ICZM PLAN FOR RUTLAND ISLAND USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

K. Selvavinayagam

Abstract

The purpose of the study was to develop an Integrated Coastal Zone Management plan for Rutland island. For this study three dimensional elevation model, coastal biodiversity and landuse/landcover pattern change were analysed using SPOT 1993 and IRS 1C 2003 satellite imageries. Visual interpretation technique was carried on SPOT 1993 and IRS 1C 2003 satellite imageries for estimating landuse change. Three dimensional elevation model, drainage pattern and landuse change maps were overlaid for developing an integrated coastal zone management plan for Rutland island. Development and management measures for Rutland island are also discussed in this paper.

INTRODUCTION

ICZM is a continuous and dynamic process that unites government and the community, science and management, sectoral and public interests in preparing and implementing an integrated plan for the protection and development of coastal system and resources. Coastal area management needs an integrated, interdisciplinary and multi-sectoral approach in the development of good management plans. Solutions to problems and issues are seldom straightforward and require an integrative approach.

A fundamental objective of resource planners, managers and indeed of most human societies is to manage the natural resources. Development need to be aimed at enhancing nature's contribution to human welfare and not just anticipating and preventing undesirable effects. To overcome the effects caused by the human intervention, climatic change, over exploitation etc., recent technology such as remote sensing and GIS are the effective tools that could be used to putforth management solutions through interdisciplinary studies with an integrative approach and in a perspective way.

The objective of the present work is to provide the best long term and sustainable use of coastal natural resources as well as perpetual maintenance of the most beneficial natural environment. The only possibility for maintaining spatial environment could be achieved through an integrated planning and hence integrated coastal zone management was attempted for the study. ICZM can minimize the costs and costly delays in project implementation; minimize the losses to various users; minimize damage to the marine environment; make the most efficient use of infrastructure, information and technology available to marine development sectors; and avoid conflicting use of coastal and marine environment.

STUDY AREA

Rutland lies south east of Little Andaman and 55 km south of South Andaman across the Duncan passage; and is an area of high biological productivity. It is located between latitude 11°28’00” to 11°20’00” and longitude 92°35'00" to 92°45'00" E. It occupies an area of 14027.52 ha with an average altitude of 224 meters and a shore length of 98.2 km (SPOT, 1988) (Fig. 1). Highest peak in Rutland is Mt. Ford - 435m. Rutland with its diverse forest habitats is an important ecotourists paradise. The forests are rich in faunal diversity with birds, and are an ideal place for the bird watchers. The island is partially populated but largely virgin. The island has sweet water streams running throughout the year. Geology of Rutland island is mainly with basic and ultra-basic igneous rocks. The underlying rocks are essentially sandstone. Rutland is dominantly with rugged terrain, N-S folded structure that is longitudinal to the eastern and western coasts and transverse to northern and southern coasts. The mountainous origin of the islands also gives rise to an extremely convoluted coastline especially on the east with innumerable coves, deep inlets and wide bays. The higher ground is near the eastern shores. Slope of the Rutland island observed through digital elevation model is as follows, central portion 0° – 10° , south western 10° – 20°, south eastern 10° – 40°, southern 0° – 20°, northern western 10° – 20° and north eastern 25° – 80° (Fig. 2).

METHODOLOGY

Methodology adopted for the study is given below.

