Use of Remote Sensing and GIS in The Study of Settlement Change: A Case Study of Balasore-Bhadrak Coastal Zone, Odisha

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Abstract:
The study aims to quantify the changes in the distribution of human settlement in a coastal environment with the application of remote sensing and GIS technologies and emphasized on the possible causes for the changing nature of settlement patterns in Balasore-Bhadrak coastal zone of Odisha. Quantification of settlement was done by on screen digitization of Toposheets (1932 and 1976), satellite images of Landsat data (1998 and 2012) in GIS environment. The result shows that about 62 percent settlements are newly grown, 32 percent settlements have no change and 6 percent settlements are erratic in nature. The main driving forces for this change in the settlement distribution are population growth and permanent migration and fishing. On the other hand frequent landfalls of cyclones, devastation of floods are also responsible for changing distribution of settlement in this coastal zone.

Key words: Settlement, factors, Remote sensing, GIS

Introduction:
The physical or the natural landscapes of the study area, along with its resources provide the conditions which control the development of cultural landscapes. Human settlement and distribution, density and growth of population as well as types and patterns of rural and urban settlements are the main components of cultural landscape. In order to study the settlement we need to considered several aspects. These are its distribution pattern, morphology, arrangement system, individual components, structural design, societal aspects, economic settings, physical location etc. most of these aspects are possibly geographical in nature and are related to other branches of social sciences. Now a day geographers used different modern tools to study the spatial pattern and distribution of settlement. Remote sensing and geographical information system are now used for the study of spatial dimensions of settlement successfully. In this study of settlement of Balasore- Bhadrak coastal zone extensive application of remote sensing and GIS shows the spatio-temporal characteristics as well as changing nature of settlement.

Study area:
Balasore-Bhadrak Coastal Zone has a great variety of coastal landscapes that reflects the differences in biophysical condition and cultural heritage. The coastal landscape is located in the north-eastern district of Odisha State which covers the coastal blocks of Balasore and Bhadrak districts. It is bounded by Bay of Bengal in the east, Medinipur district (West Bengal) in the north, Jaleswar, Basta, Nilgiri, Oupada, Soro and Simulia Blocks (Balasore) and Tihidi, Dhamnagar block (Bhadrapurak) and Mayurbhanj district in the west and Dhamra River in the South (fig.1). It comprises of five blocks of Balasore district namely; (i) Bhograi, (ii) Baliapal, (iii) Balasore, (iv) Remuna, (v) Bahanaga and two blocks of Bhadrak district namely; (vi) Basudevpur and (vii) Chandbali (fig.1.1). It is located between 20°45' to 21°47' North latitudes and 86°37’30” to 87°29’ East longitudes. The total geographical area of the coastal landscape is 2347sq.km, which has a massive coastline of 141 kms in length.
The typical characteristics of the Balasore-Bhadak coastal landscapes with its sea beach, sand dunes, mangrove vegetation, mudflats, creeks, aquaculture practices, agriculture, tidal waves, salt marshes etc. signify the importance of the coastal zone. This coastal zone occupies 30% of the total geographical area of both the districts but accommodates about 41% of the total population. It has a total population of 1,495,465 (2011) and the density of population is about 637 persons/sq.km where the state population density is 270 persons/sq.km. Its strategic location and huge pressure of population are responsible for regular occurrences of natural calamities like floods, cyclones, sea water intrusions, coastal erosion and problems like salinization, biodiversity loss, property loss, uncontrolled development of infrastructure and environmental loss. This hampers the stability of its natural resources which in turn affects the coping capacity of the society living in the coastal zone. The transport and communication systems are also poor in the coastal zone which makes less feasibility. Therefore use of remote sensing data and geographical information technologies are very much significant in the study of spatial as well as temporal change in settlement in the coastal region.

**Objectives:**
The primary objective of the study is to explain the settlement landscape pattern of the area and its modifications made by natural and human induced forces. To established the primary objective some related works taken into account on the following heads:

i) To study the distributional pattern of settlements in the coastal area.
ii) To delineate the changes in the settlement distributional pattern.
iii) To identify the inherent responsible factors behind the changing pattern of settlement in the coastal environment.

