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LAND USE PATTERN IN BHITARKANIKA WILDLIFE SACTUARY, Odisha, Eastern India

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Abstract—*Ecology and human being are closely related to each other. It is the nature of human to adapt itself to the present environmental conditions and also depend on the nature for livelihoods. In the same context, coastal zone is one of the most protective zones in the world. Coastal zones are rich in resources and fulfil human's both economic as well as nutritional need. Since ages people living around coastal zone have extracted its product and sustain their livelihoods. But, presently in most part of the world, the over exploitation of coastal resources have been a cause of concern for many scientist, researches and policy maker. One of the most valuable coastal resources is mangrove. Mangrove is a type of plant that grows along the margin of sea and land. They survive on salt water and have strong roots that penetrate deep within the soil. The community that has been living around the mangrove forest depends on it in various ways. Mangrove not only protects the community from the cyclones, storms, erosion control and prevention of salt water intrusion but also provide them with all the products that are used by the community for the livelihoods. In this context the spatial extension of mangrove forest in the study area is essential to examine and put to analysis.*

INTRODUCTION

Coastal ecosystem has been the most productive and dynamic one. Mangrove is the most dominating vegetation in the tropical coastal area. At present the mangrove forest is declining faster. The assumed rate of declining the mangrove forest is 2–8 per cent per year, or 0.6 per cent of all inland forest in the world (Spalding, 1997). This degradation is both natural as well as anthropogenic. Around 4461 sq. km area under mangroves is in India, which is 0.14 per cent of the country's total geographical area. About 57 per cent of the mangroves in India is found along the eastern coast. There is a report by NRSA a decline of 59.18 sq. km of mangrove between 1972–75 and 1980–82. According to Government of India report (1987), India lost 40 per cent of its mangrove area during the last century *(*Reddy, et al., 2007*).* In this context it becomes important to see the changes that have taken place in the study area over the past 25 years. Bhitarkanika is the second largest mangrove forest cover in India after Sunderbans in West Bengal. Bhitarkanika mangroves have been a major source of livelihood for the local people who depend on it for subsistence as well as commercial use. Therefore, the land use land cover mapping of remote sensing data will actually give us the idea about the people's dependence.

DATA SOURCE

The satellite imageries are intended to use for land use changes and identification of critical areas. For this paper satellite image is used to show the Land cover change. Landsat 5 TM 1992, Landsat 7 ETM 2002 and Landsat 8 ETM 2017 are used for classification. All three satellite image is of the month of February and March.

METHODS AND TECHNIQUES

The satellite data has been used since long for mapping and generating coastal maps. The maps generated, using satellite data, were mainly coastal wetland maps at 1:250,000, 1:50,000 and 1:25,000 scales. On the basis of remote sensing data, mangroves of Indian coast has been studies extensively on the basis of, (i) extent (areal extend), (ii) density of the community, (iii) condition, and (iv) diversity. The requirement of the study defines the scale at which the mapping is to be done so that details can be extracted from the remote sensing data (Nayak and Bahuguna, 2001). Since the current study is mainly focused on the presence or absence of mangroves and its areal extent, a course resolution satellite data of 1:250,000 scales is enough for mapping. For the current study, Landsat data of 30 mts. resolution has been taken of three time periods. Landsat Thematic Mapper 1992 has been used as the base map for the classification. All the satellite images were taken in the month of March to get the same landscape of the study area throughout the time period. Also getting satellite images of same seasons is considered to be ideal to avoid confusion while mapping. It is well known that season wise the satellite images changes and the landscape also gives different colour, tone, texture of the same feature. The data set obtained (three time period) is first geometrically corrected. Then the images are georeferenced to SOI topographic map at 1:50, 000 scales using ground control points and then brought into WGS 84 datum and UTM projection. All the data sets then put into

ERDAS IMAGINE 10.1 to do layer stacking after which the FCC (False Colour Composite) of each images are generated. After this each images are put in ARC GIS 10.9 to extract the boundary of the study area from the Landsat data through *Extraction by Mask* process. The satellite images of all the time period are classified by using the software ARC GIS 10.9, where each class for the classifications are digitized into polygons, lines, points, wherever necessary. Field verification is first carried out in order to know the ground truth. The visual interpretation of the satellite data is difficult without the field verification and training data sets which is latter matched with the remote sensing image to do the final classified maps. The images were carefully classified and interpreted on the basis of tone, texture, colour, pattern, etc. The current classification is done by digitizing each polygon on the satellite imagery for each class. The references for verification were SOI topomap, goggle image and field survey. After accurate verifications the land use/land cover boundaries were vectorised. The dangle arcs, dangle nodes, pseudo node, overshooting, etc. were edited and the land use land cover layers were cleaned to create topology of the study area. The layers were transformed to geographical coordinate system. The attributes for each polygon were entered. The layer of three years were analysed using the overlay technique to detect the changes over the time span. Then the statistical analysis was performed to derive the area statistics over these referenced years.