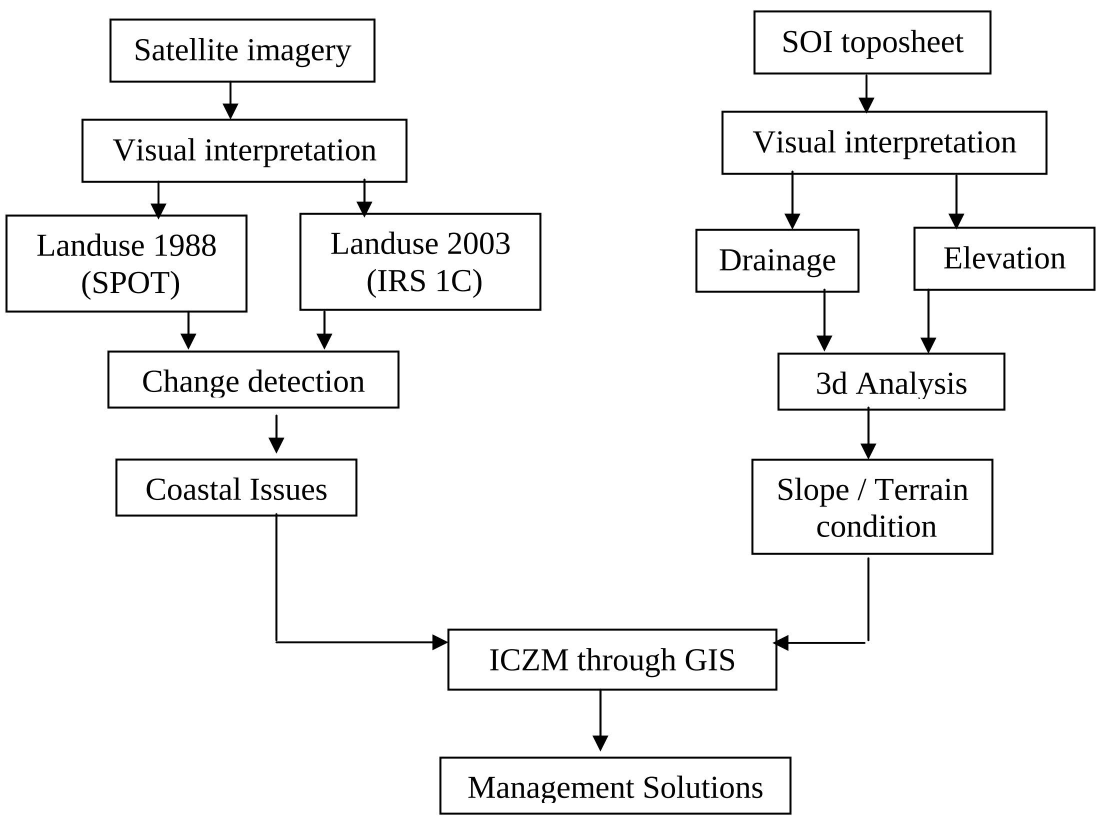

Fig 3. Methodology adopted for developing ICZM plan

Results and Discussion

Landuse change

For sustainable utilization of the land ecosystem, it is essential to know the nature, characteristics, extent and location of soil resources, its quality, productivity, suitability and limitations for various land uses (Chaurasia et al 1996). In order to improve the economic condition of the area without further deteriorating the bio-environment, every bit of the available land has to be used in a most rational way. This requires the present and past landuse/landcover data of the area (Chaurasia et al 1996). The conventional methods of detecting landuse/landcover changes are costly, low in accuracy and do not present a picture of a large area. Remote sensing, because of its capability of synoptic viewing and repetitive coverage, provides full information on landuse/landcover dynamics on a very large scale. The changes in landuse/landcover due to natural and human activities can be observed using current and archived remotely sensed data (Luong 1993).

SPOT imagery of 1993 and IRS 1C imagery of 2003 were visually interpreted for estimating the landuse change (Figure 1 and Table 1). According to the landuse change observed; reserved forest is found to be 11374.24 during 1993 and 11322.10 during 2003. There is a loss of about 49.14 hectares in reserved forest. Settlement area is absent in 1993 but it is 211.08 hectares in 2003. Coral reef is observed to be 1718.77 hectares in 1993 and 2076.43 hectares in 2003. There is an increase of 357.66 hectares in coral reefs. Sandy area is observed to be 115.21 hectares in 1993 and 51.96 hectares in 2003. There is a decrease of 59.25 hectares in sandy area. Mangrove is observed to be 457.15 hectares in 1993 and 348.64 hectares in 2003. There is a decrease of 108.51 hectares in mangroves area. No degraded mangroves were noticed in 1993 but 66.75 hectares of degraded mangrove area is observed in 2003 imagery. The major coastal issues through landuse change were the loss of reserved forest, loss of sand, loss of mangroves and increase in coral reefs.

