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THE DECADAL CHANGES AND SOCIO-ECONOMIC STRESSES ON COASTAL AREA THROUGH REMOTE SENSING AND GIS TECHNOLOGY: A REVIEW OF PURI, ODISHA

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ABSTRACT

Coastal areas of Odisha are vulnerable to climate change. Along the 480 km coastline most of the coastal areas are facing threats due to climate change. In addition to threats due to natural hazards, these coastal regions also face immense population and developmental pressures. The increase in the intensity and frequency of cyclones and accelerated sea level rise related to increased sea surface temperature have led to flooding, coastal erosion and shoreline retreat causing damage to coastal ecosystems and resources in these regions. Coastal areas are the key system for global sustainability. Coastal regions gained importance because of multiple uses, like high productivity of the ecosystem, highly concentrated population, industrial friendly, waste disposal, tourism, transportation, strategic planning in military and many more. These coasts are always in a dynamic state trying to change, and nature always works for maintaining the equilibrium. In this scenario, coastal management has become the important issue in past few decades. Thus, coastal vulnerability assessment methods have been developed to identify and manage vulnerable areas over the coast. In recognition to these risks, the present review, the main focus is on the coastal area of Puri beach- the Ballighai beach which is very close to Jagannath Mandir and Swargdwar. Proper planning with awareness and protection strategies for Indian coast must be taken swiftly by the coastal management and policymakers to safeguard coastal ecosystem and livelihoods. In recent years, there has been much focus on the coastal vulnerability assessments using various kinds of data. Most of the reported studies over Indian coast are based on Remote Sensing and GIS methods. Thus this review tries to explain the importance of remote sensing and GIS in estimating the effects of changing climate on coastal areas.

Keywords- *Latex, Aqueous extract, Methanolic extract and Phytochemical constituents*

INTRODUCTION

Coastal environments occupy one of the most dynamic interfaces on earth, at the boundary between land and sea, and they support some of the most diverse and productive habitats accordingto the Intergovernmental Panel on Climate Change report (IPCC, 2001). These are the transition areas between land and ocean (Wieneke, 1991). Extreme weather events have been historically disastrous and continue to have overwhelming impacts world-wide. The world has experienced
1.5 times more extreme weather related catastrophes in 2016 than the average in the last 30 years(Jones, 2016). Studies indicate that the developing countries are more vulnerable to

natural disasters (Watson, 2007; Ferrier and Spickett, 2007). In the eastern region of India, the frequent extreme events have been damaging Odisha for a long period of time, which is particularly vulnerable due to its geographical location and climatic conditions (OSDMA, 2016). Odisha, a state in the eastern part of India, has 30 districts with 314 blocks and 317 tehsils with Bhubaneswarbeing its Capital. It extends over an area of 155,707 km2 and has a coastline stretching up to 480 kms which also has a high density of population on the coastal areas rendering it vulnerable to cyclones and floods (Singh and Jeffries, 2013). The normal rainfall in the state is 1451.2 mm. Withthe majority of the population dependent on agriculture, river systems play an important role in their livelihood while making them prone to multiple floods. The extreme events like floods, cyclones, droughts, heat waves and lightning have claimed the lives of millions of people and havehad devastating impacts on the communities. They have especially caused damage to the livelihoods and hurt the income of people in the state (Government of Odisha, 2015). The livelihood of people living near or on the coastal area has been impacted for the long term due to the increase in frequencies of extreme events such as cyclones, floods etc., and it indirectly affectsthe prospects for better income, healthcare, food security and development. The nature of employment is mainly climate sensitive in Odisha and extreme events cause damage to an already poor infrastructure and livelihood resources. Limited comprehensive studies are available to understand the extreme weather events and its effects on livelihoods of people in Odisha. In addition to that, it tries to explore livelihood resilience among the community, programs and strategies undertaken by the government in the line of extreme weather events in the state. Further,this study tries to provide possible recommendations for it.

Puri is a district in Odisha which is famous for the Jagannath Mandir that is believed to be one ofthe chardham. So clearly it can be said that the tourists and visitors will always be there due to oneor other celebration and as the population rate will be higher more will be the pollution which willgive rise to global warming due to which the impacts of climate change will be more severe. The construction and population has increased a lot in the last three decades which also means that theshops on the beach have also increased. There is very less difference between the coast and land. Due to climate change there are several impacts observed such as the change in precipitation leading to floods and droughts which may give rise to different kinds of diseases and may affect the human health directly or indirectly. Even the warming of the oceans alters the food chain andthe breeding and mating pattern of the mammals which hampers the marine life. The pollution onbeach and coast also has stopped migratory birds, Olive Ridley turtles to come and breed on coastor beach.

