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Research Paper

Socio-Economic Impact Assesment of Chilika Lake on Its Surrounding Zone: A Review Based On Geospatial Appraisal

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Abstract:
Chilika, the largest brackish water lagoon of Asia is famous for his Scenic beauty and its aquatic resources. This pear-shaped logged water body once formed part of the sea-bed. With the geological and geomorphologic passage of time and by silt deposits and sandy ridges, it was eventually separated from the sea by a group of islands with less than 200 m in width. The major portion of the Lake is located in Krushnaprasad block of Purl district. The western bank of Chilika is surrounded by Madras-Howrah railway line and Madras-Calcutta National Highway (NH5). Now a days, Chilika lagoon is facing some issues like, the Lake is now shrinking slowly and the depth of its water swallowing because of the continuous and increasing rate of siltation of the Lake, Because of the changing nature of the Lake water the brackish water species including shrimp, crabs and fish are dwindling, Nalabana island of the Lake is the finest place of migratory birds in winter, large number of dolphins are found in the Lake mostly in the outer channel and sea mouth, large number of fishermen use this natural resource (i e, water-body) as an input for their livelihood by fishing in the Lake, traditionally, the fishing was done by the fishermen with a lot of cooperation. The present study shows that the government policy of Orissa for shrimp culture in the Lake, there has been great change in socio-economic conditions of the in-habitants of the villages in and around Chilika and also in its ecosystem as well as over all environment. In last two decades, the area is so developed in Dolphin based tourism sectors. Many hotels, resorts, community places are formed in that purposes. Many local people are engaging in that sector. Per capita income is now high. As a result of it, education and cultural sectors are developed rapidly.

Key Words: *Brackish Water, Dolphins, Lagoon, Migratory Birds, Siltation, Tourism*

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I. Introduction:

Land Use Land Cover (LULC) types and their changes are in the mainstream of Global Change Impact studies. Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types. Water types include wetlands or open water. Land use shows how people use the landscape – whether for development, conservation, or mixed uses. The changes in the physical characteristics of the earth's surface e.g. deforestation, afforestation, distribution of water bodies, soil and types of vegetation as well as anthropogenic changes such as proliferation of manmade structures are captured in the term land use. Land Use / Land Cover (LULC) generally refers to the categorization or classification of human activities and natural elements on the landscape within a specific time frame based on established Scientific and methods of analysis of appropriate source materials. The patterns of these changes are natural and socio-economic drivers over time. Therefore, understanding changes in LULC types of a region is important for sustainable management of natural resources. The land use and land cover changes of a region is characteristic of the human use of the land and can also be representative of the economic activities. The patterns of these changes are normally a combination of natural and socio-economic drivers over time. This field helps to better understand the human and environment dynamics leading to change land use and land cover. This takes care of

changes in terms of their type, magnitude and location as well. Hence, it is very important to understand the decadal land cover change by satellite based measurement for sustainable development and management of the overall ecosystem of a region.

Over the years, Land-change Science established itself as the foundational ground for studying global environment change and overall sustainability of an ecosystem (Turner et al, 2007).This requires the integration of social, natural, and geographical information Sciences. LULC is considered as one of the major concerns in global environmental change and hence the overall sustainability of an ecosystem. The LULC, driven by rapid urbanization and increasing economic activities put a lot of pressure on natural resources. Various studies have demonstrated that conversion of various land cover types to agriculture and urban landscapes have negative impacts on nutrient cycling, erosion control and climate regulation and water availability and soil fertility (Leh et al, 2013, Xiong et al, 2014,).Thus it is important to understand the consequences of the LULC change and hence the overall impact it can have on a whole ecosystem using satellite based measurements over decades.

LULC Science has been able to provide routine services for monitoring and modeling of land use / cover patterns. By satellite data and GIS software we are able to update, analyze the previous maps and also create the new LULC maps over decades. Coastal ecosystems are key ecosystems considering their importance in providing goods and services. Coastal zones are most vulnerable for land use changes in this rapid industrialization and urbanization epoch. Coastal areas are vulnerable to climate change impacts due to factors such as: sea level rise, changes in storm surge and precipitation, increased coastal water temperature and ocean acidification. Coastal managers use land cover data and maps to better understand the impacts of natural phenomena and human use of the landscape. In this study, an attempt has been made to develop an understanding of changes happening in the Chilika and its neighboring areas using long-term satellite data records. Because, there is a serious problem in changing the environment. Moreover, this change could be the result of complicated interactions of socio economic and biophysical situations like economic diversification, technological advancement, demographic pressure and many other related conditions (Reid et al., 2000)

Study Area:

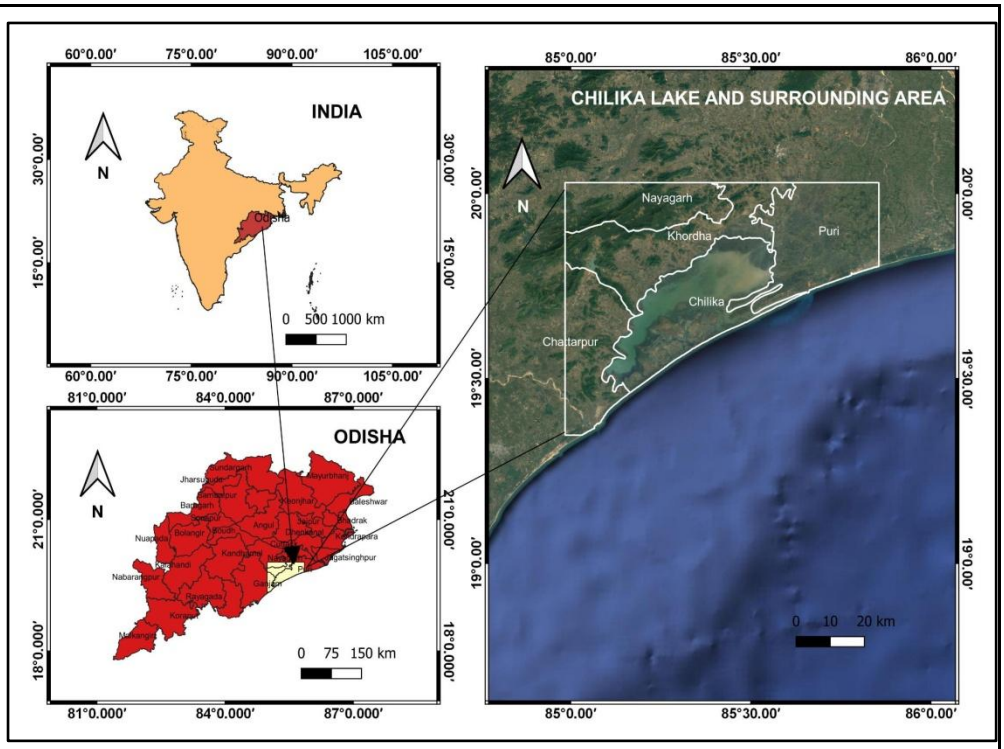

Fig:1 Study Area

Our study area (fig.1) is Chilika Lagoon and its surrounding areas. It is situated on the east coast of India and is the largest brackish water wetland of Asia and also a Ramsar site. The Chilika lagoon spreads for around 830 Sq. km. along the east coast of India in the Odisha state. Chilika catchment is situated on the east

coast of India which covers Puri and Khurda districts adjoining Ganjam district of Odisha state. It has been formed due to the silting action of the Mahanadi river, which drains into the northern end of the Lake, and the northerly currents in the Bay of Bengal, which have formed a sandbar along the eastern shore leading to the formation of a shallow lagoon. The western and southern margins of the Lake are fringed by the Eastern Ghat hill range. The north shore of the Lake is part of Khordha district, and the western shore is part of Ganjam district of Orissa. The shallow water body (average depth 2 m) is about 65 km in length, spreading from northeast to southwest parallel to the coastline with a variable breadth reaching 20.1 km. The Lake is divided into an outer channel with a narrow neck leading into the sea and the main body of the Lake with a muddy bottom rich in organic matter. According to the Salinity and Depth the Lake is divided into 4 sectors as Northern, southern, Central and Outer Channel. The study area becomes a major hotspot of biodiversity which serves as natural habitat for a range of species, birds, fishes and prawns etc. Chilika Lake is one of the Ramsar Sites which has a complex ecosystem. It is important to study the landuse and landcover of the catchment area and its pattern over years to access and monitor the ecosystem ensuring wise use of the wetland system for productive resources. There is a serious threat to the lagoon ecosystem had also adversely affected the biodiversity and livelihood of local communities.

To restore this unique ecosystem, the Government of Orissa created the Chilika Development Authority. The Chilika Development Authority (CDA) made an artificial mouth near the village of Sipakuda (Roy 2001). The new mouth was opened on 23 September 2000 with an initial cut of 80m in length to the existing spit of around 200m in width (Venkatarathnam 1970). The Chilika Development Authority initiated the restoration of the lagoon with an ecosystem approach and active community participation. So, It is important to study the landuse and land cover change over decades to access and monitor the ecosystem.

Geology, Geomorphology

The Lake is of estuarine character in an ephemeral environment. Geological studies indicate that the coastline extended along the western shores of the Lake in the Pleistocene era with its northeastern region lying under the sea. That the coastline has moved eastward over the ages is supported by the fact that the nearby Konark Sun Temple, built originally on the seashore a few hundred years ago.