3-dimensional model

Slope of the island observed through digital elevation model is as follows; central part 0° - 10°, south western 10° - 20°, south eastern 10° - 40°, southern 0° - 20°, northern western 10° - 20°, and north eastern part 25° - 80° (Fig. 2). It is observed that mostly the north eastern portion of this island is having more peaks whereas other parts of the island are found with moderate slopes.

Drainage

Stream processes in any terrain are controlled not only by the climatic conditions, but lithology and geologic structures also have great control as they influence the nature of flow, erosion and sediment transportation. The degree of dependence varies with the physical and chemical properties of the rocks. The permeability, the structural characteristics and the degree of jointing/fractures also affect the extent to which the materials can be detached by fluvial processes (Derbyshire et al., 1981). The role of rock types and geologic structure in the development of stream networks can be better understood by studying the nature and type of drainage pattern and by a quantitative morphometric analysis (Nag and Chakraborty 2003). Drainage pattern observed in

Rutland area were dentritic in nature. This pattern exhibits that the mountains may be volcanic / metamorphic in origin. There are about 498 streams in the northern portion of Rutland Island and about 338 streams found in the southern portion of the Island. The streams generally follow a steep slope in northern portion but they follow a gentle slope in southern portion of the island. Depending upon the elevation of the terrain, drainage pattern and river flow direction, particular sites were specified for erecting dams. However subsurface study is also necessary to find the exact location for erecting dam. Since Rutland Island is near South Andaman and has enough potential for fresh water supply, the following locations are suggested for pumping stations to meet out the demand of South Andaman. Water may be carried out to South Andaman Island during summer months through pipe line connectivity. The borehole location mark is shown in figure 2.

Coastal Issues

Degradation in mangroves is observed in northern portion of the Island. Development of settlement area and more sedimentation in coastal environment are the major issues for the degradation of mangroves. Loss in the reserve forest is attributed to the development of settlement area. The loss in reserve forest is observed at northeastern portion of the island. Gentle slope and sparse forest cover, favours the development of settlement in this portion. Sand area was found to have decreased in almost all the parts of the island. This may be due to sand mining or due to natural processes.

Management Issues

Tourism is a main sector of the world economy, accounting for nearly 11 per cent of global GDP (Topfler;1999). Nature-based tourism now comprises 20 per cent of the world travel market, and ecotourism 7 per cent (TIES: 1999). According to a report presented at a WTO seminar Spain earlier this year, 20 million+ Europeans consider the environment as their main motivation for travel (WTO: 1999). There is a general agreement that ecotourism is a type of travel to a natural area that supports conservation activities, contributies to local community development and leads to greater understanding and appreciation of the natural and cultural environments. However, conservation is the primary objective of ecotourism.

"Ecotourism is a concept that grew from the need to meet the objectives of nature conservation while recognising the rights of local people to utilise their locally available natural resources. Conservationists realised that the imposition of the western model of protected area management in areas where local people relied on natural resources for their daily sustenance was unjust and indefensible...Conservationists who recognised the injustice of the Western model of protected area management sought to implement a more considerate form of conservation that acknowledged the rights of indigenous people, did not forcibly evict them from their homes or deny them access to traditional resources in the name of conservation of nature... Tourism was introduced as a tool for nature's conservation. To compensate for reduced consumption of forest products income for communities is generated through the community involvement in a tourism enterprise. The process was called ecotourism" (Lincoln International; 1998). In Rutland Island Ecotourism site selection was observed based on the criteria where sandy beach was available; Slope of the terrain was less that 20° and ground water of good quality was available. Based on the above criteria sites for ecotourism were suggested as the selected portion of the island as shown in ICZM plan map (Fig. 2).