LAND USE LAND COVER CHANGE ANALYSIS

Land cover and land use classification of the study area over the past 25 years has been analysed and its detail is presented in table no. 3.3. The statistical calculation of each polygon in the study area revels that agricultural land is the most dominant land use practice in the study area and the most dominant land cover in the study area is mangroves. The change matrix in detail can be clearly seen in the table no. 3.3 and table no. 3.4.

Table No. 2: Land Use Land Cover Pattern in the Study Area, 1992 and 2002

Classes	Area in Sq Km. (1992)	Area (in %)	Area in Sq km. (2002)	Area (in %)	Change in Area 1992-2002 (Sq km.)
Cropland	236.49	47.09	229.75	45.75	-6.74
Salt Plain/Water logged Area	5.12	1.02	12.22	2.43	7.1
Water Body	67.18	13.38	67.18	13.38	0
Rural Settlement	2.81	0.56	7.23	1.44	4.42
Agricultural Land through Forest Clear	2.42	0.48	6.12	1.22	3.7
Mangrove Forest	172.54	34.36	165.97	33.05	-6.57
Open Forest	1.5	0.30	1.50	0.30	0
Degraded Mangrove	14.12	2.81	6.10	1.21	-8.02
Total	502.18	100	502.18	100	-6.11

Source: Landsat 5 TM 1992, Landsat 7 ETM 2002

Table No. 3

Land Use Land Cover Pattern in the Study Area, 2002 and 2017

Classes	Area in Sq Km. (2002)	Area (in %)	Area in Sq km. (2017)	Area (in %)	Change in Area 2002-2017 (Sq km.)
Agricultural land	229.75	45.75	204.11	40.64	-25.64
Salt Plain/Water logged Area	12.22	2.43	28.34	5.64	16.12
Water Body	67.18	13.38	67.18	13.38	0
Rural Settlement	7.23	1.44	15.52	3.09	8.29
Agricultural Land through Forest Clear	6.12	1.22	10.12	2.02	4
Mangrove Forest	165.97	33.05	147.43	29.36	-18.54
Aquaculture	4.60	0.92	12.33	2.46	7.73
Open Forest	1.50	0.30	1.5	0.30	0
Degraded Mangrove	6.10	1.21	13.13	2.61	7.03
Casuarinas Plantation	1.51	0.30	2.51	0.50	1
Total	502.18	100	502.18	100	-0.01

Source: Landsat 7 ETM 2002, Landsat 8 ETM 2017

Cropland which is the most dominant land use in the study area has shown a declining trend from the year 1992 to 2017. The agricultural land decreased by (-25.64 Sq km.). The change analysis map shows that major changes have taken place along the boundary of mangrove forest also along the river creek because of anthropogenic factors. This change in the study area is the one of the factors for mangrove forest decrease in the study area. As for the change analysis map the area under the mangrove forest, which is the most dominant land cover in the study area has decreased to (-18.54 Sq km.) in the past 15 years. The mangrove forest is typical evergreen forest which is partially submerged in salt water. A major part of Bhitarkanika National Park is covered with the mangrove forest. In spite of increase protection and consequent regeneration there has been decrease in the area of mangrove forest. Also, two new land cover features have been noticed in satellite image for 2002. The casuarinas plantation and shrimp farms patches have been immerged clearly in 2002 satellite image. The area of the following land cover has shown a rapid increase in the final image classification, that is in 2017 Landsat 8 ETM.

