, but also at the regional/local level. There exists a plethora of studies targeting the global and national level issues of climate change. But the studies focusing the regional level understanding of the concept of climate change and its impacts for effective mitigation and adaptation, being dearth, are a necessity of the day. In view of this, the present study is an addition to the available climate change literature. The main focus of this study is on the socio-economic impacts of climate change in Odisha, a coastal state of India. Precisely, it is a study of an overview of the issues, challenges and policy options concerning climate change in Odisha. In this study, it is hypothesized that the climate change through its adverse effects on agriculture, industry, mining, forestry, water resources and human health has disturbed the social and economic

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livelihood patterns of people, and has hindered the pro-poor growth strategies of the state.

Climate change, its projected magnitude and diverse impacts have become a serious matter of concern all over the world (Stern, 2007). Climate change is one of the most important global environment challenges facing humanity with implications for food production, water supply, health and like (Sathaye et al., 2006; Ravindranath and Sathaye, 2006; Hamsa et al., 2011). Indeed, climate change has the potential to derail the current growth strategy and deepen poverty. Continuing climate variation is predicted to alter the sectoral growth, including the ability of the poor to engage in farm and non-farm sector activities (Ihugba et al., 2009). The direct impacts of extreme climate-induced events could include loss of life, livelihoods, assets and infrastructure (Besada et al., 2013). All these could affect the economic growth, and nullify the effectiveness of macro-economic policies and pro-poor initiatives (Richards, 2003).

Climate change is the change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (Tully, 2008; Prasad et al., 2009; Eslamian, 2014; Chavan, 2016). Climate change is evident from the observations of increase in global average air temperature, sea surface temperature, extreme weather events, widespread melting of snow and ice, storm surges, and coastal flooding (IPCC, 2007). Climate change is a global negative externality primarily caused by the building up of Green House Gas (GHG) emissions in the atmosphere (Harris, 2006).

The impact of climate change is different in different parts of the globe (Stern, 2007). Some regions and economic systems see its positive impacts, whereas others experience losses (Antle, 2008; Ninan and Satyasiba, 2012). Researchers are of the view that the impacts of climate change are modest in developed countries, and many of them are going to gain from climate change in future (Mendelsohn et al., 1994; Mendelsohn and Dinar, 2003). Ciscar et al. (2012) found that the impacts of climate change would vary largely among the regions, with the developing regions like Africa, Asia, Latin America and India in particular experiencing the most negative effects of such change.

India has been subjected to the problems of climate change due to its unique geophysical and hydro-climatic conditions (Mall and Kumar, 2009). India's climate is both diverse and changing. The south experiences tropical climate, through to more temperate conditions to the alpine regions of the north where elevated areas receive sustained winter snowfall. The Himalayas provide a barrier to the cold winds of continental Asia and helps the development of the monsoon during the rainy season when over 70 per cent of the annual precipitation in India falls (World Bank, 2008). This results in a warm climate across most of India throughout the year, where temperatures not only exceed 40^{o}, but also fall below freezing in the deserts of the north and Kashmir (Liggins, 2008). Throughout the 21^{st} century, India and other countries in South-Eastern Asia have been projected to experience warming above the global mean. India has started to experience greater seasonal variation in temperature, with more warming in the winter than summer (Christensen et al., 2007). The longevity of heat-waves across India have extended in recent years, leading to warmer temperatures at night and hotter days – this trend is set to continue (Cruz et al., 2007). These heat-waves lead to increased variability in summer monsoon precipitation, with drastic effects on the agricultural sector in India (TERI, 2003).

Thus, climate change by exacerbating chronic environmental threats and ecosystem losses, constrains the livelihood opportunities, especially for poor people. In India the key sectors including agriculture, water, natural ecosystem, biodiversity and health are vulnerable to climate change mainly due to GHG emissions (MoEF, 2010). The climate change in India has been observed in terms of the increased frequency of extreme events such as heat-waves, floods and droughts thereby leading to India's food and water security problems (Majra and Gur, 2009; Chauhan, 2009). The Indian Network for Climate Change Assessment Report-2010 warns of impacts such as sea-level rise, increase in cyclonic intensity, reduced crop yield in rain-fed crops, stress on livestock, reduction in milk production, increased flooding, and spread of malaria. In India climate variability and climate change pose huge risks to human life and threaten the sustainability of the country's socio-economic growth (Sheereen, 2012; Mishra, 2014; Karmakar and Mukhopadhyay, 2014).

In view of India's immense geographic diversity, the impacts of climate change vary across states, sectors, locations and populations. This further adds to the complexity of developing and implementing mitigation and adaptation strategies. Consequently, appropriate approaches need to be tailored to address the regional level vulnerabilities which in turn necessitate understanding the state specific causes and impacts of

climate change. It is with this backdrop, the primary objective of this study is to analyze the socio-economic impacts of climate change in a most vulnerable coastal state of India, i.e., Odisha. Besides, it also focuses on the policies designed and implemented so far to address climate change impacts, and the way forward.

The rest of this study is organized in following sections as follows:

- The climate change in Odisha;
- The noticeable socio-economic impacts of climate change with respect to various sectors in Odisha;
- The government policies and actions implemented so far to adapt and mitigate the vagaries of climate change in the state;
- The possible means of enhancing the climate change adaptation and mitigation strategies; and
- Conclusions.