REVIEW

A review process for this work was studied. A number of papers, peer reviewed journals, and literature regarding the topics such as climate change, coastal vulnerability, human intervention, extreme events, population growth on coast, pollution on the beach were studied.

The primary questions followed here are: How climate change has impacted the frequency of extreme events? How the extreme events have impacted the livelihood of the people relying on thecoast for their day to day earnings? What implementations, laws did the Government examine and implemented to cope up with the impacts? What precautions were taken meanwhile if there is anydisaster?

The main focus was on climate related extreme weather events that occurred in Odisha and included situations such as floods, cyclones, rainfall, temperature and heat waves. The main keywords searched were climate change, extreme events, natural disasters, adaptation, vulnerability, livelihood, government mechanisms, management strategies, Puri, Odisha, India, etc.

IMPACT OF EXTREME EVENTS ON LIVELIHOOD IN ODISHA

There have been observable changes during the last some decades in the land- sea boundary because of different powerful forces which were not considered normal. The hazards have been taking place with more intense damage in both the economic and life loss, for example, the 1999 Odisha Paradip cyclone caused severe loss of life and property. The Indian coast is subject to severe weather events, such as cyclones and super cyclones (ICZMP, 2010).

IMPACT OF HEAT WAVES ON LIVELIHOOD IN ODISHA

Heat waves have caused thousands of health related issues and deaths each year in Odisha. Swelling, fainting, dizziness, headache, weakness, skin infections, vomiting, diarrhea are the majorsigns and symptoms of health related issues due to heat waves in Odisha along with increased mental stress (Patel, 2018). Heat waves also adversely affect old people, children, labourers, vendors, rickshaw pullers and people living in urban slums (Mishra, 2017). Heat waves affect mostof the districts in Odisha (Government of Odisha, 2015) and with the overwhelming majority of people employed in the unorganized sector, long duration. Heat waves force people to stay indoorsand lose out on income earning opportunities (OSDMA, 2016). Excessive heat affects the healthworkers causing heat stroke and lowering their productivity (Government of Odisha, 2015). The increase in economic activities in Odisha have gradually increased the temperature and intensifiedheat waves, which have directly impacted the livelihoods of people engaged in outdoor based activities. The main reason for the increase in temperature and the frequency of heat waves are the industrial sector and coal fired plants that every year emit million tons of carbon dioxide whichis roughly equivalent to 3% of projected growth in anthropogenic greenhouse gases worldwide (Parichha, 2016). Climate change along with increasing urbanization, industrialization and population growth has been responsible for the intensification of heat waves in Odisha (OSDMA,2016). Several studies have demonstrated that the fall in groundwater levels and water sources has impacted the livelihood of people by impacting agriculture (Moharana, 2013; OSDMA, 2016). Another study also points out that a rise in temperature affects the agricultural sector in coastal areas of Odisha (Mishra and Sahu, 2014). Livestock are also affected by heat stress and fall ill by impacting the rural livelihoods dependent on animal husbandry (Patel, 2018).

IMPACTS OF DROUGHTS ON LIVELIHOODS IN ODISHA

Among all other extreme weather events in Odisha, droughts are the most recurrent and often affectvast geographical areas. The state has experienced drought since independence and over the yearsthe new areas are also becoming drought prone with drought impacting districts (Roy *et al.*, 2002).In 2015-2016, 27 out of 30 districts in the state were affected by drought (Open Government Data,2016). As an agricultural state, there have been 5 years (1965, 1974, 1976, 1979 and 1996) in thelast 50 years when the rainfall was below 1000 mm (OSDMA, 2016). Given the growing frequencyand extent of droughts, there was a crop failure, land alienation, unemployment, indebtedness, migration for small and marginal farmers and agricultural labourers which were more severely affected (OSDMA, 2016). In some districts of Odisha, it has also been evident that even the agriculture land holders are forced to change their livelihood or migrate for work due to continuousdrought (Patel, 2018).