Chilika Lake is bordered between the sea and mountains. Formation of a barrier spit near Palur due to littoral drift and creation of a sand bar along the eastern shore have transformed the Lake gradually into a shallow lagoon. Presently, the sea is connected with the Lake near Satapada through a number of shoals, sand spits, sand bars, openings of shallow depth, and a narrow channel. The presence of these features considerably reduces tidal flow in and out of the Lake. In the past, discharge of sediment by the tributaries of the Mahanadi River made the Lake shallower, and subsequently, the Lake was separated from the sea after the formation of the spit (Krishnan, 1968)

The catchment area (fig. 2) of Chilika Lake has a rock, sand and mud substratum. It contains a wide range of sedimentary particles such as clay, silt, sand, gravel and shell banks but the major part of the catchment area is silt. Around 1.6 million metric tons per year of sediment is deposited in Chilika Lake by rivers Daya and several streams. It is conjectured that a rise in worldwide sea levels over the last 6,000–8,000 years occurred with a pause in the rise of sea level about 7,000 years ago, which could have resulted in the formation of a sandy beach near the coast at the Southern sector. With rise in the sea level, the sandy beach grew gradually, progressed seaward to the northeast and formed the spit of Chilika. The abrupt change in the direction of the coast north of the Lake, strong winds shifting sand to the shore, long shore drift, the presence or absence of strong rivers and tidal currents in different areas are the reasons attributed for the growth of the spit.

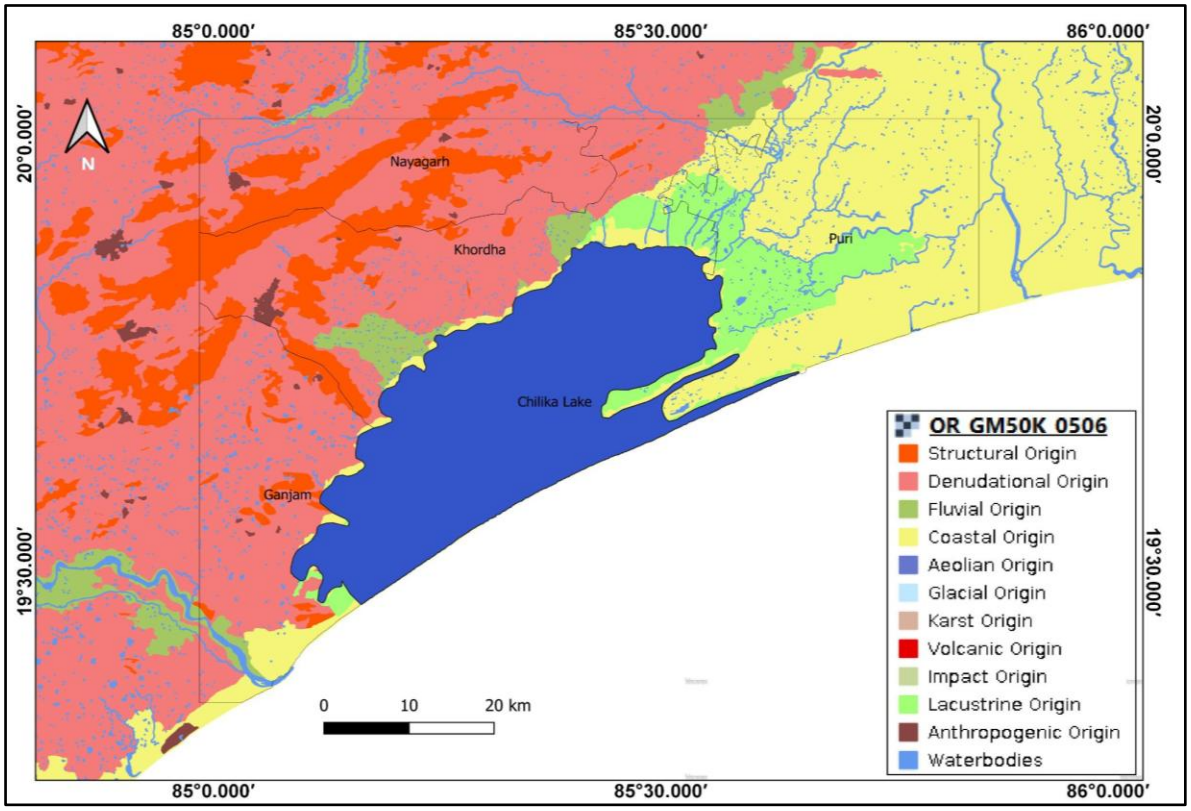

Fig:2 Geomorphology Map of the Study Region

Source: Bhuvan Geoportal, ISRO

Several erosional and depositional landforms are the major structures observed in the Lake and its surroundings. Khondalites, unclassified granites, laterites, charnockites, anorthosites, granulites, laterites and alluvium are observed to be the main rock types around Chilika Lake. Some islands of Chilika comprise Eastern Ghat rocks. Many structural and denudational hills of khondalite, charnockite, gneisses, anorthosite and granite are observed towards the western phalanges. The hills are followed by lateritic plains. Large tract of alluvial plains extending to more than 400 km^2 surround the north part of the Lake. This low-lying area is mainly built by recently deposited sediments having very gentle slopes. This region is drained by the Mahanadi Delta and its distributaries Bhargavi, Luna and Makara, which have extremely gentle elevation and sediment deposition. Two distinct shore terraces parallel to the northern shoreline mark the shoreline terraces formed due to continuous deposition and emergence of the lagoon floor. Many sandy beach ridges are observed along the eastern part separating the Lake from the open sea. Some of these ridges rise up to 5-6 meters with characteristic swales in between which are occupied by creeks and marshes. The open coast is marked by the presence of a prominent spit connected to the mainland at its southern end.

Soils

Four major categories of soils are present in the Lake based on the Harmonized World Soil Database. The hills on the west are marked by Nitisols (deep and dark brown clayey soils) whereas the deltaic region has Lixisols (soils with subsurface accumulation of low activity clays and high base saturation). A patch along the northern sector has Solonchaks or strongly saline soils. Arenosols or sandy soils with very weak soil development mark the coastal zone of Chilika.

Hydrologic soil groups (HSGs) are a fundamental component of the USDA curve number (CN) method for estimation of rainfall runoff; yet these data are not readily available in a format or spatial resolution suitable for regional to global Scale modeling applications. They developed a globally consistent gridded dataset defining HSGs to fill this gap. The resulting data product—HYSOGs250m—represents rainfall runoff potential at 250-m spatial resolution. The four standard classes—A, B, C, and D—correspond to soils with low, moderately low, moderately high, and high runoff potential, respectively. Wet soils have high runoff potential (regardless of texture) due to the presence of a groundwater table within 60 cm of the surface. These soils are

assigned dual HSGs, as a less restrictive class group can be assigned (according to texture or KS) if they can be adequately drained.

- HSG-A has the lowest runoff potential (typically contains more than 90% sand and less than 10% clay),
- HSG-B has moderately low runoff potential (typically contains between 10 to 20% clay and 50 to 90% sand),
- HSG-C has moderately high runoff potential (typically contains between 20 to 40% clay and less than 50% sand), and
- HSG-D has the highest runoff potential (typically contains more than 40% clay and less than 50% sand).

Pixel Value	Description
1	HSG-A: low runoff potential (>90% sand and <10% clay)
2	HSG-B: moderately low runoff potential (50-90% sand and 10-20% clay)
3	HSG-C: moderately high runoff potential (<50% sand and 20-40% clay)
4	HSG-D: high runoff potential (<50% sand and >40% clay)
11	HSG-A/D: high runoff potential unless drained (>90% sand and <10% clay)
12	HSG-B/D: high runoff potential unless drained (50-90% sand and 10-20% clay)
13	HSG-C/D: high runoff potential unless drained (<50% sand and 20-40% clay)
14	HSG-D/D: high runoff potential unless drained (<50% sand and >40% clay)

The soil Grids were stacked into a multi-band raster (text Stack) using the raster::stack function. For the purpose of this analysis, we refer to individual grid cells (~ 250-m x 250-m) in the raster stack (1 m depth) as soil pedons. Each grid cell in the raster stack (or pedon) was re-classified into one of four HSGs (hsgStack) according to USDA specifications. This allowed us to infer the water transmissivity of each layer in the profile from the stacked texture classes. Note that integers 1, 2, 3, and 4 were used to represent HSGs A, B, C, and D, respectively. The raster::max function was then used to determine the largest value of each grid cell in the raster stack, allowing us to infer the most restrictive layer in the pedon. This value (maxHSG) was used to assign HSGs for each pixel in the stack, thus representing soil runoff potential for each pedon. Shallow soils (bedrock within 50 cm of the surface) were reclassified to HSG-D (maxHSGR). Dual HSGs were assigned to pedons with shallow water tables (< 60 cm from the surface) using the depth to groundwater table dataset. Integers 11, 12, 13, and 14 were used to denote dual HSGs A/D, B/D, C/D, and D/D in the dataset.