Climate Change in Odisha

Odisha is one of the coastal states of India which has a higher proportion of poor in its population among Indian States and Union Territories. In terms of climatic features, the state is coming under tropical zone and is characterized by high temperature, high humidity, medium to high rainfall, and short and mild winters (Mishra and Sahu, 2014a). Climate change has special relevance for Odisha for two reasons: firstly, due to its location and geophysical conditions, climate change could have a disproportionate effect on the state; and secondly, the state has an urgent development imperative due to the fact that a large percentage of its population is still deprived of a decent standard of living. The state's fluctuating weather conditions suggest that it is reeling under climatic chaos. For more than a decade now, it has been experiencing contrasting extreme weather conditions: from heat waves to cyclones, and from droughts to floods. In the last four years, calamities have claimed more than 30,000 lives. They have not only become more frequent, but have hit areas that were never considered vulnerable. As a result, Odisha's economy has been ripped apart. With a 480 km coast line that is prone to climate-mediated cyclones, coastal erosion and water resources dependent on monsoons, Odisha is relatively more vulnerable to climate change.

Odisha is placed at the head of the Bay of Bengal where weather is formed. So, even a slight change in the sea's behaviour can have an immediate impact on the coast. The Bay is the centre of low pressures causing heavy rains and cyclones in the sub-continent and especially in Odisha. These cyclones and depressions involve circulation over thousands of kilometres and form links between Odisha's atmosphere and the entire planetary circulation system. Climate change is evident in Odisha from the facts of high variability of rainfall, leaving people with two peak periods of food shortage, drought and dry spells at an interval of every two years in western Odisha with a major drought in every 5-6 years, flash floods during rainy season, heat-waves in summer, and intense coastal flooding and cyclones.

Floods have become an annual affair. Areas with no history of floods such as districts in western Odisha were submerged in last few flood situations. The frequency of cyclones has increased in the coastal Odisha. The tropical super cyclone of Odisha in 1999 took a toll of about 10,000 lives (Gupta, 2011), and brought severe socio-economic devastation to the state. During 1804-2010, both cyclones and floods have occurred for 126 years in the state (Bhatta, 1997; Chittibabu, 2004), and in particular, outbreak of floods has been reported for nine consecutive years during 2001-2010[1]. Between 2011 and 2015, the state witnessed two severe cyclones—the *Phailin* in October 2013 and the *Hud-Hud* in October 2014—which caused extensive damages to crops and infrastructure especially in coastal districts. Ironically, Odisha suffered one of its worst droughts in 2001. It affected the lives of 11 million people in more than two-thirds of the state's districts, engulfing earlier drought-free districts like Sundergarh and Kendrapada. The state government put the economic loss due to crop damage at Rs. 642.89 crore. A heat wave in 1998 killed around 1500 people, mostly in coastal Odisha, a region otherwise known for its moderate temperature. The mean daily maximum temperature of the state is gradually increasing as also the mean daily minimum temperature.

The Titilagarh and Koraput belt comprising entire south and western Odisha has witnessed an exceptional rise in daily maximum and minimum temperature. About three decades ago western Odisha was a known calamity hotspot, but now the coastal areas are also experiencing heat-waves. Since late 1990s, Bhubaneshwar, the capital city of the state, has been experiencing a mean maximum temperature about 42°C—which is comparable to Sambalpur located in the interior. In

[1] Various *Annual Reports on Natural Calamities 2001-2013*, Special Relief Commissioner, Revenue and Disaster Management Department, Government of Odisha, Bhubaneswar.

1999 cyclone, around 2,00,000 trees were uprooted in about 25,000 hectares of reserved forest in Odisha. In the districts of Jagatsinghpur and Kendrapada, the forest cover has been reduced by 50 per cent due to this super cyclone. The micro-climate of the region has changed after this loss in vegetation. Temperature data of the coastal region during 1998-2000 showed wide fluctuations, and the average temperature has risen. The change in climate following the super cyclone of 1999 possibly caused the state's mango and mahua trees to flower unusually early.

Apart from more frequent extreme weather events like cyclones, floods and droughts, large-scale impacts of climate change include an increase in sea level causing economic loss and disruption of life. It is important to note that the vagaries of climate change led to displacement of large number of people leading to rapid urbanization, straining resources and putting more pressure on civic amenities. Thus, declining crop yields, reduced fresh water supplies, rising sea-levels, increased floods, droughts, and extreme weather events, biodiversity loss, and higher risk of diseases are all evident the unfavourable effects of climate change in the state. In this context, the next section proceeds to outline the socio-economic impacts of climate change in Odisha.

Impacts of Climate Change in Odisha

In Odisha, climate change has been hindering the growth rate of the economy. The impacts of climate change are meagre yield, poor human health, erratic rainfall, modified biodiversity, aquatic response and change in vegetation, etc. Individual or simultaneous storms, floods, heat-waves, lightening events, vector diseases and droughts in consecutive or same year have shattered the economy of the people (Mishra and Jena, 2015).

Odisha is experiencing distinctive changes in the climate pattern. Atmospheric temperature is going up in the state making the summer seasons almost unbearable. Low pressure is becoming a regular phenomenon causing an unpredictable rain pattern across the state. Frequent floods and droughts since 1998 crushed the economic strength of coastal Odisha. It's not only natural disasters, but the rise in sea level and the Bay of Bengal expanding towards the coastal landscape taking many villages, farm lands into it have become more a problem of the villagers who live along the coastline and derive most of their livelihood from the sea. Once proud to have a little over 480 km long coastline, people of Odisha are now seeing it as a danger. Starting from the northern coasts of Odisha to the southern coasts, many villages have been the victim of the wrath of the ocean. The villages most affected by the climate change are the coastal villages in the district of Kendrapara. The cluster of seven villages called Satabhaya is the burning example. The 1930 land records show an area of 320 sq. km. for the Satabhaya cluster near the port town of Paradip in Odisha. The 2000 land records indicate that this area has been reduced to 155 sq. km. with five of the seven villages being swallowed by the sea.