In India, though a huge quantity of surface water (Elango and Mohan, 1997) is available, the topography and other factors limit the storage of this water. Elango and Mohan (1997) suggested that failures in ground water recharge could be avoided by constructing the artificial recharging structures at places where they are more effective in recharging the aquifers. The location of site for construction plays the primary role in the effectiveness of any artificial recharge structure (Jothiprakash et al., 1997). Extensive studies have been carried out by several workers in delineating groundwater potential/prospective zones Geographical information system (GIS) has been found to be an effective tool. In recent years, extensive use of India topographical maps, collateral information and limited field checks, has made it easier to establish the base line information for ground water prospective zones (Singh et al., 1993; Chi and Lee, 1994; Haridass et al., 1994; Tiwari and Rai, 1996; Das et al., 1997; Ravindran and Jeyaram, 1997; Pratap et al., 1997; Pal et al., 1997; Pradeep, 1998; Subba Rao and Prathap Reddy, 1999; Thomas et al., 1999; Harinarayana et al., 2000; Muralidhar et al., 2000; Obi Reddy et al., 2000). The occurrence and movement of groundwater in an area is governed by several factors such as topography, lithology, geological structure, depth of weathering, extent of fractures, slope, drainage pattern, landuse and landcover, climatic conditions and inter relationships between these factors (Pratap et al., 2000). Most of the above studies were mainly to identify areas having groundwater potential, but very little work has been done in identifying zones suitable for groundwater potential/prospect zones. Delineation of potential zones for artificial recharge is also governed by several factors such as geology, permeability, soil depth, drainage intensity, soil texture, water holding capacity and physiography. In Rutland Island, the construction of artificial recharge structures are suggested based on the criteria where slope was less than 30°; high drainage density and buried pediment zones were present. Based on the above criteria sites for artificial recharge structures were suggested at the selected portion of the island as shown in ICZM plan map (Fig. 2).

Utilitarian approach is suggested for sustainable management of the coastal resources in Rutland island

- ☞ No development activity should be promoted in wetland areas
- ☞ No development activity should be promoted within 10 meters buffer of 1st, 2nd and 3rd order streams and within 20 meters buffer for rivers.
- ☞ Erosion activity of the streams should be checked in the highest elevations by erecting antierosion structures.
- ☞ The ICZM plan must be strictly followed for the better utility of the Rutland Island.
- ☞ No permanent concrete structures should be developed in this island.

Conclusion

Landuse change detection, 3 dimensional modeling and drainage pattern were studied. It is found that there is a decrease in sand, forest cover and mangroves. The decrease is attributed to the development of settlement. Through 3d elevation and drainage pattern, sites for dam construction and borehole location were identified. By integrating landuse, 3d elevation and drainage maps, ICZM plan map was prepared and sites for ecotourism and artificial recharge were suggested. According to the ICZM plan map management solutions were also suggested. If this plan map is implemented this would be of immense use to Rutland Island.

Acknowledgement

I am thankful to Prof. S. Ramachandran, Vice Chacellor, University of Madras, for his support and encouragement.

REFERENCES

Chaurasia R. Closhali D.C. Dhaliwal S.S. Minakshi Sharma P.K Kudrat M. and Tiwari A.K (1996) 'Landuse change analysis for agricultural management – a case study of Tehsil Talwandi Sabo, Punjab. Journal of Indian Society of Remote Sensing, Vol 24, No. 2. pp 115-123.

Chi, K and Lee, B. (1994). Extracting potential groundwater areas using remotely sensed data and Geographic Information Techniqes. Proc. Reg. Sem. Integrated applications of remote sensing and Geographical Information Systems for land and water resources management held at Bangalore, India, from No. 16-19, 1994, pp 64-69.