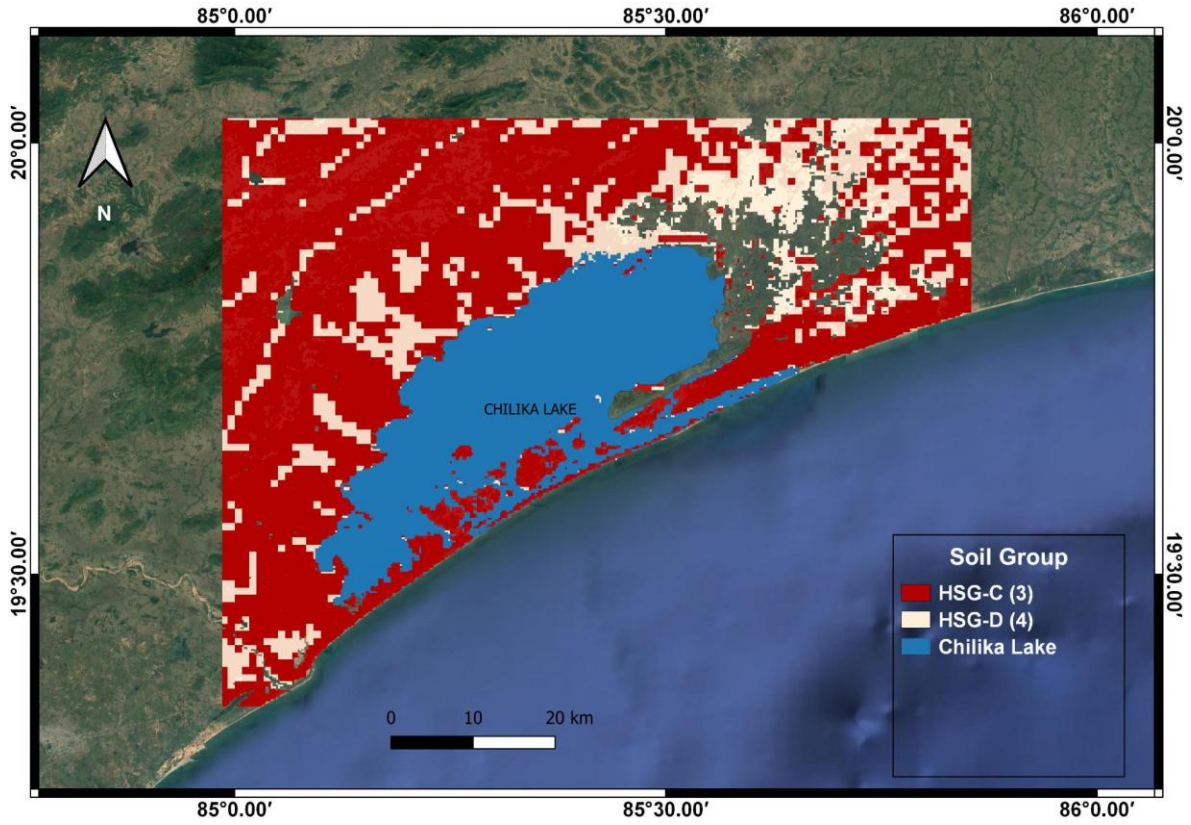

Fig:3 Soil Map of the Study Region

Source: ORNL DAAC, EARTHDATA

The above figure (fig. 3) is our present study area, Where we see two types of soil group as per HSGs soil group. The red legend which pixel value 3 is under HSG-C means this soil has moderately high runoff potential and In these soil <50% sand and 20-40% clay particles are present. This Soil group covers most of the area in our present study area. Like that whitish red legend whose pixel value 4 is under HSG-D. It denotes high runoff potential soil and <50% sand and >40% clay particles present in soil texture, respectively. And by blue legend Chilika Lake water area is denoted.

Physiographic

Based on the relief feature, Odisha state can be broadly divided into four physiographic divisions (fig. 4): 1.Northern plateau, 2. Central table, 3. Eastern Ghat and 4.Costal plains. Our present study area is under eastern ghat and coastal plain regions.

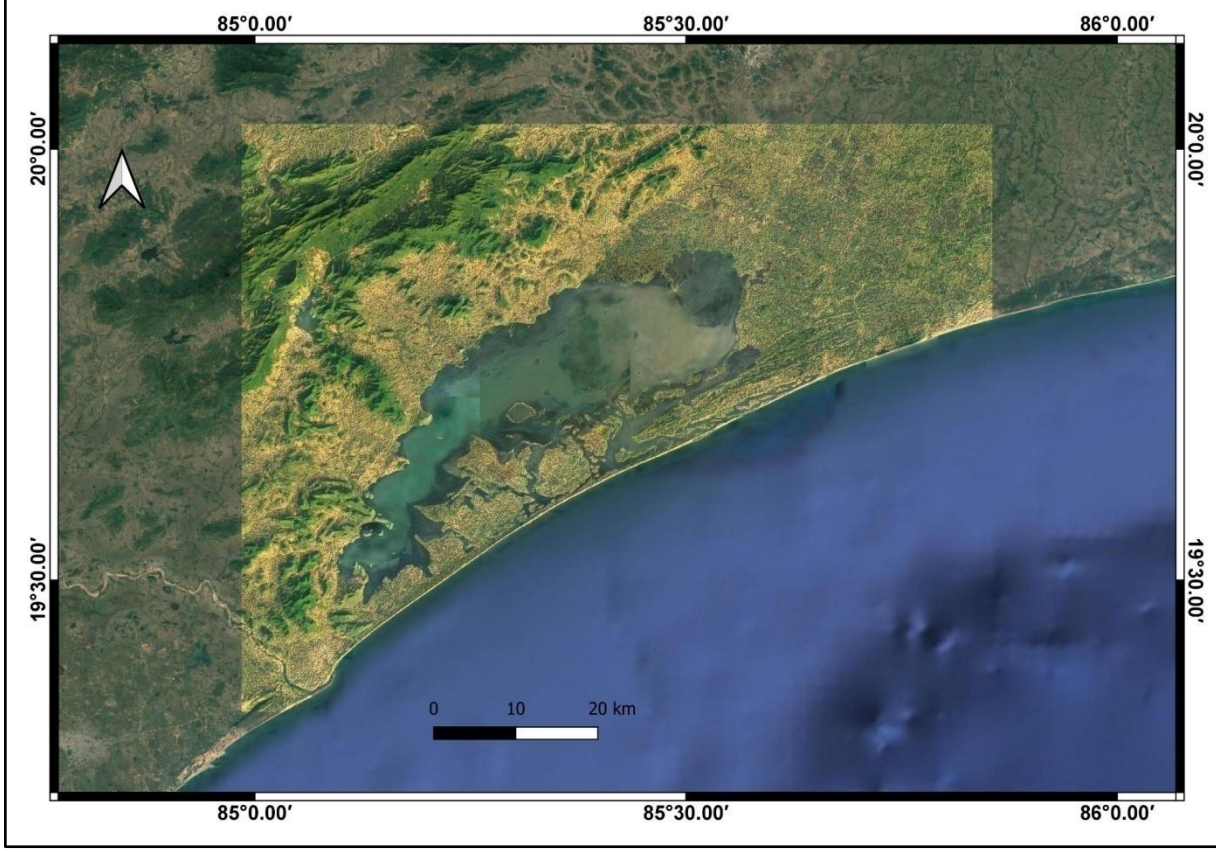

Fig:4 Physiographic Map of the Study Region

Eastern ghat region consists of hill ranges which belong to the mainline of eastern ghats along with some plains and valleys lying between them. This area consists of the districts of Koraput, Kalahandi and Phulbani except the northern part of Boudh sub-division, the western and extreme northern portion of Gunjam district. The southern portion of the Koraput sub-division is a plateau with an elevation of more than 610 m MSL.

The coastal region runs from north to south having a width between 24 to 72 km from the sea coast in the districts of Balasore, Cuttack and puri. The eastern part of Ganjam district also comes within this range. The coastal plain is characterized by a number of deltas mainly formed by the rivers Subarnarekha, Mahanadi, Brahmani and Baitarini. This zone covers about 18% of the total area of the state.

Hydrological Activities

In Chilika lagoon all hydrological activities which take place are caused by coastal and riverine processes both resulting in the mixture of fresh water from rivers and salty water from the sea which makes the water brackish in nature. Three hydrological subsystems control the Hydrology of the Lake. The land-based system comprises distributaries of the Mahanadi River on the northern side, 52 river channels from the western side and the Bay of Bengal on the eastern side. The Lake is divided into four different sectors (North, South, Central and Outer) according to the variability in salinity and depth. Inflow of freshwater is via Mahanadi, its distributaries and part of western catchment; salty (sea) water is brought by mouths and the Palur Canal in the southern sector. Badaghati, Badanai, Badasankha, Kansari, Kusumi, Mangalajodi, Salia and Tarimi are the major streams which flow from the western catchment which carry the monsoon runoff from a highly gullied and ravenous catchment with marginal forest cover. The important rivers of this drainage system are the Kansari, the Kusumi, the Janjira, and the Tarimi rivers.

Climate

A tropical monsoon climate prevails over the drainage basin area of the Lake. The Lake experiences South–west and North-east monsoons during June to September and November to December. During winter

(November–January), a large portion of this lagoon remains submerged and acts as a wetland, which also serves as breeding and nesting grounds for millions of migratory bird species. High evaporation from the shallow water body during summer (April–June) and a large inflow of freshwater through various rivers and rivulets at the northern end of the lagoon during the monsoon (July–September) and post monsoon

(October–November) seasons significantly influence the water spread area of the lagoon (Mohanty et al., 1996). The catchment of the lagoon enjoys a typically tropical climate with an average annual Maximum temperature 39.9°c, Minimum temperature of 14.0°c. The lagoon experiences South-west and North-east monsoons during June to September and November to December respectively. During December and January cold wave conditions prevail for a couple of weeks due to Western disturbances in North India. In the inland hilly tract, the climate is comparatively drier with higher temperature during the hot months and slightly cooler in winter. December to February is the winter season, which is followed by a hot season from March to May. The period from June to September is the monsoon season while October and November months are the post monsoon transition months. The average rainfall in the catchment is 1238.8 mm with 72 rainy days. The rainfall generally decreases from northeast to southwest. The monsoon starts by about the second week of June and withdraws early in October. About 75% of the annual rainfall is received during the monsoon months from June to September. The Krushnaprasad Block receives the lowest rainfall of about 107.5 cm, the lowest in the State.

The wind speed is high during the month of March to July and the speed is low during the winter season. The wind speed is mostly from North and north easterly direction and during monsoon month it is mostly southerly and southwesterly direction due the influence of the South-west monsoon and the wind speed varies from 5.3 to 16.0(Km/Hour).