The first to vanish into the sea in the early 1980s were Govindpur, Mahnipur and Kuanriora villages. Two more villages—Kharikula and Sarpada—were submerged in the mid-1990s. Among the villages on the verge of being wiped off from the map are Satabhaya and Kanhapur village. Kahnapur is known as the home of the fabled Tapoi, a folk character epitomising Odisha's glorious maritime trade history. The village has shifted itself thrice leaving its original location some 1 km. inside Bay of Bengal. Present Kahnapur is hardly 50 metres from the shore now. Besides Satabhaya and Kanhapur, about twenty other villages along the coast are at risk. Most have lost around 60 percent of their lands in the sea. Tidal waves offered by the Bay of Bengal have become serious threat to the coastal villages of Astaranga Block of Puri District. Hardly 15 kms east of Chandrabhaga, the villagers of Udaykani, Chhenu, Tandahar, Kalamakani, Katakana and Kaanarapur of Astaranga Block in Puri District are now very much concerned and afraid of the tidal waves as they have been pushing them again and again from their habitations. The wrath of ocean has been so painful to the villagers living on the coasts that people desire to shift to a safer place leaving their homeland and farmland. Nature has always been rude to the villagers by taking their habitation into its fury and destroying agriculture – the basic livelihood source. Youth of the villages are now migrating to distant places and other states as labourers because agriculture, the traditional source of livelihood, is no more a dependable profession.

It has been considered that climate change impacts can be measured as an economic cost (Smith et al., 2001). Smith et al. argue that climate change can increase income inequalities between and within countries. They further state that a small increase in global mean temperature would result in net negative market sector impacts in many developing countries and net positive market sector impacts in many developed countries. Besides such market oriented impacts, the

climate change can also result in pronounced non-market impacts such as health impacts in developing countries. The economic impact of climate change in Odisha is observed in each sector of the state—be it agriculture, food, fisheries and animal resources, forests, water resources, health, industry, or mining; everywhere the effect is quite noteworthy.

Climate Change and Agriculture

The adverse effects of climate change falls heavily on climate sensitive agricultural sector (Nordhaus, 1991; Cline, 2007). Studies have predicted that agriculture yield will likely be severely affected over the next hundred years due to unprecedented rates of changes in the climate system (Jarvis et al., 2010; Thornton et al., 2011). Climate change is likely to have both positive and negative impacts on agriculture (Antle, 2008) depending on the physiological characteristics of the region and the crops being produced. The effects of climate variables are more pronounced on agriculture in regions where agriculture is backward or primitive with less scope for technological adoption and transmission (Mishra et al., 2015). Odisha is such a state where agriculture is not only primitive, but a gamble in monsoon. Agriculture holds a predominant position in the state's economy. About 80-85 percent of the state's population lives in rural areas and depends on agriculture. This sector contributes about 26 per cent to the Gross State Domestic Product. With almost 60 percent of land under rain-fed agriculture and with water-dependent rice, as its main crop, the agriculture is particularly vulnerable to the vagaries of climate change. Further, paddy fields in the coastal areas are prone to frequent erosion, salinization and inundation.

In 1999, two cyclones hit the state in quick succession. The second one, the *Super Cyclone* which lasted for three days, caused two million tons of rice crop damage, and devastation of 17,000 sq. kms of agricultural lands in the state. In total it caused a damage of 18.43 lakh hectare crops in the state (Nayak, 2009). According to Disaster Management Plan for Odisha, 2013-14, around 9.19 lakh hectares of cropped areas were extensively damaged by the floods between 2001 and 2008. As per the reports of special Relief Commissioner, 82.48 lakh hectares of cropped areas were damaged while 10,305 people had lost their lives due to floods, cyclones and droughts between 1999 and 2008[2]. In 2013, due to *Phailin* cyclone about 12,92,967 hectares of agriculture, horticulture and perennial crops have sustained more than 50 per cent loss (GoO, 2013). In 2014, due to *Hudhud* about 2,47,557 hectares of agriculture area affected out of which an area of 40,484.50 hectares have sustained crop-loss of more than 50 percent (GoO, 2014).

Climate projections indicate that drier areas will become further drier, and flood prone areas will be subject to more flooding. Other problems such as pest and disease outbreaks are also likely to increase due to climate variability. There are two ways—direct and indirect—the climate change can affect the food production system. The climate change can affect directly through temperature, water balance and atmospheric composition as well as extreme weather events, and indirectly through the distribution, regularity and severity of pest and disease outbreaks, incidence of fire and soil properties. These direct and indirect effects on agricultural system will not only respond to climate change, but through fluctuating yield will have a negative impact on production and distribution. It has been observed that in the last 50 years, the food production has decreased by 40 per cent in the state (Odisha Economic Survey, 2009-10, 2012-13). The empirical studies reveal that climate has significant influence on the agricultural production of Odisha (Mishra et al., 2015). The socio-economic impacts associated with the physical impacts on crops are mainly influenced by the interaction between producer and consumer behaviour as well as possible adaptation that farmer could undertake in response to climate change. In this situation, adaptation could be one of the better options available to counter the adverse effects of climate change on agriculture (Smith et al., 2001; Reidsma et al., 2010; Deressa et al., 2008). The major adaptation strategies of farmers include double seeding (for some crops), changing planting dates, multiple cropping, changing crop varieties, increasing irrigation, shifting the land use pattern and migration. Empirical studies reveal that the major barriers for the farmers to adapt to climate change are their poor economic conditions and the poor infrastructure facilities in the areas in terms of unavailability of irrigation water, and lack of extension services (Mishra and Sahu, 2014b). In this context, Swain (2014) advocated for crop insurance in rural agricultural sector to adapt the economic loss due to adverse effects of climate change on agriculture.