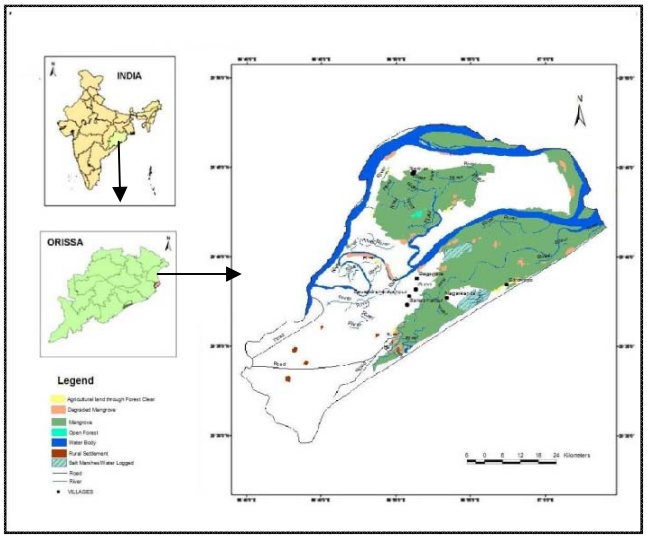
Patches of degraded mangrove forest area has shown increasing trends. This degradation patches are more

prominent in the Sunirupi Reserve Forest. This particular reserve forest lies along the coast of Bay of Bengal and out of all reserve forest found inside the Bhitarkanika Wildlife Sanctuary, this part is the most degraded one both by naturally and human interference. Based on the fig no. 3.2, area under salt plain and water logged has shown a maximum increase in area which is of 16.12 Sq km. in the past 15 years (2002-2017). The patches of both salt plain and water logged area are once again predominantly found in the Sunirupi Reserve Forest. The salt patches are mainly because of the Bay of Bengal Sea, which deposit the salt with the evaporation of sea water. An increase in the agricultural land through forest clear is a matter of concern. This particular land use class has increased from only 6.12 Sq km in 2002 to 10.12 Sq km in 2017. This shows the pressure of population in the study area. Over the period of time the population has also increased and with it increased the pressure on land. Therefore, the agricultural land through forest clear is mostly found along the periphery of the forest boundary that is the buffer zone of the study area. Also this particular class is predominant along the Bhitarkanika Reserve Forest area. Rural settlements have shown a wide scale increase in the study area. The population have increased both in buffer and outer buffer zone in the study area. Increase in population led to increase in rural settlements to many folds over the years. In the satellite image new land use class called aquaculture land is also visible. Aquaculture has been growing at a faster rate in the study area. The aquaculture or shrimp farming have caused the following changes in the study area:

- It illegally deprives the local people of their land. The land is actually bought from the local people at a very low price and thus the local people are not part of the income profit. Mainly the outsider is the owner of the shrimp farming land.
- The process of constructing a shrimp farm, leads to large scale destruction of mangroves.
- The land which is used for shrimp farming is productive for the same till 5 – 6 years, after which the productivity of the land for shrimp cultivation decreases and eventually the land is left as such. This particular piece of land becomes completely useless either for agriculture or for mangrove regeneration. Therefore rampant cutting of forest and eventually conversion of forest land into shrimp farming is a major concern.
- Shrimp farming also causes decline in the catch of fishes and other marine products.

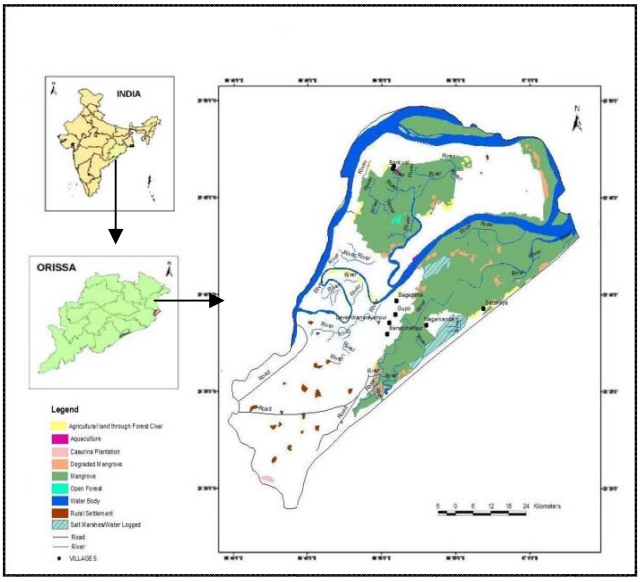
The mangrove forest provides the local people energy in the form of fuel woods, also provide them with fodder, house construction materials, etc. Not only this mangrove forest is a source of livelihood for the local people as it provide them with fishes, crabs, honey, etc. which they sell in the local market and earn money. The over exploitation and over commercialization of mangrove forest has damaged the area and thus need urgent attention by the policy and law maker.