Das, S., Behera, S.C., Kar, A., Narendra, P. and Guha, S. (1997). Hydrogeomorphological mapping in groundwater exploration using remotely sensed data – A case study in Keonjhar District, Orissa. J. Indian Soc. Remote Sensing, 25(4): 247-259.

Derbyshire, E., Gregory, K. J. and Hails, J.R. (1981). Studies in physical geography, geomorphological processes. Butterworths, London, 101 p.

Elango, K. and Mohan, S. (1997). Technical report on effectiveness of percolation ponds, Indian Institute of Technology, Chennai, Submitted to Science and Technology, New Delhi.

Haridass, V.K., Chandrasekaran, V.A., Kumaraswamy, K., Rajendran, S. and Unni, K. (1994). Geomorphological and lineament studies of Kanjamalai using IRS – 1 data with special reference to groundwater potentiality. Trans. Instt. Indian Geographers, 16(1): 35-41.

Harinarayana, P., Gopalakrishna, G.S. and Balasubramanian, A. (2000). Remote sensing data for groundwater development and management in Keralapura watersheds of Cauvery basin, Karnataka, India. The Indian Mineralogists, 34(2): 11-17.

Jothiprakash, V., and Mohan, S. and Elango, K. (1997). Influence of percolation ponds – A source for sustainable drinking water supply in rural areas. Proc. Nat. Workshop on water resource and water quality management for sustainable drinking water supply, TWAD board, Tamil Nadu, held at Chennai from Nov. 16-17, 2001, pp. III 85-90.

Lincoln International, 1998. Training Manual: Ecotourism Conservation Training for Policy Makers and Trainers of Ecotourism Guides, funded by ASEAN-New Zealand Economic Cooperation Programme.

Luong P.T. (1993), 'The detection of landuse/landcover changes using remote sensing and GIS in vietnam', Asian-Pacific Remote Sensing Journal, No.5, Vol. 2, pp. 63-66.

Muralidhar, M., Raju, K.R.K., Raju, K.S.V.P. and Prasad, J.R. (2000). Remote sensing applications for the evaluation of water resources in rainfed area, Warangal district, Andhra Pradesh. The Indian Mineralogists, 34(2): 33-40.

Nag S.K. and Surajit Chakraborty (2003). Influence of rock types and structures in the development of drainage networks in hard rock area. Journal of Ind. Soc. of Rem. Sens., vol. 31, No. 1, pp 25-35.

Obi Reddy, G.P., Chandra Mouli, K., Srivastav, S.K., Srinivas, C.V. and Maji, A.K. (2000). Evaluation of groundwater potential zone using remote sensing data – A case study of Gaimukh watershed. Bhandara district, Maharastra. J. Indian Soc. Remote Sensing, 28(1): 19-32.

Pal, D.K., Khare, M.K., Rao, G.S., Jugran, D.K. and Roy, A.K. (1997). Demarcation of groundwater potential zones using remote sensing and GIS techniques: A case study of Bala valley in parts of Yamunanagar and Sirmaur district, Remote sensing for Natural resources, Ed. K.V. Ravindran et al., ISRS-NNRMS publication, pp. 395-402.

Pradeep, K.J. (1998). Remote sensing techniques to locate groundwater potential zones in upper Urmil river basin, District Chhatrapoor – Central India. J. Indian Soc. Remote Sensing, 26(3): 135-147.

Pratap Kamaleshwar, Ravindran, K.V. and Prabakaran, B. (2000). Groundwater prospective zoning using Remote Sensing and Geographical Information System: A case study in Dala – Renukoot Area, Sonbhadra district, Uttar Pradesh. J. Indian Soc. Remote Sensing, 28(4): 249-263.

Ravindran, K.V. and Jeyaram, A. (1997). Groundwater prospects of Shahbad Tehsil, Baran District, Eastern Rajasthan: A remote sensing approach, J. Indian Soc. Remote Sensing, 25(4): 239-246.