[2] Various Annual Reports on Natural Calamities 2001-2013, Special Relief Commissioner, Revenue and Disaster Management Department, Government of Odisha, Bhubaneswar.

Climate Change and Industry

The economic growth of Odisha since 2005-06 has been mainly induced by the growth of the industrial sector. Odisha's substantial mineral resource endowments have led to the growth of metallurgical and non-metallic mineral based and other energy intensive manufacturing industries in the state (Ghosh et al., 2014). Given the resource base of the state, twelve industrially active zones have been developed across the state, viz., Rourkela-Rajgangpur, Ib valley and Jharsuguda area, Hirakud, Talcher-Angul, Choudwar, Balasore, Chandikhol, Duburi, Paradeep, Khurda-Tapang, Joda-Barbil and Rayagada. The growth in an economy, when fuelled by the growth in the manufacturing sector, usually puts additional pressure on the demand for natural resources and contributes to climate change (Rock and Angel, 2005). About 65 per cent of all industrial units in Odisha fall under the critical polluting red category identified by the Ministry of Environment and Forest, Government of India. In terms of CO_2 emissions, during 1980-2000, Odisha ranked ninth among all the states in the country with an average annual emission of 8539.78 kilo ton of CO_2 with a CAGR of 6.74 per cent per annum (Ghoshal and Bhattacharya, 2008).

Nanda et al. (2011) pointed out that rapid industrialization and wide spread mining activities in Angul district of Odisha have made the groundwater contamination by fluoride and the occurrence of several health problems in the vicinity. In the Angul district, the industries such as coal mines of MCL, Aluminium Plant of NALCO and its CPP, Talcher Super Thermal Power Station and Talcher Thermal Power Station of NTPC and other small units release thousands of gallons of waste water to the river, which contains obnoxious substances like SS, TDS, ash, oil & grease, heavy metals, fluorides, phosphorus, ammonia, urea and acids (Reza and Singh, 2010). The fly ash generated during these power plant operations and ash ponds in the coalfield area also create environmental hazard particularly in water by increasing the suspended, dissolved and heavy metals concentration. These have been observed to put adverse effects on human health and aquatic ecosystem directly or indirectly (Mukherjee et al., 2003). The Angul-Talcher industrial and mining area has also been substantially adding to the rise in temperature and flow of heat-waves thereby affecting the local social and economic activities. Similarly, emissions from thermal power plants, coal mining, refractory and sponge iron units of Jharsuguda district have shot up atmospheric temperature, thus making the socio-economic living of people intolerable.[3]

The main environmental concern associated with the sponge iron industry is air pollution that has adversely affected the health and livelihood patterns of the people of Odisha. Most of the sponge iron factories in the state are not properly disposing their solid waste leading to air and water pollution, and degradation of land. Thus, the manufacturing sector is a part of the climate change equation which not only contributes to GHG emissions, but also causes change in temperature and precipitation pattern. The manufacturing sector is capital intensive, with many long-life fixed assets, long supply chains and significant water requirements, which are negatively impacted by floods, droughts and extreme weather events (Smith, 2013). The manufacturing sector uses a good percentage of electricity that is generated by hydropower, and lower annual rainfall in the state has reduced the electricity generating capacity of hydroelectric power plants. The manufacturing sector is one of the biggest casualties of reduced generation capacity of hydropower dams because of droughts and reduced rainfall.

Climate variability in the state has contributed to reduced crop production that directly impacts the manufacturing sector. Some industries such as agro-processing are major consumers (and polluters) of water. Water resources are generally scarce and are likely to become more so with climate change. The rising temperatures are expected to strengthen coastal winds and storms, which will affect ship navigation and other port operations. Motor vehicle assembly, machinery, electronics and other industries that depend on export and import services are likely to be negatively affected. Therefore, the challenge before the policy makers is the adaptation and mitigation of such adverse effects of climate change on industrial sector of Odisha.

Climate Change and Forestry

Climate is an important determinant of the geographical distribution, composition and productivity of forests. Forest area affected by climate change depends on various factors like species and age of trees, possibilities for forests to migrate, and quality of forest management (Sharma and Kavikumar, 1998). Climate change impacts over forestry turn to have profound implications

[3] Reported by R.K. Sharma in *The Pioneer* on May 19, 2015.