Map No. 1: Land Use and Land Cover Map of the Study Area, 1992



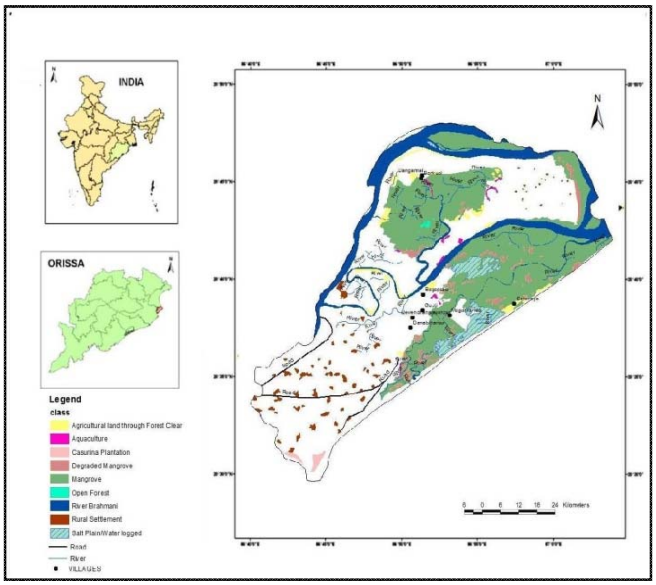
Source: Landsat 5 TM 1992

Map No. 2: Land Use and Land Cover Map of the Study Area, 2002



Source: Landsat 7 ETM 2002

Map No. 3: Land Use and Land Cover Map of the Study Area, 2017

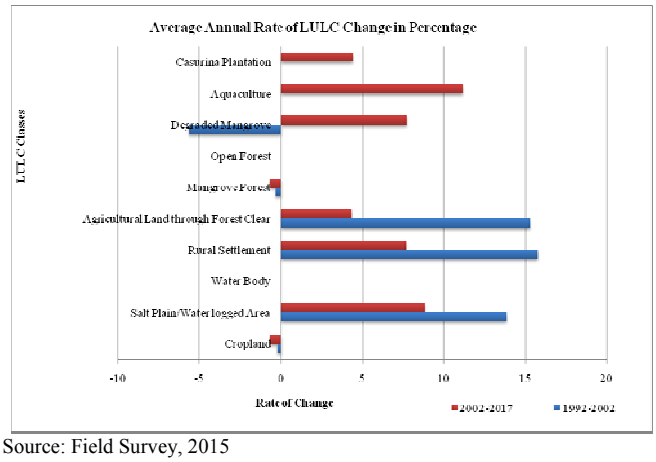


Source: Landsat 8 ETM 2017

CAUSES FOR NATURAL RESOURCE DEGRADATION IN STUDY AREA

The land use land cover map analysis gives the idea of changes that has taken place in the study area over the period of time. The analysis of satellite images, Landsat 7 ETM, 2002 and Landsat 8 ETM, 2017, shows that the natural resource base of the study area has been affected because of several reasons. Therefore it becomes necessary to point out the main reason behind the changes.

Fig No.5



Source: Field Survey, 2015

The analysis in fig no. 3.7 have shown that there has been changes in the land use and land cover in the study area and still the change is taking place which will be reflected better in the near future. Fig no. 3.7 shows the average annual rate of change in per cent that is taking place in the study area. This change is both positive as well as negative. The positive and negative changes of land use land cover have been discussed in details earlier in this chapter. The average annual rate of LULC change is calculated by using the following formula:

$$\left(\frac{A2 - A1}{A1} * 100\right) \Big/ \left(T2 - T1\right)$$

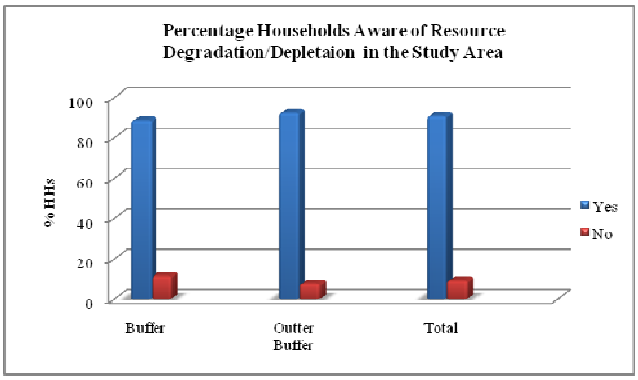
Where: A1 is amount of land cover type in time 1 (T1)