Review of Literature:
Physiographically and culturally coastal areas are very significant for the geographers. Many research works have been done on the coastal landscape. Balasore-Bhadraj coastal zone is also very significant area for researcher. Geological Survey of India made some physiographical accounts and geological characteristics though they had been worked much on the Quaternary geology of the region and its impact on geomorphology but they did not worked on the settlement landscape of the region. The first physiographical account of this area was done by Niyogi in 1970s which emphasized on the morphology and evolution of the Balasore shoreline, Orissa. D. Niyogi also worked on geological background of beach erosion at Digha. A. Gupta (1970) worked on the nature and evolution of West Bengal Coast. Many works were carried out by GSI during 1975 and 2001, but they mainly emphasized the geological formation. A.K. Dasgupta, Krishna Rao, I.V.R. and Chakladar (1980) worked on the ground water development potential of Balasore district, Orissa. Dr. Ashis Kr. Paul worked on the coastal geomorphology and environment since the year 1996. He emphasized on the physiography and environmental events of the Subarnarekha Delta plain. Prof. G.K. Panda and A.K. Kanungo also studied the spatial variation in the nature of landforms of the northern part of Orissa Coastal Zone, in the year 2007. P.K Banerjee, S. Goswami, and S. Chatterjee [1997] has worked on genetic re-interpretation of the shore parallel sand ridges of the Balasore-Contai floodplain. Socio-economic study of the coastal region dealt by Kar (2008), P. Daspatanayanak and B.K. Mishra (2006, 2007), R.N. Patra (207) et.al. L.K. Banerjee and T.A. Rao (1990) studied the mangroves of Orissa coast and their ecology: A. Mishra (1935), A. K. Nayak (2004), A.K. Biswal (1993), B.P. Chowdhury (1993), N.K. Dhal (2001), C.S. Reddy (2004), et.al also worked on the mangroves of region. Coastal Vulnerability Assessment for East Coast of India was studied by T. Srinivasa Kumar, R.S. Mahendra, Shailesh Nayak, K. Radhakrishnan, and K.C. Sahu which was published in the Journal of Coastal Research in May 2010. So none as per my knowledge was worked on the distributional pattern of settlement as well as measurement of spatio-temporal changing nature of settlement of the coastal blocks of Balasore and Bhadrak district have been studied. The author has just try to delineate the spatial distribution of settlements emphasizing temporal changes and there causes with the use of remote sensing data and application of GIS technology.

Methods and materials:
The theoretical aspects encompassing the present and previous conditions of the landscape system were collected from archival materials, different books, journals, papers, Reports prepared by different organization like CWC, OSDMA, DRDA, NABARD,, OFSDP, OSRP, SRC, WTCER, Centre for studies in social science, some information and maps prepared by NATMO, AUOT. Reports, Topographical sheets of SOI, maps and reports of GSI, Satellite imageries (Landsat data 1998 and 2012) USGS, Hyderabad, and downloaded information from Websites. Review of literature and field observation as well as frequent interaction with the local community presented a useful insight to the status of settlements. To achieve the above ends implication of modern methodology like remote sensing and GIS was felt necessary. Hence the researcher used software like ERDAS imagine 8.5, Arc GIS, and Arc. View – 3.2(a) for preparation of maps and models. The methods used are both qualitative and quantitative in nature. The study has been based on the method of multi date mapping from toposheets and the temporal satellite imageries. Toposheets of the year 1932 and 1976 and the Satellite data of the year 1998 and 2012 have been used for the study. The toposheets and Satellite imageries are visually and digitally interpreted with the help of remote sensing and GIS technology.

Result and discussion:
The area under study covers the administrative blocks of Bhograi, Bialiapal, Balasore, Bahanaga and Remuna Block of Balasore district and, Chandbali and Basudevpur Block of Bhadrak district, covering 200 gram panchayats and 1815 mouzas. Out of 1815 mouzas, 1589 mouzas are inhabited and 226
mouzas are un-inhabitated because of adverse physical and climatic conditions. Total number of household in this area is 341,192 (Census 2011) contains total 1,495,465 population, providing an average 48742 household/block in which maximum number of households exists in Bhograi Block and minimum in Bahanaga block of Balasore district in the area (table.1.01 and fig.1.2). The village wise distribution of household shows that (fig.1.3) maximum concentration of the household is along the villages near to the coast. Sartha village of Balasore block has maximum concentration of household. Nearly 89% of the coastal population resides in rural areas. Though major problem in this area is the inadequate supply of safe drinking water, in recent time, according to the official record, as many as1410 villages have already received facilities of safe drinking water, 179 villages have not the any source of safe drinking water. They carry drinking water from the neighbour villages which is more or less 2-3 km away from them. The settlement maps in the year 1932 and 2012(fig.1.5 & 1.6) of the coastal area reveal that there is only one urban centre (Balasore town) in 1932 but now there is another growth of urban centre viz. Basudevpur (NAC). Except these two the whole area is covered by rural settlement.