for traditional livelihood, industry, biodiversity, soil and water resources, and these lead to changes in agricultural productivity. Odisha is endowed with vast forests extending over 37.34 per cent of its geographical area that are rich in floral and faunal diversity. Diversity of forest ecosystems comprises natural teak, Sal, and bamboo forests in the hinterland and lush green mangroves on coast. Forests provide livelihoods to a large proportion of tribal populations and rural poor in Odisha. Overall, 40 per cent of state's population depends on forests for their livelihood. Studies have revealed that forest resources contribute about 25 to 52 per cent to the household income of people living in and around forests. And, forest resources contribute about seven per cent to Gross State Domestic Product. This fact underscores the vital role that the forest resources play in the economy of rural communities in general and tribal in particular. The forests also have important ecological functions, checking soil erosion and reducing the impact of droughts, floods and cyclones. Forestry sector is also particularly important both from climate mitigation as well as adaptation perspectives. About 50 per cent of the forest area of the state has been estimated to be in various stages of degradation. The deforestation in the state has been mainly due to expansion of mining sector, urbanization, industrialization, infrastructure building, and increased household demand for fire-woods. This deforestation has been estimated to contribute to about 20 percent of total CO_2 emissions leading to adverse climate impacts in the state. Tribal people in Odisha are dependent on a wide variety of native plants for food and medicine. But due to deforestation and desertification, local tribes are failing to collect food for survival and medicinal plants for healthcare. Thus, large scale plantation for creating forests can only save our future generations from the devastations that we can only imagine now.

Climate Change and Mining

Mining is a major economic activity in the state and it contributes significantly to the growth process. Odisha possesses 24 per cent of India's coal reserves, 17 per cent of iron ore, 98 per cent of chromites, 51 per cent bauxite and 35 per cent of manganese. This sector provides employment to about 45 thousands manpower every year. In spite of such a contribution, mining in Odisha has serious local environmental and social impacts. These include air pollution (particulates), water pollution (mine water discharges), social impacts (displacement and rehabilitation) and forest impacts (most of the mining area is in forest areas or in their vicinity). Mining being energy intensive is also a big contributor to global GHG emissions. In Odisha, the percentage of degraded forest is higher in mining districts compared to non-mining districts. The percentage of degraded forest to total forest cover increased to 47.98 in 2007 from 44.24 in 1997 in mining districts and to 44.6 in 2007 from 42.76 in 1997 in non-mining districts. This has resulted in increase in temperature of mining districts, and experiencing increased heat-waves and erratic precipitation patterns. Mining districts in the north-western part of the state are experiencing droughts in recent years. Along with coastal districts, the interior mining districts are experiencing severe floods in recent years. Water scarcity is also a problem in mining districts. The occurrence of forest fires is more a concern for non-mining districts. All these have resulted in loss of human well-being of people in the state.

Climate Change and Wetland

In Odisha, the loss of wetlands is also a key concern. The expansion of agricultural and urban areas in recent decades have reduced wetlands and contributed to changes in the hydrological characteristics of many drainage basins. These changes include an increase in river discharges, a reduction in groundwater levels and base flow discharges. Loss of wetlands has been accompanied by a corresponding loss of ecological and cultural functions. Climate change also affects biological, biogeochemical and hydrological functions of wetlands. An increasing temperature affects the wetland by thawing permafrost, which is crucial for maintaining the water table in ecosystem. Economically and ecologically important coastal ecosystems are significantly damaged from climate change effects, such as sea level rise, changes in atmospheric temperature and variation in the rainfall patterns. And, many valuable economic and ecological functions including tourism, fisheries, storm and floodwater protection and biodiversity have been threatened by climate change. The greatest impacts of climate change on many aquatic ecosystems are the exacerbation of already existing stresses resulting from human activity. Over the past few decades, coastal wetlands, saltwater marshes, and mangrove systems have disappeared at a rate of 0.5 to 1.5 per cent per year in some regions of the state. Temperature changes and sea level rise further accelerate these trends. Being water dependent, the fisheries sector in Odisha has been impacted by climate change. The livelihoods of the fisher folks are affected most, not only due to sea level rise and climate mediated hazards, but also due to erratic rainfall that affects the

open reservoirs and ponds/tanks. Animal resources that support a large part of rural livelihoods are impacted by heat stress and other climatic impacts. Methane emission from the livestock is also a key concern in this situation.

Climate Change and Water Resources

In recent years, the demand for water has increased tremendously due to an increasing population, expanding agriculture and rapid industrialization that are responsible for considerable imbalances in the quantity and quality of water resources (Gupta, 2011). And, the climate change has further aggravated the problem. The effect of climate change on water resources is observed in terms of increase in water pollution due to warm air, higher water temperature and changes in precipitation patterns; changes in the availability of drinking water supplies due to changing rain pattern, increased evaporation and salt water intrusion; water body boundary movements and displacements due to rising sea levels; and changing aquatic biology due to increase in water temperature and changing flows. The impact of climate change on the quantity and quality of groundwater resources is important because human existence rely on groundwater as a drinking water source (Kundzewicz and Doll, 2000). Thus, in Odisha surface water flow, groundwater recharge and discharge, water quality and water temperature have been affected by climate change. Odisha which traditionally receives 120 days of rainfall now receives rainfall only for 90 days, and that too is erratic. The average annual normal rainfall shows a declining trend. This has decreased from 1502 mm during 1961-2000 to 1482 mm after 2000. Thus, river flow is gradually decreasing. This is very much indicated by the progressively increasing intensities of flood in September and dryness in April in the river Mahanadi and other rivers. The water quality in the rivers and lakes is degrading due to the increased flow of sediment and pollutants with higher run off, decreased flushing, and higher salinity levels with reduced stream flows.