A2 is amount of land cover type in time 2 (T2)

Land use like, aquaculture and casuarinas plantation have shown an annual rate of change of 11.2 per cent and 4.41 per cent respectively for the year 2002 to 2017. The land use land cover classification for rural settlements shows that the annual rate of change has decreased by 8.08 per cent for the year 2002 to 2017. Mangrove forest patch is showing an increase rate of annual change from 1992 to 2002 and from 2002 to 2017.

The degradation and depletion of natural resource throughout the world has become a burning topic. And the main reason for this is population pressure on natural resource and unsustainable use of it. This over human interference with the nature has led to the loss of species in general and biodiversity in particular (Enrlich, 1988). Similar fate is now showing in the Bhitarkanika Wild life Sanctuary. Before analysing the factors responsible for degradation of natural resource in the study area, a simple question was put to the respondent of the households, that weather they think there has been degradation and depletion of natural resource in the study area. Fig no. 3.8 shows the awareness of the people of the study area regarding natural resource depletion.

Fig No. 6



Source: Field Survey, 2015

More than 90 per cent of households in study area said that they were aware of the fact that there has been resource degradation and depletion in the study area. Even though

Bhitarkanika was declared a wildlife sanctuary in 1975, there was no restriction on use of forest products on local people. The locals in the study area were free to use the mangrove forest products for their subsistence as well as commercial needs. But this actually did not check the degradation of mangrove forest. During the early times, the use of mangrove forest was less and the locals very much interested in protecting the forest where they were living since ages. But with the growth of population and more commercialization of mangrove forest products the pressure was quickly felt by the Government of India. Therefore in order to protect the rich resource, the 165 Sq km. of forest area inside the Bhitarkanika Wildlife Sanctuary was declared as National Park in 1998. This declaration put restriction on local people and thus the dependence on mangrove forest decreases a lot. Also the declaration of National Park has also cause many livelihood shifts among the local people and forced many to migrate to other place for better earning.

Even though a National Park is a protected area, the local people dependence on it cannot be ignored. The people who were living along the periphery of the forest boundary still extract forest products for both subsistence as well as commercial use. In the next chapter the dependence of local people on mangrove forest has been discussed in details. In this chapter we will try to focus on why this degradation is taking place in the study area.

The use of mangrove forest for fuel and fodder has been widely discussed in the next chapter. The buffer zone villages have shown heavy dependence on mangrove forest for the same than the outer buffer one. All the buffer sample villages for the study are those which lie along the forest boundary. Low income group people dependency is quite high on the mangrove forest for fuel and fodder than the middle and high income group. 98 per cent of the fuel need of the households among the lower income group in buffer zone is extracted from the mangrove forest. Thus, the heavy dependence on mangrove for fuel and fodder and unscientific, unsustainable cutting of mangroves has led to depletion of forest woods.

From the land use land cover change analysis of satellite images 2002 and 2017 it has been noticed that the patches of shrimp farming/aquaculture has increased from 4.60 Sq km. in 2002 to 12.33 Sq km. in 2017. In the study area shrimp farming is an age old practice. This method of farming is mainly found near the mangrove forest belts as it depends on tide. Location close to the seacoast and mouth of the river bank provide ideal conditions for shrimp farming. The average size of a shrimp pond is usually more than 5 hectares. Usually before constructing a shrimp pond a large of mangrove forest is cleared. There is no official data available regarding the mangrove forest area lost to shrimp farming. However, the satellite image classifications and field survey in the study area, give ample evidence that majority of the shrimp farms located close to the National Park, and these has been constructed by clearing the mangrove forest. Also in the satellite images the patches of shrimp ponds are very prominent and are all surrounded the National Park.