IMPACT OF CYCLONES ON LIVELIHOOD IN ODISHA

Among all the extreme events that have affected Odisha, cyclones have caused the most severe damage and have devastated Odisha; it has claimed thousands of lives and has been devastating for peoples' livelihood. Even though Odisha has been vulnerable to cyclones, people were unprepared for the magnitude loss and death that the super cyclone in 1999 caused. Tens of thousands of people were killed in the Super Cyclone in 1999. It wreaked havoc on climate sensitive livelihoods of people ranging from agriculture to fisheries. Most of the people engaged in fishing activity were affected very badly in the Super Cyclone where 76970 boats and nets weredamaged (OSDMA, 2016). Agriculture was ravaged due to saline water inundation ruining the livelihoods of farmers (Sinha, 2002). During the Super cyclone over 1 million hectares of land was affected. The cyclone wreaked havoc three weeks prior to the harvest destroying paddy fields, vegetable crops and sugarcane (Sinha, 2002). A number of cyclones have affected the state with devastating impacts on the livelihood of the people. Some of the cyclones listed are Super Cyclone1999, Cyclone Phalin 2013, Cyclone Hudhud in 2014, Cyclone Titli in 2018, Cyclone Fani in 2019and Cyclone Amphan in 2020, these cyclones' strong winds have caused significant damage to theinfrastructure like electricity network, property loss, and loss of life. More than 30 lakh consumerswere affected for days. There was no electricity, food and several amenities were not available fordays. This kind of damage causes huge losses to livelihood and to the local community as well asto the economy. Recovering from these losses is a big challenge. Though the state has a huge marine, mineral and tourism potential; it's very much dependent on primary resources like agriculture,

fishing, forestry and mines. It needs a lot of time to be back on track and understand the economic impacts (Odisha+ 2020). A lot has changed since the 1999 Odisha cyclone such as weather forecasting systems and early evacuation has consistently reduced damage caused by cyclones throughout the state. It's very clear that the state is losing a huge amount of capital in almost every year due to the natural calamities and thereby causing poverty in the state. The Odisha state Disaster Management Authority (OSDMA) soon after the Super Cyclone has taken some major steps but this concept needs more intensive research, skilled and experienced personnel, a deliberate and high level discussion to find out an effective solution in order to cater to the ill effects of the natural calamities on the economy of the state (Odisha 2020).

IMPACT OF FLOODS ON LIVELIHOOD IN ODISHA

Floods are the most frequent and devastating natural disaster in Odisha. Nearly 1.40 lakh hectaresof geographical area is flood prone in Odisha (OSDMA, 2016). With a large number of communities residing along the riverside locations or coastal areas, flooding has become a regularfeature of life. In 2006 floods over 67 lakh people were affected, in 2007 more than 27000 houseswere damaged and in 2008 over 45000 houses were damaged (OSDMA, 2016). The livelihoods and property were also impacted with this destruction. The cyclones and floods cause damage to the boats, nets, community roads and fish landing centers (Iwasaki *et al.*, 2009). A study done in the Puri district of Odisha shows that floods lead to crop submergence and subsequent crop failurewhich increase the vulnerability of people (Sam *et al.*, 2017). A study conducted on farmers' vulnerability to floods and storms in Puri and Ganjam districts, illustrated that the people are dependent on sensitive livelihoods and most of these people are located in disaster prone areas (Vivekananda *et al.*, 2014).

VULNERABILITIES ASSOCIATED WITH COAST

There have been significant changes in the weather patterns during the last few decades due to which the climate change is triggered and extreme events have drastically increased. The cyclonesand floods taking place very often with more intense damage have caused both life loss and economic loss. The cyclones are not the only factor making the coast vulnerable, but different factors which are emerging are sea-level rise, shoreline erosion, tidal waves and currents, tsunamiand salt water intrusion (ICZMP, 2010). The scenarios such as global warming and sea-level rise (SLR) have drawn so much attention in the coastal perspective. Human activities such asinfrastructure, increase in population density, ocean acidification, sand mining, etc., are making the actual natural system more vulnerable. Vulnerability arises due to complex interaction of various natural and human induced coastal processes (Mujabar and Chandrashekhar, 2011). Thereare different natural and anthropogenic phenomena that require comprehensive study to understandthe coastal vulnerabilities and their order of risk. Proper assessment of vulnerability requires qualitative data; some of them are listed below.

a. *Coastal Geomorphology*

It is a dynamic process that requires the necessity of monitoring continuously and detailed study. The vulnerabilities are studied. The various features of Indian coastline are rocky headlands, tidalinlets, estuaries, lagoons, barriers, etc., (Sanjeev, 1993). Geomorphology has been considered as an important parameter in understanding the dynamic coast.