Climate change has been adversely affecting the fish stock due to higher water temperatures and low-oxygen content of the water bodies. This has reduced fish production in the state. The fishing's share to Gross State Domestic Product has decreased from 1.55 per cent in 2000-01 to 1.11 per cent in 2009-10. Increase in sea level has resulted in submergence of low-lying areas, erosion of sea beaches and increase in the area of coastal wetlands, coastal flooding and increase in salinity of estuaries and fresh water aquifers. As a consequence of these adverse effects, the net sown area has declined and crop yield pattern has been disturbed in the state. The irrigation intensity has also reduced to about 30.9 per cent. Odisha has recently about 54,69,336 hectares of degraded land which constitutes 5.18 per cent of total geographical area of India. It has been estimated that about 29 lakh hectares of cultivable land, nearly 45 per cent of total cultivable land in Odisha, are facing high degree of soil erosion. All these have a direct impact on agriculture. Water erosion is the most pronounced process of land degradation and desertification. Water erosion is witnessed in an area of 32,06,507 hectares of land in the state. Another major feature relating to climate change impact in Odisha is that it has more area getting waterlogged than any other state in the country. This creates flood situations basically in urban slum areas, surface and groundwater pollution, contamination of drinking water, and outbreak of water-borne diseases.

Climate Change and Human Health

As the quality of life strongly depends on climate, climate change affects human amenity. Climate Change is projected to increase threats to human health, particularly in lower income populations, predominantly within tropical/sub-tropical countries (Smith, 2003). There are both direct and indirect effects of climate change on health (Patil and Deepa, 2007). The consequences of climate change on human health can be categorized as asthma, respiratory allergies and airway diseases; cancer; cardiovascular disease and stroke; food-borne diseases and nutrition; heat-related morbidity and mortality; human developmental effects; mental health and stress-related disorders; neurological diseases and disorders; vector-borne and zoonotic diseases; and water-borne diseases (Patra, 2013). Odisha is a relatively poor State of India having low nutritional status and poor health infrastructure, and thus, prone to climate induced health related problems. In Odisha, damp, humid and hot weather, and frequent flooding have caused the spread of vector-borne diseases such as malaria, dengue, chikungunya, filariasis, etc.; changes in sea temperature, reduced access to clean drinking water (due to drought and flood damaged water & sanitation infrastructure) have increased the risk of diarrhoeal disease; increased salinity in soil and drinking water due to sea level rise in coastal belts have caused elevating blood pressure; the intensity and frequency of extreme weather events like heat-waves, cyclones, droughts and floods have increased health related issues such as heat strokes, skin diseases, eye diseases, injuries, psychological distress and human mortality; air pollution from industrial pollutants and

automobile emissions has increased the diseases like allergies, asthma, bronchitis, heart attacks and other cardio-vascular diseases; altered food productivity and associated pest and diseases especially in agriculture have resulted in malnutrition, hunger, impaired child growth and development.

According to the Ministry of Health & Family Welfare, Odisha provided the evidence of 22 per cent of the total malaria cases occurred in India during 2007-08 (Dogra and Srivastava, 2012). According to Health Ministry Report, the number of malaria patients in Odisha has been rising at a faster pace, and in 2014 it was about 3.88 lakh, i.e., 36.26 per cent of total malaria afflicted people in India (Parida and Bhatia, 2015). Similarly, Odisha reported 1520 cases of dengue in 2012, 3490 cases in 2013, 1547 cases in 2014 and 1002 cases in 2015 (Mishra et al., 2016). Dwibedi et al. (2011) observed that chikungunya virus has been rapidly spreading in Odisha since 2006. During April 2011 to March 2012, 174 positive cases for chikungunya virus were identified in Odisha (Mohanty et al., 2013). According to the Ministry of Health & Family Welfare, Government of India, the number of cases of acute diarrhoeal diseases in Odisha was 7.43 lakh, i.e., 6.35 per cent of total cases in India which slightly decreased to about 6.0 lakh, i.e., 5.51 per cent of total cases in India in 2012. In 1998, the heat-wave in Odisha was recorded as one of the worst, claiming more than 2000 lives.[4] Thereafter, every year heat-wave has been taking a substantial toll of lives in Odisha. As on May 18, 2016, the heat-stroke cases reported was 191, and as on June 6, 2015, the heat-stroke cases reported was 150 in the state. In 1999, Super cyclone in coastal Odisha recorded as one of the severe cyclonic storms, claiming nearly 10,000 lives.[5] In 2013, *Phailin* cyclone left 44 people dead, damaged 2,56,633 houses and affected 13 million lives. The cyclone and floods affected 44,806 fishermen households and 1564 artisan households (GoO, 2013). In 2014, *Hudhud* cyclone left three people dead, damaged 44,413 houses and affected 33,43,966 lives. Fish farms to the extent of 53.15 hectares have also been silted. About 718 traditional craftsmen have been affected with damage of their equipments and raw/finished materials (GoO, 2014). From all these, it is inferred that in Odisha, there is increased health risks due to the climate change and in particular, there is the potential of aggravating infections, vector-borne, water-borne, and food-borne diseases (Shope, 1990).

The climate change, thus, affects people's livelihood, economy, increase poverty and displace people. Climate change impacts hold serious implications for communities, business and for the state's future growth and development. This climate change is an additional burden in the state because ecological and socio-economic systems are already facing pressures from rapid population, industrialization and economic development. Since poor are the most vulnerable to climate change, the efficient climate change adaptation and mitigation is a serious concern in Odisha because majority of people in Odisha lack basic amenities like pucca house, safe drinking water, sanitation, access to electricity, access to clean cooking energy, all weather roads, transportation and so on. Thus, poverty eradication and improving standards of living of people can reduce climate related vulnerability (Gupta, 2011). In other words, it is the quality of socio-economic development that would provide an insurance against the impacts of climate change and increase the adaptive capacity of the vulnerable. In this context, the next section briefly reviews the policies and actions taken by the state government for integrated management of climate change.