Shrimp farming is a very profitable business as the local price of shrimps per kg is quite high in comparison to other fishery items. The rapid commercialisation of this business has added to the existing precarious situation of mangroves in the study area. The shrimp farming adversely affects the survival and growth of the mangrove forest because the farmers of shrimps block and redirect the brackish water of the rivers and creeks to the ponds of the shrimps. This brackish water of the tidal rivers is very essential for the shrimps to survive in the pond and get the exact nourishment for the growth. During the field survey, it was observed that everywhere where there is shrimp ponds, a narrow channel have been dug to bring the brackish water to the shrimp ponds. This actually blocks the natural flow of the river and thus starves the mangrove plants whose survival solely depends on availability of tidal water. And thus leads to degradation and eventually destruction of mangroves. The patches of degraded mangrove have also increased to many fold in the past decades. The patches of degraded mangrove are also quite prominent in the satellite images mainly at the tail of the Sunirupi Reserve Forest of the Bhitarkanika Wildlife Sanctuary. Although the shrimp ponds are also seen in numbers at Bhitarkanika Reserve Forest, but the degradation process is slow in comparison to former one because of the dense mangrove cover in the Bhitarkanika Reserve Forest.

The shrimp farming generates huge amount of solid waste after each cycle. These wastes are deposited at the bottom of the shrimp ponds and these are to be removed before the next cycle. Generally these wastes are deposited to the nearby fields or mangrove forest. This eventually leads to the degradation of mangrove land. Therefore in the satellite images we can clear see the patches of shrimp farming and degraded mangrove existing at a close proximity.

CONCLUSION

The Remote Sensing data has proved to be the most important source of secondary data to observe the changes temporal change over the space. These large data base has been extensively used by many researchers for mapping vital mangrove areas and also mangrove species of stress. A routine monitoring of mangrove resource gives the idea not only the spatial distribution but also the health and status of these natural resources.

It has been noticed that land cover and land use pattern have undergone significant changes in the study area with the change in socio –economic condition of local people. A net change of 4 Sq km have taken place in the study area was observed because of conversion of forest land into agricultural land by the local people. The present study also shows a negative change in mangrove areal extension in the study area. The mangrove forest has shown a decline over the past 25

years. The net areal change is (-18.54) Sq km for mangrove forest.

Remote sensing and GIS techniques play an important role in getting a synoptic view of the status of the present vegetation cover of any area (Reddy, et al., 2007). A satellite image of different time period helps in the comparative study of the present and the past situation. Thus this is of great importance not only for the researchers, but also for planners, policy makers and for the Government to implement policies and laws to save the degradation of natural resources.

The study area is going through the land use land cover changes. Both the buffer and outer buffer zones are showing major changes since 1992. While in case of buffer zone (area of relative resource availability) the changes in land use land cover that have been observed through satellite images are, negative changes in the areal extension of mangrove forest while positive changes have been seen in forest clear patches, degraded mangroves, salt plains and water logged areas. At the same time in the outer buffer zone (relative resource scarcity) rural settlements have increased at a faster rate and also with it increases shrimp farms. Therefore we can conclude that both the zones in the study area are showing major changes in terms of both land use and land cover.

In the current chapter, it has been discussed at length about the change in land use land cover in the study area. Population pressure on land has caused serious changes over the space. The satellite images of different time periods have shown a negative changes in the mangrove forest while there has been positive changes in the land use patches of shrimp farming, agricultural land through forest clear, degraded mangrove and salt plain/ mud flats in the study area. All this seriously need to be introspected by the policy maker and the Government. Even though, there has been some conservation and restoration plans is going on in the study area by the Government of Odisha and Department of Forest, Odisha, the check on mangrove forest depletion has not been successfully implemented.

The dependence of local people on mangrove forest will always be there. Since ages they have been living in the vicinity of mangrove forest and the forest has provided them with both subsistence as well as commercial products. With the commercialization of forest products the people start exploiting the natural resource base of the study area. This unscientific and unsustainable overexploitation of mangrove forest needs to be checked without interfering with the rights of the local people on forest because by the law of the Forest Act, local people cannot be deprived of extracting the resources from the forest. They can use it for both subsistence and commercial purposes for their livelihoods. But the over exploitation of forest is not allowed and the locals need to follow this. But the remote sensing data of different time period has shown some serious changes over the study area and this has to be taken seriously in order to save the mangrove forest as well as the people's livelihood in the Bhitarkanika Wildlife Sanctuary. The current scenario, if remained unchecked, has the potential to destroy the livelihoods and increased livelihood vulnerability of the local people.

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