The temperature and precipitation (fig. 5) nature of this area over 33 years are described in below-

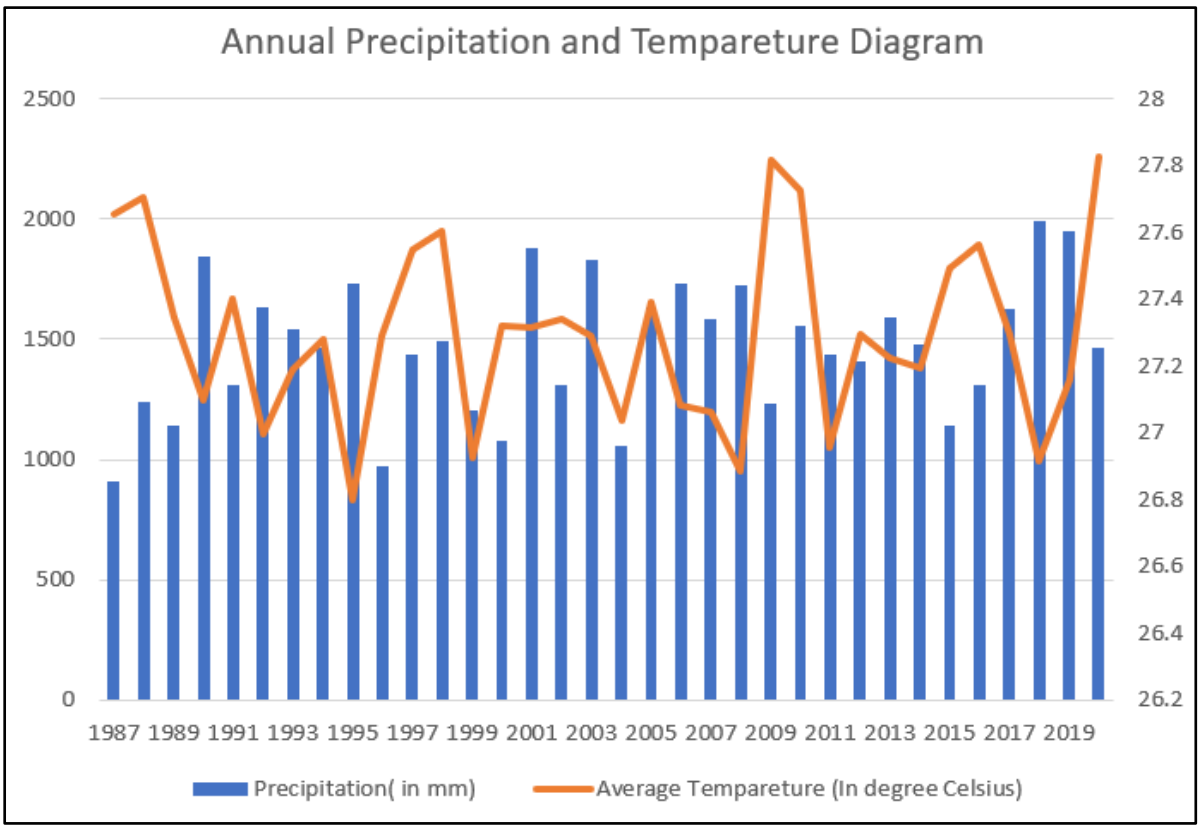

Fig: 5. Showing Temperature and rainfall

Forest

There is a large forest area both on the coastal side and around the Lake which is being covered by casuarina (near the sea shore), eucalyptus and cashew under both a SIDA-supported and the government's own social forestry programme. But the tribals and the local communities entirely depend upon the forest to meet their own fuel requirements and they also cut and sell it in the local market. Also, the tribals supply bamboo to the fishermen to make fishing tools and leaves to make leaf-plates. It was stated by the people that they have to go deeper and deeper into the forest as forests are getting cleared and denuded. It contributes to floods and sedimentation in the Lake. Hence, the forest is significantly linked to the Lake and the fishing community in many ways.

Floral Diversity

Phytoplankton's

Phytoplankton community of Chilika Lagoon consists of a mixture of marine, brackish-water, and freshwater taxa, mainly represented by four groups of algae – diatoms (Bacillariophyceae), dinoflagellates (Pyrrophyceae and Dinophyceae), blue-green algae (cyanobacteria), and green algae (Chlorophyceae). A maximum number of 128 species of phytoplankton have been reported from the Lake (Panigrahi et al., 2009). Diatoms are the dominant group and are represented by 79 species (41 centrals and 38 pennales). The dinoflagellate population is represented by 13 species. Blue-green and green algae (with 9 families and 15 genera) are represented by 18 species each. Some of the recent dominant taxa of phytoplankton, including those distributed throughout the lagoon as well as those in the more freshwater-influenced northern sector and the saline-water-dominated outer channel area, are reported elsewhere (Panigrahi et al., 2009). But in present total 390 specieses are present. Cyanophyceae species are 43 types, Volvocales species are 10 types, Chlorococcales species are 33 types, Conjugales are 67 types and many other species like Ulotrichales, Oedogoniales, Bacillariophyceae, Dinophyceae, Euglenophyceae, Xanthophyaceae. The phytoplankton assemblages of the lagoon are dominated by diatoms, certain dinoflagellates, and blue-green algae during the summer season when the salinity in most parts of the lagoon is about 17 psu. However, during the winter season, the plankton flora is mainly represented by blue green and green algae. Phytoplankton species composition also varies spatially between seasons. In general, the outer channel area has higher species diversity than the other regions.

Algal and Plants

The northern and central part of the Chilika Lagoon is densely covered with macrophytes which have a cyclic growth. They grow luxuriantly in the late monsoon and post-monsoon periods and start decomposing in the beginning of summer, with an increase in salinity. The cyclic growth and decomposition of aquatic weeds have been significantly influencing the oxygen saturation of the lagoon water. Hence, levels of DO increase during the post-monsoon period due to the photosynthetic release, and its decrease has been noticed when they start decomposing in the summer. Recent surveys revealed that an overall 726 species of flowering plants belonging to 496 genera and 120 families are present in and around Chilika Lake. This represents about one-fourth of the vascular plant species of the Orissa state. Fabaceae is the most dominant plant family followed by Poaceae and Cyperaceae. Certain species were found to be characteristic to specific islands. The flora is predominantly of aquatic and sub-aquatic plants. The species reported are from the families Leguminosae, Poaceae, and Cyperaceae and the endemic Cassipourea ceylanica along with five species of seagrass. Wild plants of horticultural importance and interesting plant groups such as insectivorous plants, epiphytes, parasites, and lithophytes are also found in the Lake environment. Mangrove associates, such as Aegiceras corniculatum, Excoecaria agallocha, Salvadora persica, Pongamia pinnata, Colubrina asiatica, Capparis roxburghii, Macrotyloma ciliatum, and many others, are found in abundance.

Faunal Diversity

Birds

Chilika Lagoon receives thousands of avian guests coming from faraway places like Siberia during winter months. The presence of such wonderful birds adds to the bounty of the amazing coastal ecosystems along Orissa, for which millions of tourists come here to witness this unique phenomenon of nature. Chilika Lake is the largest wintering ground for migratory birds on the Indian subcontinent. It is one of the hotspots of biodiversity in the country. Some species listed in the IUCN Red List of Threatened Species inhabit the Lake for at least part of their life cycle. Chilika Lake is famous for the vast numbers of migratory waterfowl that flock there every winter, and the Lake is reputed to support the largest concentration of migratory waterfowl in India summer. In the 1960s, the Lake annually supported millions of ducks and thousands of geese in the winter months, butover the past two decades populations have declined considerably, although the numbers are still impressive (Ram et al., 1994). As with many reports about Chilika Lake, various sources provide quite different views, and species list and total numbers vary considerably. Scott (1987) reports "over 150 species' ' and "no comprehensive counts have been made". Dean and Saltink, reported that 500,000 – 700,000 migratory birds annually, consisting of over 150 species. Bandyopadhyay and Gopal (1991) record about 150 species of which 97 are migrants, and that in 1989-90, when conditions were particularly suitable, about two million migratory birds visiting Chilika Lake. Ram et al. (1994) report of over 160 species, of which "at least 97 species are migratory", but do not give total numbers, other than quoting Bandyopadhyay and Gopal (1991). The Asian Waterfowl Census reports that in 1992, Chilika was comprehensively counted, and that there were indications that the area "supports up to a million waterbirds", although they recommend a count augmented by aerial surveys. In all, they report a total of 103 waterbird species at Chilika.

The first migrants, usually Golden Plover Pluvialis fulva and Green Sandpiper Tringa ochropus, arrive in September when Nalaban Island is still submerged – they converge on the periphery of the Lake, near

Balugaon. Ducks usually arrive by late September or early October and Nalaban usually surfaces by January. During the present survey, Nalaban had just barely surfaced, and consisted mainly of one large mudflat, with some 'ridges' with several decimeters elevation, and a few semi-artificial hillocks. The latter were observed to be mainly used by birds of prey and ibis. Total 869 birds ringed in Chilika between 2001 -02. The species types are given below-

Fishery

The 323 species of fishes found in the Lake involve 261 fin-fish species, 28 prawns, and 34 crabs out of which 65 species breed in the Lake (Chilika Development Authority, 2008). Of these, 27 fishes and two genera of prawns are freshwater species. For centuries, fisher folk evolved exclusive rights of fishing through a complex system of partitioning the fisheries of the Lake, harvested the Lake in a relatively sustainable fashion and developed a large range of fishing techniques, nets, and gear. Butter catfish and Wallago attu are the most common types of fish found in the Lake. Eleven species of fish, five species of prawn, and two crab species are commercially important. The commercially important prawn species are giant tiger prawn, Penaeus indicus (Indian white shrimp), Metapenaeus monoceros(speckled shrimp), Metapenaeus affinis (pink prawn) and Metapenaeus dobson (Kadal shrimp). Mangrove crab is the most important commercial crab available in the Lake. Fish landings in the Lake, which fluctuated widely in the past, have recorded a remarkable recovery after the opening of the new mouth and dredging of silt-choked old mouth Magarmukh in 2000–2001.

Dolphin

The Irrawaddy 150 Chilika Lake dolphin (Orcaella brevirostris) is the flagship species of Chilika Lake. Chilika is the only home to Irrawaddy dolphins in India and one of only two lagoons in the world that are home to this species (Sutaria, 2007). It is classified as critically endangered in five of the six other places it is known to live (Cetacean Specialist Group, 1996). A small population of bottlenose dolphins also migrates into the lagoon from the sea.