Government Policies and Actions

Odisha is endowed with rich natural resources which have made the state more vulnerable, since three-fourth of its population depends on climate sensitive natural resources based livelihood such as agriculture, forestry and fisheries. The nature, scale and magnitude of the climate change impacts are relatively high given that the state's agriculture is largely rain-fed and is periodically exposed to climate induced extreme events. For more than a decade, the state has been experiencing contrasting extreme weather conditions; from heat-waves to cyclones; from droughts to floods. In last few years, calamities have claimed some thousand lives. Considering the concern, the state has formulated Climate Change Action Plan 2010-15 in a holistic manner to address the issues of mitigation and adaptation. It focused on 11 critical sectors, viz., Energy, Mining, Industry, Forestry, Water, Agriculture, Coasts & Disasters, Urban, Health, Transport and Fisheries & Animal Resources. These sectors are having linkages to

[4] Odisha State Disaster Mitigation Authority. Available from: http://v3.osdma.org/. (accessed on 10 June, 2016)

[5] Available from: http://www.greenpeace.org/india/campaign.htm (accessed on 10 June, 2016)

climate change, and thus, can go a long way in reducing the vulnerability. The purpose of this government plan was to strengthen institutional capacities of different State level agencies to integrate environment and climate change issues in development planning, policies and sectoral programmes. The budget for climate change response actions has been estimated to be Rs. 17,000 crore for a 5-year period between 2010-11 and 2015-16. The main purpose was to put economy of Odisha in a carbon-conscious and climate-resilient development path. The sectors including energy, forests, coasts and disasters, agriculture, water resources and urban constitute about 80 per cent of the overall budget. In FY 2011-12, the total public expenditure made by the State in adaptation relevant departments was only 1.71 per cent towards climate-oriented activities. The Forest and Environment Department made 20.33 per cent, Water Resources 4.16 per cent and Agriculture 0.02 per cent towards climate-oriented activities. Out of the total external aided projects expenditure of about Rs. 386 crores, 24 per cent goes towards funding climate oriented activities.

In October 2013, World Bank had agreed to provide non-lending technical assistance to Odisha for implementation of its action plan particularly for some demonstration and institutional arrangement projects. The demonstration projects include installation of solar PV panel in the boats plying in Chilika Lake, battery operated auto-rickshaws in Bhubaneswar, low cost sewage treatment system and maximum use of fly ash. Similarly, institutional arrangement projects plan to strengthen capabilities of State Pollution Control Board, Climate Change Cell, and green energy consumption, etc. Since December 2013, the state has been emphasizing on the massive plantation and increasing canopy density of degraded forests to mitigate a large load of carbon on environment. The state has already taken up solar project initiatives and the use of energy saving devices, for example, OREDA and OMFED have been working to promote improved *Chullah* and bio-gas plants for energy saving. The state is in the process of providing incentives to private households for having roof top solar projects and rain water harvesting system. Emphasis has also been given to promote regulated irrigation measures in the areas under major and medium irrigation projects.

The progress report of the climate change action plan of government of Odisha, which was released in July 2015, mentions that the budget allocation for climate change related activities as a percentage of total budget allocation has increased from Rs. 1,700.17 crore (3.3 per cent) in 2012-13, to Rs. 2,184.35 crore (3.6 per cent) in 2013-14 and Rs. 3,207.26 crore (4 per cent) in 2014-15. During 2010-15, the climate change adaptive measures taken up in the state include disaster preparedness, construction of flood and cyclone shelters, and improvement in agricultural productivity including cultivation of climate resilient crop varieties, increasing perennial fruit plantation and adoption of integrated farming systems. Similarly, mitigation measures undertaken include adoption of super critical technology in power generation, higher solar power generation, efficient energy use in reduction initiative, efficient energy use in urban water supply, energy efficient building, development of inland waterways, and transportation of bulk material through rail network.

The Way Forward

In spite of the achievements of government tailored policies and actions of climate change, the state has not yet attained a milestone in this direction. Still the state economy is facing the vagaries of climate change—reduced length of winter, increased length of summer, intolerable heat-waves, erratic rain pattern, floods, droughts, cyclones, sea level rise and like. All these have taken tolls in the form of reduced agricultural produce and industrial efficiency, increased food insecurity, reduced carbon sink capacity of forests, increased coastal hazards, reduced fish production, increased health related issues, and reduction in outbound tourism. Therefore, the way forwards may be:

(i) *Efficiency in Energy Consumption and Conservation:* By bringing efficiency in energy consumption and conservation through the use of public transport system, use of bio-fuels, use of nuclear power, use of renewable sources of energy, increasing efficiency of thermal power plant, and solar radiation management, the state can reduce the adverse effects of climate change.

(ii) *Water Resource Management:* By using water-efficient technologies, recycling of waste water, adopting the use of ocean water, improving efficiency of irrigation systems, rain water harvesting, proper industrial waste disposal, improved drainage systems, conservation of wetlands, and development of desalination technologies, the state can mitigate the vagaries of climate change.

(iii) *Coastal Protection*: In Odisha, it is highly desirable that the coastal regions should be protected from the vagaries of climate change

through adaptation, research, rehabilitation, awareness, timely forecasting, evacuation and warning systems.