Singh, L.M., Roy, P.K., Roy, A.K. and Anand, R (1993). Application of remote sensing and Geographical Information in Hydrologic investigation of Imphal Valley (Manipur). Proc. Nat. Symp. Remote Sensing Applications for Resource Management with special emphasis on NE region, Guwahati, Nov. 25-27, 1993, pp 143-147.

Subba Rao, N. and Prathap Reddy, R. (1999). Groundwater prospects in a developing satellite township of Andhra Pradesh, India using remote sensing techniques. J. Indian Soc. Remote Sensing, 28(2&3):129-140.

Thomas A., Sharma, P.K., Sharma, M.K. and Anil Sood (1999). Hydrogeomorphological mapping in assessing groundwater by using remote sensing data – A case study in Lehra Gage Block, Sangrur district, Punjab. J. Indian Soc. Remote Sensing 27(1): 31-42.

Tiwari and Rai, B. (1996). Hydromorphological mapping for groundwater prospecting using landsat – MSS images – A case study of part of Dhanbad District, Bihar. J. Indian Soc. Remote Sensing, 24(4): 281-285.

Topfler, K., 1999. Editorial, Our Planet, Volume 10 (1), United Nations Environment Programme.

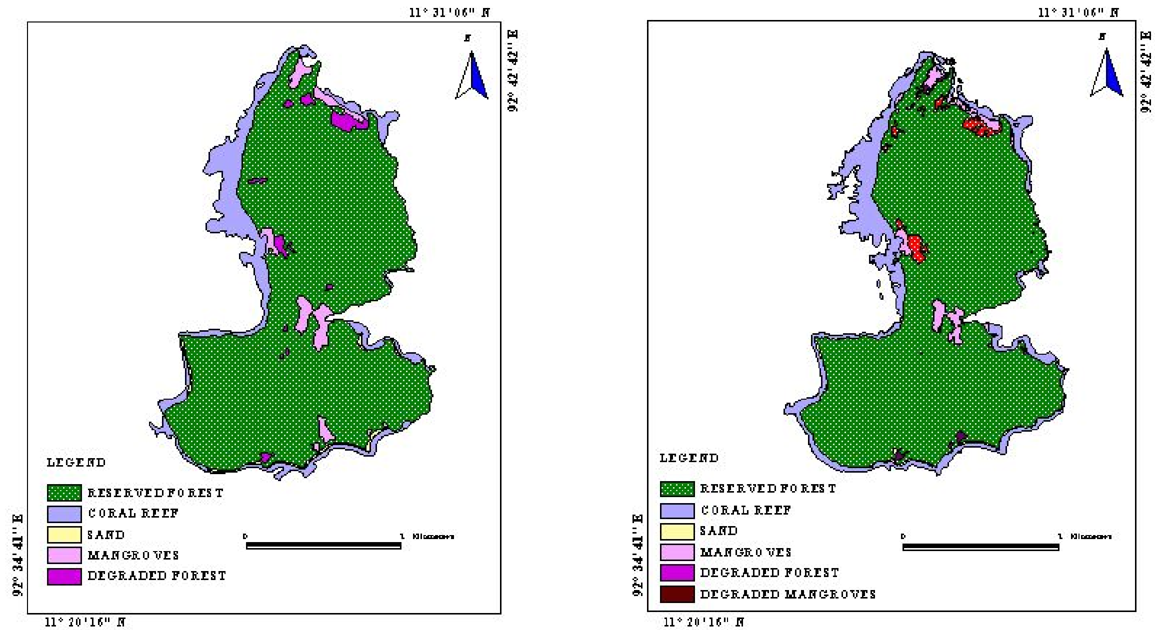

Fig 1. Land use map of Rutland island using SPOT 1993 and IRS 1C 2003 imagery

CLASS	1993 (AREA IN HECTARES)	2003 (AREA IN HECTARES)	% OF CHANGE BETWEEN (1993 - 2003)
RESERVED FOREST	11371.24	11322.10	(-) 0.43
SETTLEMENT	-	211.08	-
CORAL REEF	1718.77	2076.43	(+) 17.22
SAND	111.21	51.96	(-) 114.03
MANGROVES	457.15	348.64	(-) 31.12
DEGRADED MANGROVES	-	66.75	-
DEGRADED FOREST	205.18	2.54	(-) 7977.95