This coastal area is more ‘rural’ than other coastal areas of the country India as a whole as 89 per cent of its population lives in villages and only 11 percent in small towns like Balasore and Basudevpur (NAC), which is less than the percentage of urban population of the country as well as the state. The fertile coastal villages are more densely inhabited than those in the inland areas. In the country areas, cluster of settlements are generally formed in terms of religion, cast and family name. Another important feature is that in most cases that the settlements are located besides the road, around the agricultural fields and in the uplands of the coastal tract. Typical linear settlements are usually found along the roads and the embankment of the river side and on the linear permanent sand dunes in the north. The agglomeration of settlement is found only in Balasore town. In Chandbali block, the typical linear pattern of settlements along the roadside are developed because the low land areas are highly prone to flood. Flood is occurred during south-west monsoon every year. The low relief and peculiar drainage system influenced this type of growth of settlement. Four parallel linear pattern settlements developed at Chandbali, Chartia, Dhamra and Amarnagar to Basudevpur. Along the shore line, the Nuna bandh which was made to restrict the sea water ingression to the agricultural field has mostly populated by settlements. The large villages like Amarnagar, Balusahi, Krishnaprasad, Dhakata, Bijipur, Karanpali Balinunda and many other medium and small villages developed on the Nuna bandh. On the other hand coastal tract of Basudevpur Block is mostly populated than that of the Chandbali block. Some rectangular pattern of settlement noticed due to criss-cross of roads developed by Orissa Government. The mostly populated villages in this part are Sareshwarpur, Probodhpur, Iram, Tilada, Nuagaon, Sudarshanpur, Bachhada etc. In the north or north eastern part of the coastal tract, the Bhograi block is the most inhabited block. The proximity to Digha tourist spot of West Bengal, the location of famous temple of Lord Shiva in Chandaneswar, the development of Talsari and Udaypur beach and fertile soil of the area are the most important factors for the development of huge settlement in the area. Settlement of the coastal part of the block developed on the stable sand dunes are in linear patterns (fig.14). Five linear stretches of settlement are noticed on stable sand dunes, many cluster of settlement are also developed. Some linear pattern of settlement, though small in size also developed in the Baliapal block. Rest of one coastal track the Southern part Baliapal block, Balasore block, Remuna and Bahanaga are inhabited by scattered settlement.
The study reveals that about 62% settlements are newly grown in the area (fig. 1.5, 1.6, 1.7 & 1.8). The important reasons behind the change were the migration of the Bengali people during the British period and the availability of huge fertile arable land. Tourism development, religious activities, aquaculture farm development, marine fishing facilities, transport development etc. are also influenced the growth of settlement in the area. The study also shows that about 6% settlements are eradicate in nature due to the extreme events that are frequently devastated the area regularly such as river course change, flood, drought and cyclones. About 32% settlements have no change.

### Table-1.01: Population and household concentration:

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>Total number of household(2011)</th>
<th>1991</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Population density</td>
<td>Population</td>
</tr>
<tr>
<td>Bahanaga</td>
<td>32,765</td>
<td>99257</td>
<td>443</td>
</tr>
<tr>
<td>Balasore</td>
<td>55,813</td>
<td>156214</td>
<td>431</td>
</tr>
<tr>
<td>Baliapal</td>
<td>43,176</td>
<td>125777</td>
<td>538</td>
</tr>
<tr>
<td>Bhograi</td>
<td>66,280</td>
<td>226029</td>
<td>689</td>
</tr>
<tr>
<td>Remuna</td>
<td>42,480</td>
<td>67277</td>
<td>239</td>
</tr>
<tr>
<td>Basudevpur</td>
<td>52923</td>
<td>191240</td>
<td>491</td>
</tr>
<tr>
<td>Chandbali</td>
<td>47,755</td>
<td>177897</td>
<td>337</td>
</tr>
<tr>
<td>Total / average</td>
<td>341,192</td>
<td>1043691</td>
<td>445</td>
</tr>
</tbody>
</table>

Source: Census of India

Fig.1.4: Linear settlement pattern developed on the stable sand dune ridges and road side situation

Source: SOI Toposheets 1976
Fig. 1.5: Distribution of settlement in 1932

Fig. 1.6: Distribution of settlement in 2012

Source: Computed by the author from SOI Toposheets (1932) and LANDSAT Satellite image (2012)

Fig. 1.7: Spatial Changes of settlement from 1932 to 2012

Source: Computed by the author

Fig. 1.8: Temporal change of settlement (1932-2012)
Conclusion:
The study of settlement change of the coastal blocks of Balasore and Bhadrak district of Odisha reveals that the application remote sensing and geographical information technologies in delineating the temporal and spatial characteristics of settlement are the most significant modern geographical tool in present day context. The study reveals that the major land use pattern of the coastal region is agriculture accompanied with aquaculture farms which are the main reason behind the development of settlement in the area. The settlements are grown on the permanent sand dune, road side and on the agricultural field in cost of forest clearance. Mostly settlements are linear in pattern. The study reveals that about 62% settlements are newly grown in the area during the period 1932 to 2012. The study also reveals that the natural and cultural phenomena are responsible for the growth of new settlement. But frequent landfalls of cyclone, floods are creating critical situations to the local community and result for the movement of settlements. Therefore, the present research work reveals that remote sensing and GIS are vital geographical technologies for the study of settlement in both temporal and spatial aspects. Delineation in changes of settlement is made feasible by these modern technologies in less time consume, at low cost expense and with greater precision.

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