Fig:6 Irrawaddy dolphins

Source: Google Webportal

Chilika fishermen say that when Irrawaddy dolphins (fig.6) and bottlenose dolphins meet in the outer channel, the former get frightened and are forced to return toward the Lake. Some Irrawaddy dolphins used to be sighted only along the inlet channel and in a limited portion of the central sector of the Lake before the opening of the new mouth. After the opening of the new mouth at Satapada in 2000, they are now well distributed in the central and the southern sector of the Lake. The number of dolphins sighted has varied from 50 to 170. A 2006 census counted 131 dolphins, and the 2007 census revealed 138 dolphins. Out of the 138

dolphins, 115 were adults, 17 adolescents, and six calves. Sixty adults were spotted in the outer channel followed by 32 in the central sector and 23 in the southern sector (Das, 2008). The state's Chilika Lake is known for its Irrawaddy dolphins, drawing in a large number of tourists every year. Officials said they counted 188 dolphins, including 162 Irrawaddy dolphins and 26 bottlenose dolphins, in Chilika Lake in 2021. They sighted 163 dolphins — 146 Irrawaddy and 17 bottlenose — in the Lake in 2020.

Tourism

Chilika Lake is a popular destination for ecotourism. Nalabana Island is the popular bird sanctuary, known as the Chilika Wildlife Sanctuary. Due to a wide range of species of birds, Chilika Lake acts as a popular birding site. It is also quite popular for fishing and angling, and visitors have the opportunity to take the boat cruise around the Lake. Visiting the sightseeing destinations around the Lake can be an enchanting experience. Therefore, the tourism industry rapidly grows day by day and it also influences the economic status of this area. Most of the people involved in this activity work for earning.

Problems

Chilika is facing the biggest threat mainly because of anthropogenic activities including creating big structures, large-Scale deforestation which is supposed to protect it from the high tidal flooding activities; it being an important Ramsar site of India and the largest brackish water lagoon of Asia. Its biodiversity and aquatic resources including fishes, crabs and prawns etc. are continuously losing their counts due to deforestation which resulted in embankment of the coast by sands. The major issues faced by Chilika are due to over-fishing throughout the year and rapid growth of dolphin tourism which leads to an increase in both the number of fishing and tourism boats which disturb the ideal biodiversity in the Lake ecosystem. Ecosystem of the Lake had completely been disturbed when the two natural mouths got silted due to deforestation. Therefore, the major problems are-

- Siltation due to littoral drift and sediments from the inland river systems
- Choking of the inlet channel as well as shifting of the mouth connecting to the sea
- Decrease in salinity and fishery resources
- Proliferation of freshwater invasive species
- An overall loss of biodiversity with decline in productivity adversely affecting the livelihood of the community that depended on it(Chilika Framework - An Integrated Management Planning Framework for Conservation and Wise Use) etc.

Though it is our concern to investigate the LULC types and changes in the study and mouth shifting of Chilika Lake, it is mandatory to study the demographic character of our study area. Because by studying demographic characteristics we can understand our study area's socio-economic conditions which help to study the dependence of man on the environment, rate of change in this area and the Scope for sustainable management of environmental resources.

Demographic Characteristics of the Study Area

Our present study area Chilika Lagoon and its surrounding area is situated on the east coast of India and is the largest brackish water wetland of Asia and also a Ramsar site. The lagoon is oriented parallel to the coast between the Eastern Ghats and the Bay of Bengal and is connected to the Bay of Bengal through a 25km long narrow outer channel separated from the sea by a narrow spit (Asthana, 1979).The Chilika lagoon spreads for around 830 Sq. km. along the east coast of India in the Odisha state. Chilika catchment is situated on the east coast of India which covers Puri and Khurda districts adjoining Ganjam district of Odisha state. Its catchment also covers 18 blocks of Puri, Khurda, Nayagarh and Ganjam with an area of 3987 sq. km. (Chilika Atlas, 2007). This area's demographic structure is very important for our study. It directly or indirectly influenced the Chilika Lake and the surrounding area's land cover change.

Population

Demography is the Science of populations. Demographers seek to understand population dynamics by investigating three main demographic processes: birth, migration, and aging (including death). Population refers to a collection of humans. Demography is a social Science which entails the statistical study of populations. Population, in simpler terms, is the number of people in a city or town, region, country or world; population is usually determined by a process called census (a process of collecting, analyzing, compiling and publishing data).

Population density is a measurement of population per unit area. Population density calculated by total population of blocks divided by total area. Our present study area means Chilika Lake and the surrounding area which includes a small part of Puri, Gunjam, Khordha and nayagram districts. This area has a moderate to dense population which directly or indirectly influenced the Chilika Lake environment. In the Chilika block

most of this population's economy depends on Chilika Lake and forest resources. Because it is a Ramsar site and also a biodiversity hotspot it attracts tourists. So based on this, the tourism population of this area is growing rapidly. Here, the 2011 census data table of population given below-

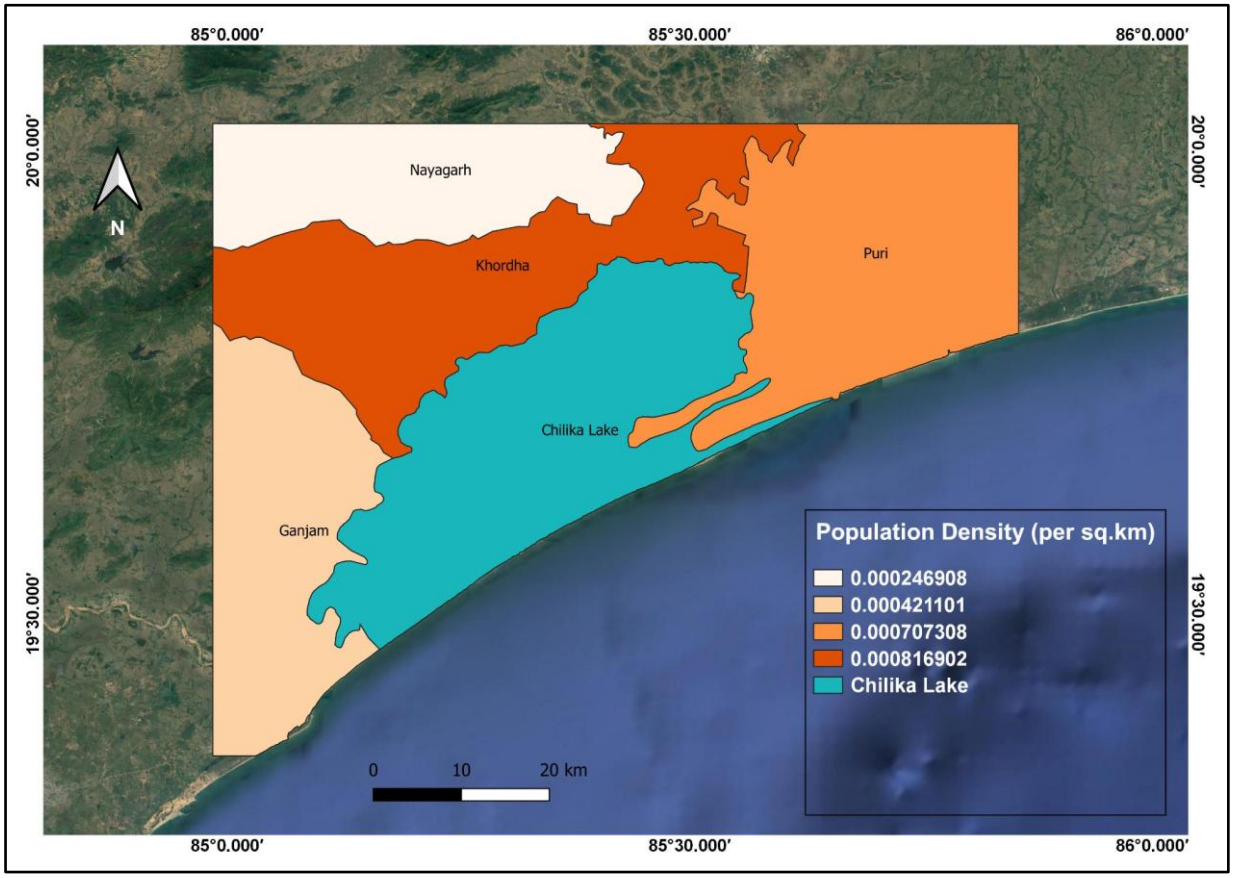

Fig:7 Population Density Map In The Study Region

The above map (fig. 7) is a population density map which was generated as per 2011 census data. By interpreting the map we see that the chilika block population density is very high and Nayagarh population density is very low. Mainly for occupational reasons this block population density is high. Approximately 70% of total population here depends on tourism, fishery and natural resource based works. The increasing population has an adverse effect on the environment of Chilika Lake and its biodiversity.