b. *Shoreline change associated with Erosion and Accretion Patterns*

The shoreline or coastal line is the boundary between land and sea and continuously change due to erosion, accretion, topography and tidal processes and sea-level changes. Shoreline change is anatural process, but it changes if human activities such as construction are performed (MOES, 2009). Shoreline change has been observed to understand the land accretion and erosion activities.

c. *Coastal Slope*

Hazards like inundation and flooding are mainly due to coastal slope and urbanization. The gentlerslopes with more sediment, rock and soil material carry into the ocean from land to coastal plains.The steeper the coast will be, it will be more prone to risk the coast. The sediment transport and soil erosion along the coast may cause more effect on the land

surface. Thus, understanding and protecting the coastal slope are also important.

d. *Extreme Events: Tropical Cyclones And Storm Surges*

Cyclones and storm surges cause coastal flooding which leads to overtopping of coastal defensesand inundation of low lying areas. On other hand these cyclonic systems provide most of the annual rainfall essential for agriculture and water resource management (Krishnakumar *et al.*, 2016).

e. *Saltwater Intrusion*

It is a natural process which is caused by higher density and solute concentration of sea water andis exacerbated by extraction of fresh groundwater in over- pumped catchments (Kacimov *et al.*, 2009). Beaches act as shields to control the saltwater to intrude into fresh water still the boundaryof the coastal aquifer depends on the amount of water flowing out of it and the balance between groundwater and salt water flow.

f. *Coastal Inundation*

It is flooding of some portion of land within the coastal zone. It's a temporary process but may bepermanent too. The temporary process is due to high tidal waves, storm surge and inland flood whereas the permanent process includes sea-level rise, climate change, etc. (Rao *et al.* 2012; Bhaskaran *et al.*, 2013).

g. *Land Use Land Cover (LULC)*

The land use land cover is very useful for coastal areas. In a simple language land use denotes theeffective use of landscape and land cover. The land can be referred as forests, vegetation, agriculture, waste land, open land, water- land, etc,; land use refers to its development, usage, etc.the increase in urbanization and industrial growth lead to and use and land cover change. The population residing near the coast also leads to LULC change which makes the coast more vulnerable to extreme events. The biological system of the coast gets disturbed due to the developmental activities and population growth (Chauhan and Nayak 2006; Arunachalam *et al.*, 2011).

ACTION AGAINST EXTREME WEATHER EVENTS

Number of strategies and laws have been implemented and taken up by people and government tobuild resilience and have proper livelihood security in order to adapt to the increasing frequency of extreme events. A number of studies show that people with low income in Odisha tend to workmore for their earning and their livelihood (Hota and Behera, 2014). Another study showed that people took up off-farm activities such as dairy, non- agricultural labor, small business and some even reduced their food intake and took up the sale of cattle (Mishra and Mishra, 2010). A numberof studies indicate that people migrate in search of work after natural disasters (Julich, 2011; Mishra, 2007; Mishra and Mishra, 2010). Some of the coping strategies for the lower earning people in Odisha was taking loans for agricultural activities from money lenders, family, self-helpgroups and banks (Patel, 2018; Mishra and Mishra, 2010).

A study undertaken in an inland and coastal area to assess the resilience of communities a decadeafter the super cyclone study showed that the recovery efforts had severe limitations. It pointed out that people resorted to wage labour besides engaging in agricultural activities. Many people started prawn cultivation after the super cyclone after the super cyclone (Chhotray and Few, 2012).Interventions and programmes were introduced by the government and NGOs to help the vulnerable communities to adapt to climate change and the effects of extreme events on their livelihood. Another study said that livelihood diversification was introduced to farmers and farmers were encouraged to use saline tolerant and low-cost rice varieties and self- help groups were promoted, with the aim of improving livelihoods and reducing disaster risk caused by extreme events (Iwasaki *et* al., 2016). In another study Swarna-Sub 1, a flood tolerant seed varietywas distributed among farmers as a strategy to adapt to the effects of the changing climate on agriculture. The yield from Swarna-Sub 1 was found to be higher compared to traditional varietiesas well as other high yielding varieties (Swarna and Puja) (Dar *et al.*, 2017). The Western Orissa Rural Livelihoods Project (WORLP) assisted farmers with crop diversification, aquaculture and vegetable gardens. It improved