(iv) *Green Economy:* By conserving wildlife and biodiversity, increasing afforestation and reforestation, and by adopting sustainable agriculture through new varieties of crops, thermal resistant crops, and alternative cropping patterns, we can be able to reduce the threats of climate change.

(v) *Industrial Efficiency:* By reducing industrial emission of GHGs through adoption of low-carbon technologies, adopting proper means of waste disposal, and by bringing efficiency in industrial energy use, we can also attain sustainable growth and development.

(vi) *Fiscal Strategies:* Mandal et al. (2013) suggested certain fiscal means of achieving low carbon economy. *First*, primary carbon tax which involves levying tax per unit of energy at the point of extraction rather than on the end user may be introduced in Odisha. Coal mines, for example, could be taxed heavily due to the high emissions per unit of output, and this may be spent on developing low-carbon technologies; *second*, the feebates method that involves imposing a fee on dirty products & production processes, and passing on subsidies for relatively clean products and processes. The thermal power plants, for instance, could be taxed for using coal as it is a polluting input, and the same may be invested on climate change adaptation and mitigation actions; *third*, an increase in energy efficiency can be achieved by introducing fuel standards of vehicles, rating of appliances, and rebates for use of improved energy efficient products; *fourth*, differential taxation policy may be introduced in which goods and services causing environmental damage in production or consumption may be taxed more heavily than goods which are believed to benefit the environment; *fifth*, subsidies and tax credits may be allowed for investing in and using renewable energy technologies; *sixth*, a climate change levy could be charged on the use of electricity, gas and solid fuels so as to encourage businesses to reduce their energy consumption or shift to renewable sources of energy; *seventh*, carbon tax could be imposed on heavy polluters in the state like iron and steel, thermal power producers on their carbon emissions beyond an acceptable level to discourage them emitting excess CO_2 and indirectly insisting them to use low-carbon technologies.

(vii) *Public Awareness:* Our problems are man-made; therefore they may be solved by man. Thus, the most important part of the climate change adaptation and mitigation is creating public awareness. If people are not aware of the issues and challenges of climate change, then they will not accept the adaptation and mitigation strategies. This would also help maintaining good human health conditions. The awareness of the benefits of immunisation, sanitation, disease surveillance, etc. can go a long-way in mitigating the plight of the affected people. Public awareness on small size of human population is an effective means of dealing with the vulnerabilities of climate change as more people means more deforestation and production of more GHGs leading to more global warming. Last but not the least is that public awareness is required to convince people about the long-term benefits of sustainable and eco-friendly life style.

(viii) *Self-Help Groups:* Women's Self-Help Groups can play an important role in a large number of measures targeted at drought/flood mitigation. They could be involved in small scale industries, running public distribution shops, Aanganwadis and day care centres, and overseeing water distribution and utilization in their community (Gulati et al., 2010).

(ix) *Alternative Employment Opportunities for Farmers:* Employment opportunities outside the agricultural sector such as engaging in construction activities, poultry farming, etc. can reduce the impacts of extreme weather events on farmers.

(x) *Skill Development:* Skill up-gradation, training, community linkages with potential private employers/industrial units can improve employability and opportunity to obtain gainful livelihood. Any perturbation in agriculture can considerably affect the food systems and thus, increase the vulnerability of large fraction of the resource-poor population (Aggarwal, 2008b). Therefore, maintaining buffer stocks of food helps in managing periods of scarcity.

(xi) *Improved Land-use and Natural Resource Management Policies and Institutions:* Crop insurance, subsidies, and pricing policies related to water and energy could help in coping with the disasters. Rational pricing of surface and groundwater, for example, can arrest its excessive

and injudicious use. Policies and incentives should be evolved that would encourage farmers to sequester carbon in the soil and thus, improve soil health, water use and energy more efficiently (Aggarwal, 2008, 2008a).

Concluding Remark

Climate change has become one of the all-encompassing global environmental changes having its deleterious effects on natural and human systems, economies and infrastructure. The impacts of climate change are being felt all over the world. It is becoming warmer, rainfall is more erratic, the sea level is slowly rising and extreme weather events are becoming more frequent and intense. Prolonged periods of drought, floods and shifting climatic zones are endangering development process. The poor and marginalized are the most affected by climate variability and change. Thus, climate change is now a serious problem to be addressed immediately and regularly for sustainable development of a nation and its states. In this context, the present study is an overview of the climate change scenario in Odisha, its impacts, the policies implemented so far to tackle it, and the way forward. The most severe impacts of climate change in the state are changes in precipitation pattern, floods, water scarcity, drought, cyclonic storms, and storm surges as well as health risks. These climate change effects, among others, affect people's livelihoods, economy, increase poverty and displace them. In view of the 1999 super cyclone that broke the economic backbone of the State, and floods, droughts and heat waves being the constant visitors to state, the state has been relatively more vulnerable to climate change over the years. In the agricultural sector, the climate change effects in terms of lower yield from crops, increased food prices, changes in food patterns and depleting livestock can have repercussions such as reduced calories intake for women and girl child, higher food insecurity and less milk/nutrition for children, and like. Similarly, degradation of forests may lead to fuel problems of tribal and poor, less income to the state, loss of eco-tourism opportunities, etc. Furthermore, climate change impact on water resources is simply a threatened for human existence. These issues have the potential to disrupt the sustainable growth strategy and intensify the poverty in the state. Thus, it is essential that the private sector units, civil society and government should work together to improve environmental performance while pursuing goals of economic development in the state. This would foster a carbon-conscious and climate resilient development path in the state.

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