Sex Ratio

Sex ratio is used to describe the number of females per 1000 of males. Sex ratio is a valuable source for finding the population of women in India and what is the ratio of women to that of men in India. In the Population Census of 2011 it was revealed that the population ratio in India 2011 is 940 females per 1000 of males. The human sex ratio is the number of females per 1000 males. Sex ratio formula is-

((Number of Females) / (Number of males)) * 1000

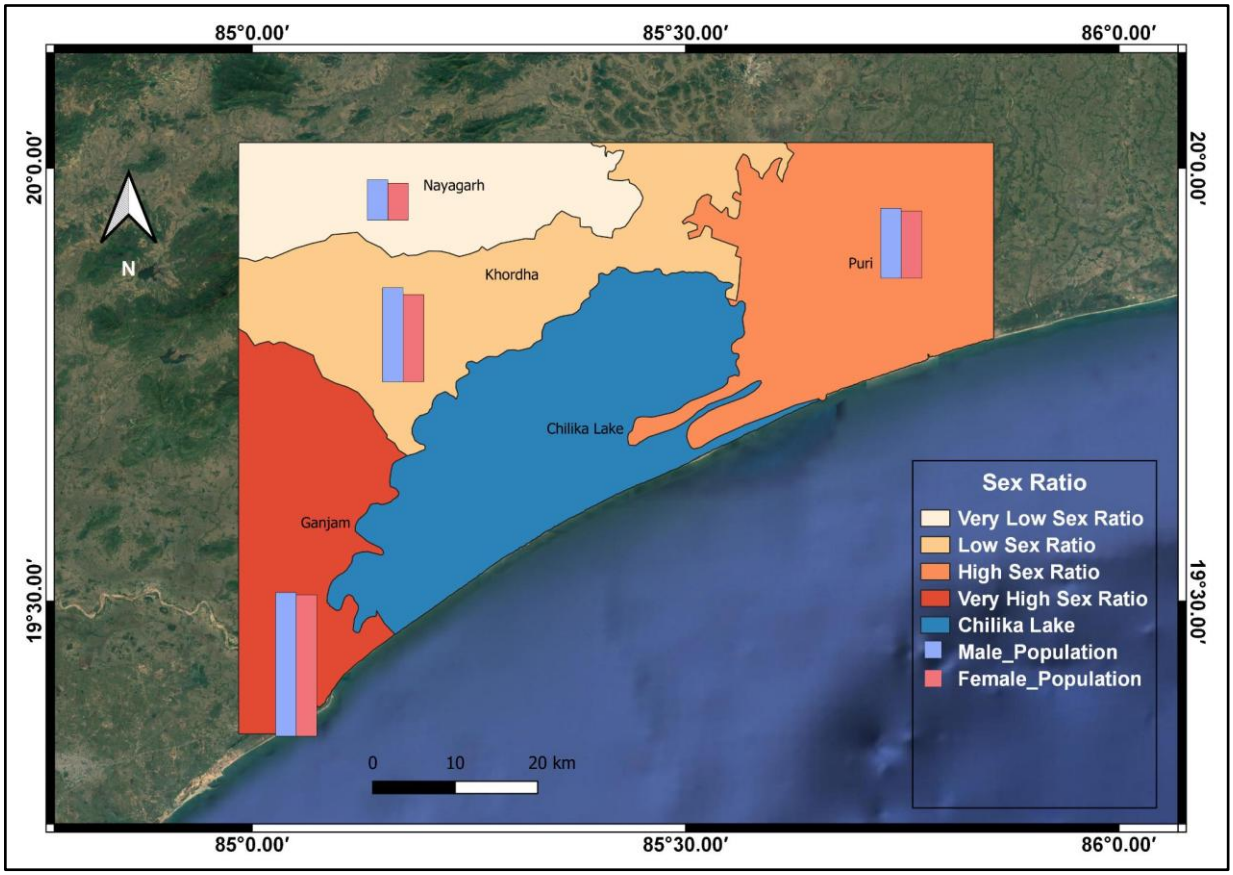

Fig:8 Sex Ratio Map showing Male and Female Population In The Study Region

From the above map (fig. 8) we also see that male and female population are more than the same. Sex ratio is slightly high from normal value. It means here male population is slightly higher than 1000 of the female population. The Ganjam is higher sex ratio among the five district of our study area. Then Puri, Khordha and sex ratio is low in Nayagarh district. But the difference between male and female population is in very negligible amount or we can say that sex ratio in those five districts are approximately normal.

Caste

Caste is a form of social stratification characterized by endogamy, hereditary transmission of a style of life which often includes an occupation, ritual status in a hierarchy, and customary social interaction and exclusion based on cultural notions of purity and pollution. Scheduled Castes (SCs) and Scheduled Tribes (STs) are among the most disadvantaged socio-economic groups in India.

Caste is a prime component to understand a demographic and socio-economic structure of an area. In the 1961 and 1971 Censuses the information was collected only for each Scheduled Caste and Scheduled Tribe. Here 2011 census data wise caste population table of our study area districts are present below-

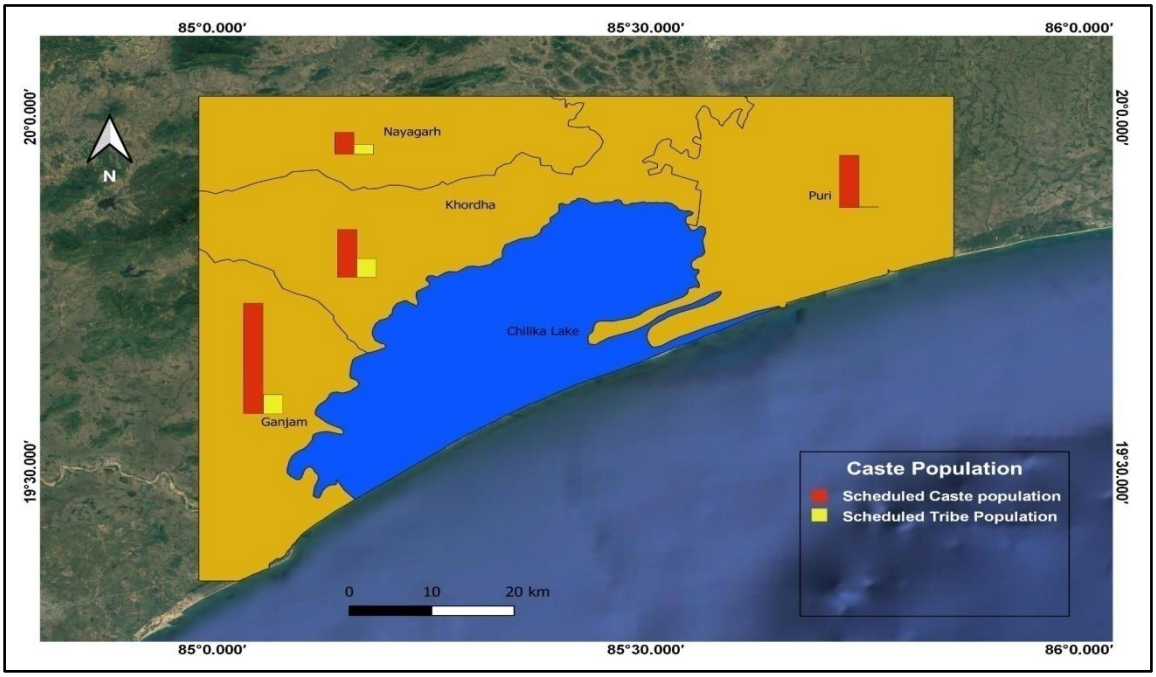

Fig:9 Histogram Showing Caste Population In The Study Region

In this above map (fig. 9) caste population is shown by histogram. Here, red colour bars are Schedule caste population (SC) and yellow colour bars are Scheduled tribe population (St). By this map and the above present statistical table we can clearly see that the Scheduled caste population is more than Scheduled tribe population in every district. Scheduled tribe population is very low in these districts and mainly in Puri ST Populationn is very low as per 2011 census data. It means here SC population character is dominated. And caste discrimination present in this area.

The term 'Scheduled Tribes' first appeared in the Constitution of India. Article 366 (25) defined Scheduled tribes as "such tribes or tribal communities or parts of or groups within such tribes or tribal communities as are deemed under Article 342 to be Scheduled Tribes for the purposes of this constitution". Article 342, which is reproduced below, prescribes procedure to be followed in the matter of specification of Scheduled tribes.

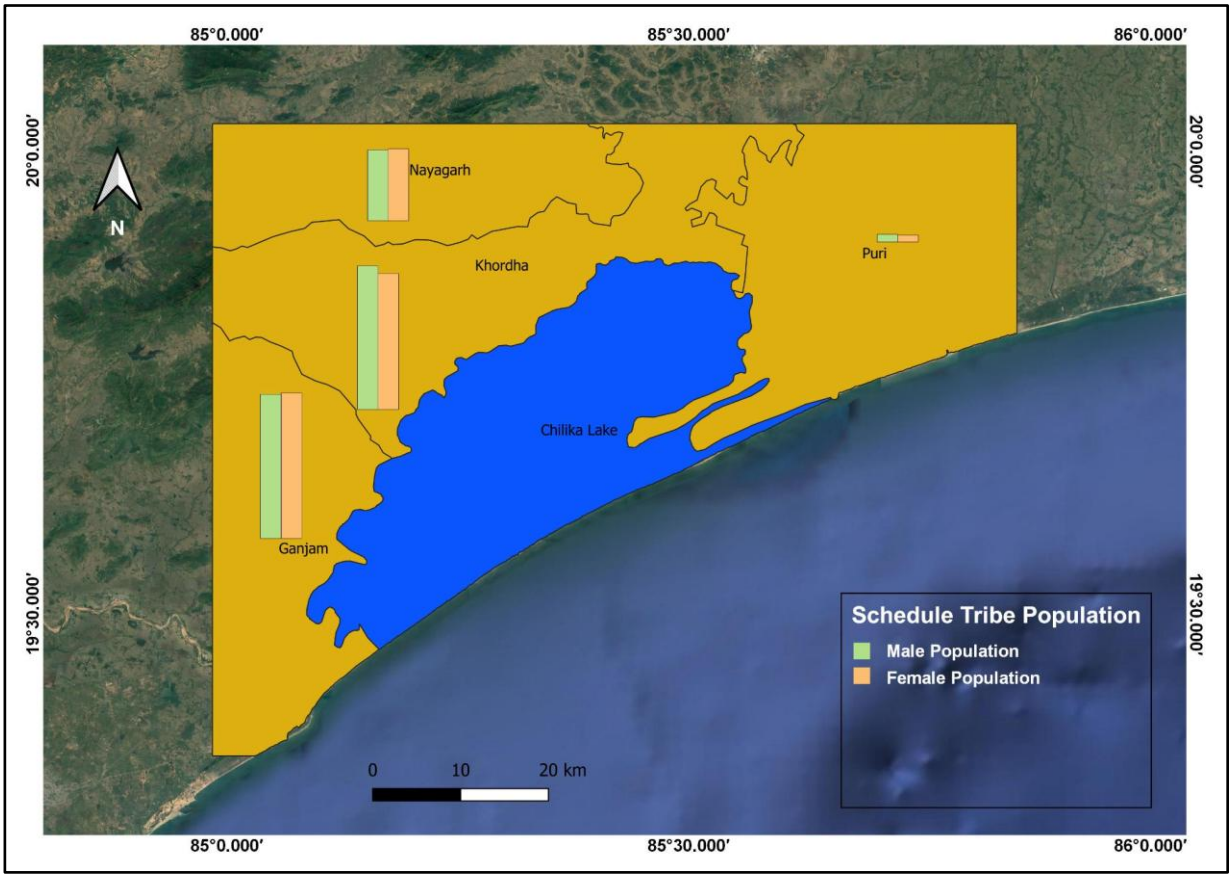

Fig:10 Histogram Showing Male and Female Schedule Tribe Population Map

In the above map (fig.10) the Schedule Tribe population is shown. Here green bars are male ST Population and pink bars are the female ST Population. In Ganjam and Nayagarh districts the female ST Population is slightly higher than the male ST Population. But in Puri, both the male and female ST Population are very low compared to the other districts. In Khordha and puri male ST Population is higher compared to the female ST Population. Thus, we can say that in the Scheduled tribe population is negligible and under this community male and female population is almost the same.