Table 1. Land use change of Rutland island using SPOT 1993 and IRS 1C 2003 data

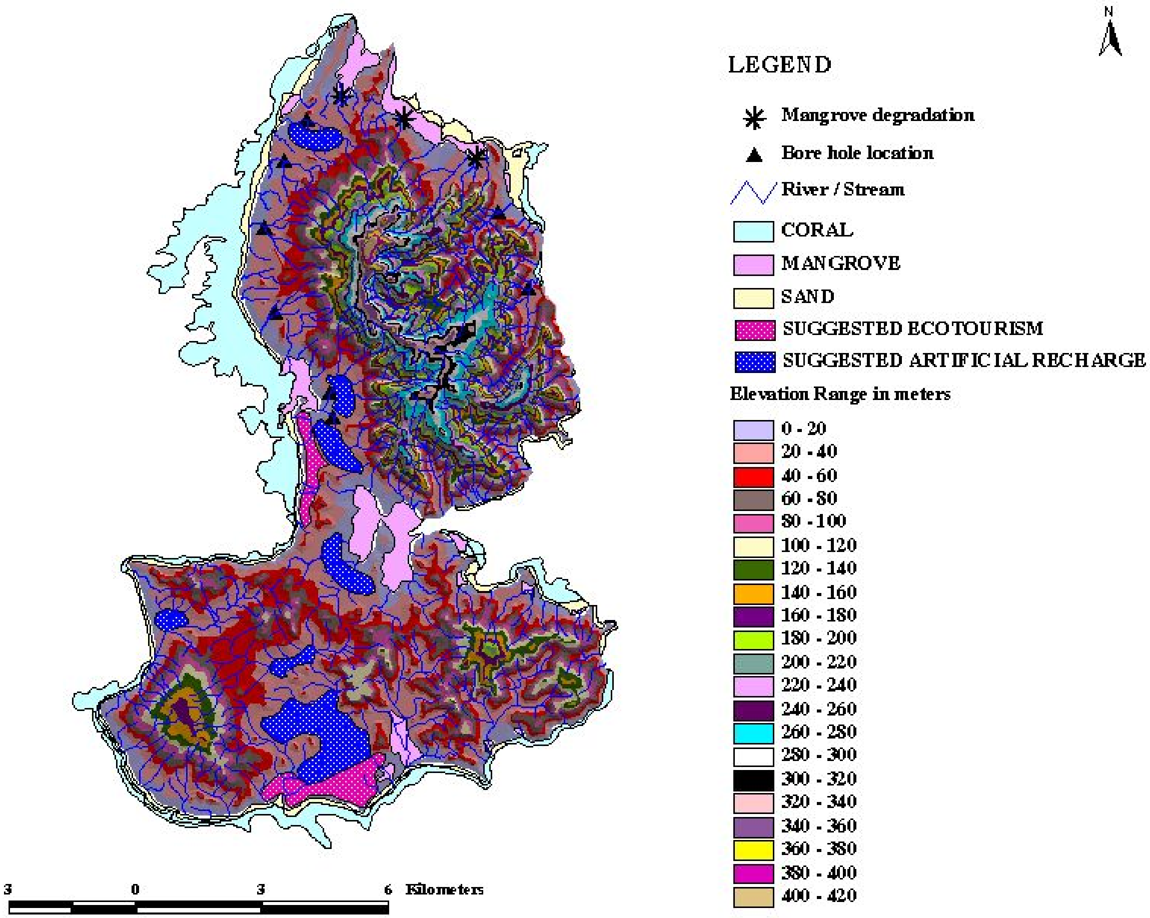

Fig 2. Integrated coastal zone management plan map of Rutland Island