the capacity of women to adapt to climate change effects that is theparticipation in self-help groups that have been strengthened and made it possible to manage common property resources more efficiently (Sharma *et al.,* 2014). The government has taken several preventive measures to help the local communities to adapt to changing climate and recurrent natural disasters. The programmes and policies have been introduced for helping the statedeal with effects of climate change and extreme events. For instance, through the State Disaster Management Plan, entities such as Indian Meteorological Department (IMD) disseminate disasteralert (OSDMA, 2016). Odisha is the first Indian State to develop a State Climate Change Action Plan. The Government of Odisha has established 11 different sectors which are relevant to climatechange. They are:

1) Agriculture
2) Coastal Zones and Disasters
3) Energy
4) Fisheries and Animal Resources
5) Forestry
6) Health
7) Industries
8) Mining
9) Transport
10) Urban planning
11) Water Resources (Gurukalyan, M., 2011).

SUMMARY AND CONCLUDING REMARKS

Odisha is one of the most vulnerable to climate change. It has a 480 kms long sensitive coast line,which continuously faces climate extremes such as cyclones, floods, coastal erosion every year. Odisha is also rainfall dependent for its most non- irrigated land (Gurukalyan, M., 2011). Climatechange threatens coastal areas, which are already stressed by human activity, pollution, invasive species and storms. Due to climate change the oceans become acidic and warmer which are likely to disrupt coastal and marine ecosystems. Odisha due to its geographical location is prone to the hazards of climate change and susceptible to the impacts of rise in sea level. Occurrence of recurring cyclones adversely affects the coastal areas of Odisha. The Government of Odisha firstlyimplemented its first ever Odisha Climate Change Action Plan in 2010 for the period 2010-2015 which specifically focused on climate change its impacts, budget and also special focus was given to women and children which was successfully implemented. In the year 2018 Second State Climate Change Action Plan for the year 2018-2023 which focused on different sectors such as agriculture, industry, forest resources, environmental priorities, energy requirements, fisheries resources, freshwater supply and human health etc. In April 2019 when cyclone Fani affected Odisha badly and destroyed many properties and life the government with public participation andhelp of NGOs started a beach cleanup “Mo beach” which meant “My Beach” in English which was started in June where local communities, Volunteers, government officers and NGOs on Tuesdays’ or weekends cleaned the beach and more than 250 quintals of waste from 19 places along the places of the shoreline of Puri district (Hindustan Times, 2019). Due t the ongoing pandemic the pollution level has gradually decreased as well as the tourist visitors in the beaches and Temples has decreased. All beaches were de-congested and visitors were advised to keep safe distance while visiting beaches (The Hindu Times, 2020). The review clearly asserts that the possibility of loss of livelihood due to extreme events and the ability to cope and adapt to its adverse effects is socially determined. The repeating nature of these disasters in Odisha when combined with the poor infrastructure prevail levels of poverty and the inability of the state to provide strong institutional support creates a vicious cycle of increasing vulnerability (Chhotray and Few, 2012). Odisha being a developing state and a coastal region faces a lot of extreme eventsdue to climate change and increase in the activities of human intervention. The monsoons have become totally unpredictable. The disasters such as cyclones and floods have become regular which directly affects the livelihood of the people as well as hampers the economic growth of thestate. Last year in 2019 when the cyclone Fani affected the state there was no communication, nofood, no house, almost nothing for the people living there. but as Odisha was the first state to implement the Odisha Climate Action

Plan the precautions and management was taken care of such as food distribution was done in the affected areas, subsidies and loans were provided to the farmers, awareness programmes were done across the state, government schemes and laws were implemented, beach cleanups were done regularly. The positive effect of all these thing were seenlike the Olive Ridley turtles which were rarely found in two or three beaches across India out of which Odisha was one of them, were again visiting to the beaches to lay their eggs as well as dueto the ongoing pandemic situation the pollution and the tourist visiting the beaches has gradually decreased.

The study of coastline is a challenging field where changes appear within a single day to decades.It's very necessary to monitor or take up adaptation strategies and implement them in advance before the hazard takes place. Adaptive strategies should be taken or else vulnerabilities would lead to adverse impacts on socio- economic and as well as livelihoods of people. Remote sensing and Geographical System Information (GIS) technologies are increasing for the use of coastal vulnerability studies.

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