Scheduled castes are sub-communities within the framework of the Hindu caste system who have historically faced deprivation, oppression, and extreme social isolation in India on account of their perceived 'low statuses. Only marginalized Hindu communities can be deemed Scheduled Castes in India, according to The Constitution (Scheduled Castes) Order, 1950.

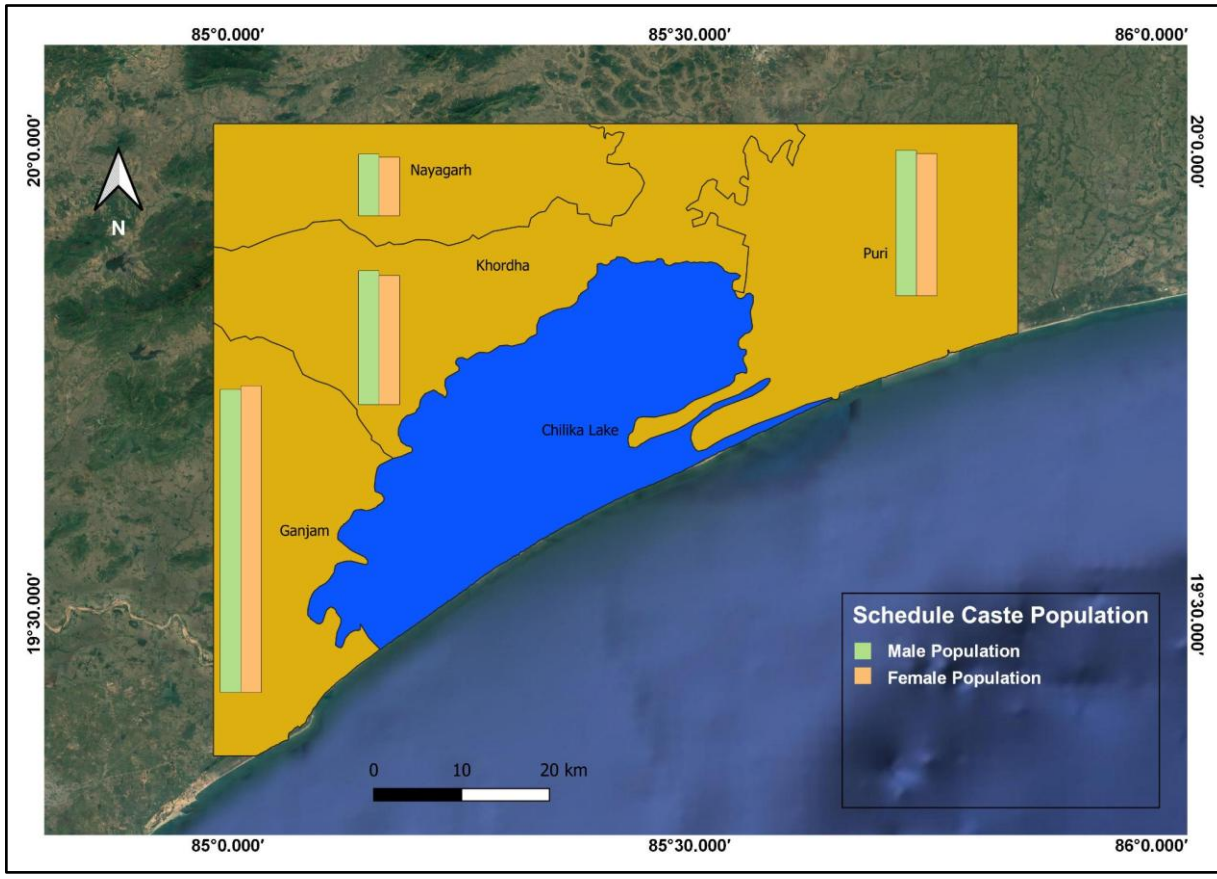

Fig:11 Histogram Showing Male and Female Schedule Caste Population Map

In the above map (fig.11) the Schedule Caste population is shown. Here green bars are male SC population and pink bars are the female SC population. In Ganjam district female SC population is slightly higher than the male SC population. But in Puri, Nayagarh and Khordha district male SC population is higher compared to the female SC population. Scheduled caste population is high in all districts. It means this is a dominant population in this area. Under this caste male and female population are more than the same means they are educated and modernized.

Literacy

Literacy is a prime factor for change in the socio-economic condition of an area. The growth rate of an area or the urbanization rate of an area depends on the literacy rate. Literacy refers to the ability to read and write at a level whereby individuals can effectively understand and use written communication in all media (print or electronic), including digital literacy (European Literacy Policy Network: European Declaration of the Right to Literacy). Improved literacy can contribute to economic growth, reduce poverty, reduce crime, promote democracy, increase civic engagement, prevent diseases through information provision, enhance cultural diversity through literacy programmes in minority languages, lead to lower birth rates as a result of increased education; and confer personal benefits such as increased self-esteem, confidence and empowerment. Here, in below Literate population data is present as per 2011 census handbook-

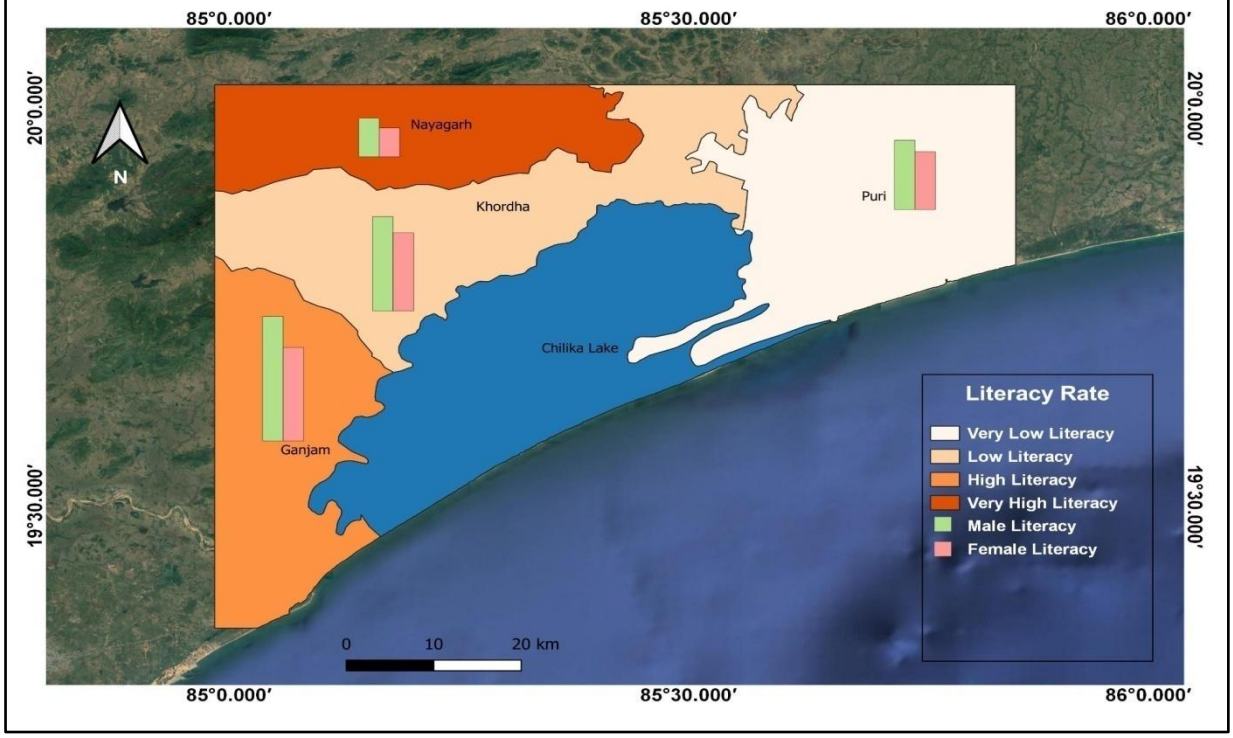

Fig:12 Literacy Map With Male and Female Literacy Population

Above map (fig. 12) is a literacy map where the total literacy rate of these four districts and the male and female literacy rate are shown in the map. As per 2011 census data, in our study area Nayagarh has a very high literacy rate and then Gunjam, Khordha and Puri accordingly. We also see male literacy rate is much higher than the female literacy rate which means male female discrepancy is present here. Females are backwarded and social, cultural diversity is present here.

Working Status

Workers means the working class population. An area's working status can influence their socio-economic condition. By working, workers generate money and resources which boost countries' economic growth and prosperity. As per census handbook workers are two types: main workers and marginal workers. Others are cultivators, agricultural labourers and other workers. And there is another class which is called Non-workers. This non-working population also influences the economic growth of a region.

Main workers were those who had worked for the major part of the year preceding the date of enumeration i.e., those who were engaged in any economically productive activity for 183 days (or six months) or more during the year. A marginal worker is one who engages in only economically productive work for less than 183 days in a year. Non-workers as defined in the Census of India are persons who did not work at all during the reference period. Here, the working population of our study area is present as per 2011 census handbook data-

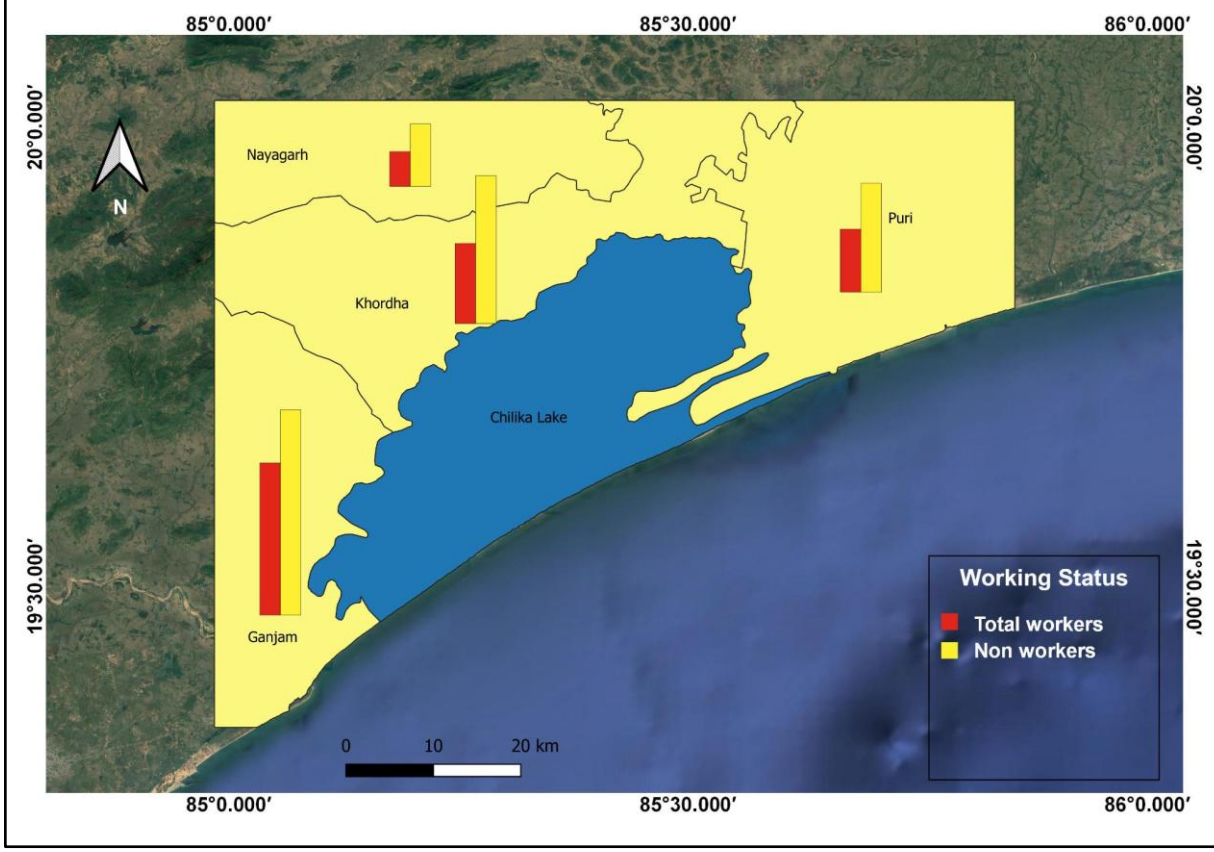

Fig:13 Histogram Showing Working Population Status

Here, we present the total working population and non-working population histogram map (fig. 13). Red colour bars are total working population bars and yellow colour bars are total non-working population bars. By this map we clearly see that in every district the non-working population is higher compared to the working population. It means the economical status of this area is not so good. Mainly in Gunjam and Khordha district, the non-working population is very high. It occurred because of the cultural backwardness and literacy crisis. In this district the literacy rate is also low therefore non-working people count is high. From the above statistical table we also see that the total working population is divided into four classes. They are- main workers, cultivators, marginal workers and agricultural labourers. To clearly understand the workers population we create the different working class population map in below-

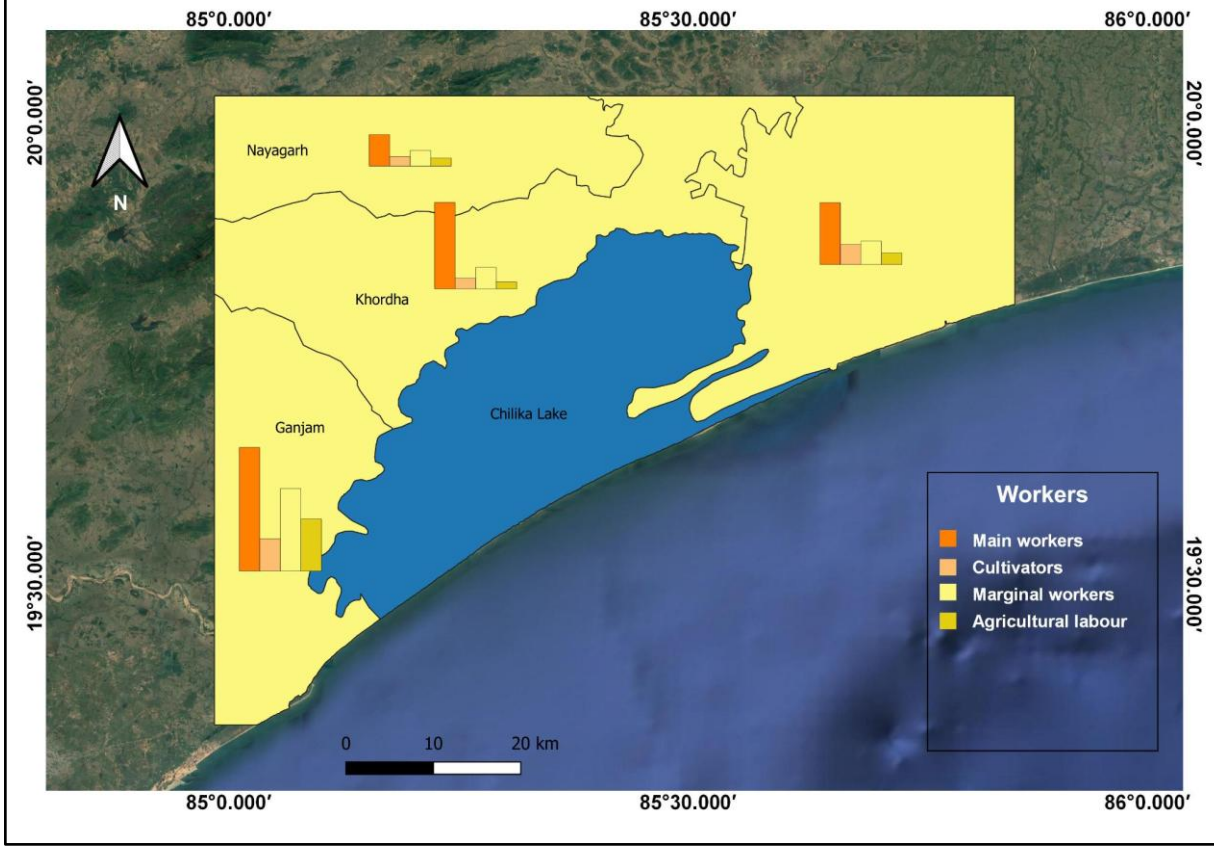

Fig:14 Histogram Showing Working Class Population

In this map (fig. 14) we create four different colour bars to show the different working class populations in these districts. The orange colour bars are the main workers whose population is high in all districts. It means this category of working class people influenced this area's economic status most. The pink bars for cultivators, whose population is low in all districts, means here the number of agricultural activities is very low. We also see that the marginal workers population is higher than the cultivators and agricultural labourers which means this is the second main working class in this area which has influenced the economy of this area. In Ganjam district, the marginal workers' population is higher compared to the other districts. And the last is agricultural labourers whose population is very low in every district. It occurs because it is mainly a tourism-based area and a biosphere hotspot area. Here most of the people depend on forest and environment resource based activities.

In our present study area, khallikote forest and Tangi forest hill are situated in the districts of Nayagarh and Khorda. In this area 52 river channels are present. River channels are present which are connected with Chilika Lake. The river carries sediments from the forest areas and deposits in the Lake. Over the past decades in this area the population has increased rapidly. And for the search of fuel requirements and forest resource based products they depend on the forest to generate money. Mainly the tribals and the local communities entirely depend upon the forest to meet their own fuel requirements and they also cut and sell it in the local market. Also, the tribals supply bamboo to the fishermen to make fishing tools and leaves to make leaf-plates. It was stated by the people that they have to go deeper and deeper into the forest as forests are getting cleared and denuded. It contributes to floods and sedimentation in the Chilika Lake. And for this Chilika Lake depth is reduced day by day and the natural mouth of the Lake was silted. It influences the land use and landcover of this area. There is a large forest area both on the coastal side and around the Lake which is being covered by casuarina (near the sea shore), eucalyptus and cashew under both a SIDA-supported and the government's own social forestry programme. Though to maintain and save the forest and environmental resources it is mandatory to study the demographic characteristics of this area. Because from this we can understand what percentage of the population depends on the forest and natural resources. In our study area mainly the ST Population is involved with this type of work. Here agricultural works options are less so mostly SC and ST Populations

involved in these works and also it is a Ramsar site and biological hotspot so a large number of people are also involved in tourism related activities. For this reason the literacy rate is not so good in these districts.

II. Conclusions

In recent day, due to technological advancement and other facilities provided by Odisha government , several developmental planning has been taken. But the planning should be precise and scientific which can able to offer some good changes. In this study, it is shown that, there is an urgent necessity to stop environmental deterioration and degradation of Chilika by different applied measures and to check the depleting stock of fish, shrimp and crab in it in order to improve and develop the socio-economic conditions of fishermen and local people in and around the lake.

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