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Study of Disaster Mitigation for Car Nicobar Island Using Remote Sensing and GIS

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Abstract: *December 26th 2004 earthquake with 9.3 Mw caused one of the deadliest Tsunami in the human history. Subsidence of land mass to 1.5 m along the eastern part of entire Andaman and Nicobar islands and up lift of 1.5 m in the western margins of the island system were observed. Most of the islands are constituted with folded mountain belts, except Car Nicobar. The epicenter of December 26, 2004 Sumatra earthquake was 163 km away from Great Nicobar, the southernmost island and hence it was strongly felt in the entire Andaman & Nicobar group of islands including Car Nicobar. Evidence of subsidence was also observed at the Car Nicobar the northernmost island of the Nicobar group (N9.2^o lat., E92.4^o long). Car Nicobar is being almost flat terrain to the east and an elevated terrain with maximum elevation of about 70 m to the west and hence the destructive Tsunami waves engulfed in the eastern part of the island. This island was worst affected in terms of damage and loss of life.*

The objective of this study is to mitigate the impact of disasters in the form of Tsunami and earthquake and cyclone for the Car Nicobar Island. Remote sensing and Geographic Information System (GIS) are important tools to prepare thematic maps by incorporating the elevation data, to delineate the extent of tsunami inundation and the areas to locate potential hazard zones of Car Nicobar Island. Preparation of inundation maps of coastal areas helps to identify regions from tsunami attack. Tsunami risk analysis helps to manage the evacuation planning and to diminish the loss of the life by tsunami. Preparation of land-use pattern is relevant for rehabilitation management and to reduce potential damages. From the past source, it is very clear that the Car Nicobar was most affected by seismic induced tsunami. The study is carried out to sort out the risks of potential inundation area due to the tsunami along heavily populated coast line and provides demarcations of suitable sites for rehabilitation and tools to generate the evacuation plane to mitigate disaster happening.

Keywords: *Disaster, Mitigation, Car Nicobar, GIS and Remote Sensing*

I. Introduction

Disasters are seen as the consequence of inappropriately managed risk. These risks are the product of hazards and vulnerability. Disaster is the tragedy of a natural or human-made hazard (hazard is a situation which poses a level of threat to life, health, property, or environment) that negatively affects society or environment. Developing countries suffer the greatest costs when a disaster hits – more than 95 percent of all deaths caused by disasters occur in developing countries, and losses due to natural disasters are 20 times greater (as a percentage of GDP) in developing countries than in industrialized countries (Wikipedia 2010). A disaster can be defined as any tragic event with great loss stemming from events such as earthquakes, floods, catastrophic accidents, fires, or explosions. Disaster is a sudden, calamitous event bringing great damage, loss, and destruction and devastation to life and property. The damage caused by disasters is immeasurable and varies with the geographical location, climate and the type of the earth surface/degree of vulnerability. This influences the mental, socio-economic, political and cultural state of the affected area. Generally, disaster has the following effects in the concerned areas, (Wikipedia 2010)

1. It completely disrupts the normal day to day life
2. It negatively influences the emergency systems
3. Normal needs and processes like food, shelter, health, etc. are affected and deteriorate depending on the intensity and severity of the disaster. It may also be termed as "a serious disruption of the functioning of society, causing widespread human, material or

environmental losses which exceed the ability of the affected society to cope using its own resources." December 26th 2004 earthquake with 9.3 Mw caused one of the deadliest Tsunami in the human history. Subsidence of land mass to 1.5 m along the eastern part of entire Andaman and Nicobar islands and up lift of 1.5 m in the western margins of the island system were observed. Most of the islands are constituted with folded mountain belts, except Car Nicobar. The epicenter of December 26, 2004 Sumatra earthquake was 163 km away from Great Nicobar, the southernmost island and hence it was strongly felt in the entire Andaman & Nicobar group of islands including Car Nicobar. Evidence of subsidence was also observed at the Car Nicobar the northernmost island of the Nicobar group (N9.2^o lat., E92.4^o long). Car Nicobar is being almost flat terrain to the east and an elevated terrain with maximum elevation of about 70 m to the west and hence the destructive Tsunami waves engulfed in the eastern part of the island. This island was worst affected in terms of damage and loss of life. (Fig 1)

Study Area

Car Nicobar falls in between Little Andaman and Nancowry (9^0 9' 43"N, 92^0 43'45''E). The Study area has shown in fig 1 covers about 127 km². It is a flat fertile island suitable for the plantation crops, and coconut and arecanut which are the major products grown in the area. The climate of Car Nicobar Island is tropical, as it is just 9 degree from the equator, with an annual rainfall of 3000 mm. The data of past ten year shows that the mean relative humidity in the Island is 79%, and the mean maximum temperatures is of 30.2^0 C, and mean minimum temperature is 23^0C.

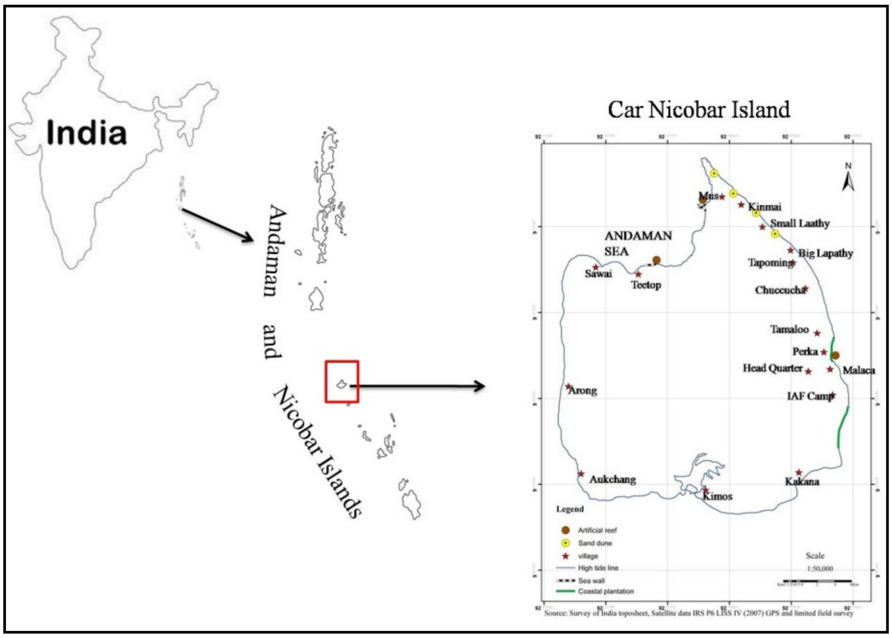


Fig 1: Study Area

II. Methodology

The IRS P-6 satellite has been found to be very sensitive system and play a significant role in mapping the tsunami efforts for sustainable development in the region. The digital analysis of the IRSP6 digital satellite data was done by using the image processing software (ERDAS IMAGINE 9.2). The various steps have been followed in order to find out the best results in deciphering the precise delineation of the various tsunami affected areas as proposed objectives. It is observed that the image enhancement techniques with brightness contrast and break points have became very successful in delineating the inundation of tsunami water on the islands by acquiring the actual reflectance values from the satellite data. The natural colour simulation was done to map coastal features precisely. The coastal mapping was made by on screen digitization. The thematic maps like coastal landuse /land cover for vulnerability assessment, contour map, DEM, transport map, evacuation map were prepared on 1:50,000 scale. Coastal ecosystem was identified by its colour, shape, texture, location and association. The classification accuracy was followed by the Space Application Centre (1992) guidelines.

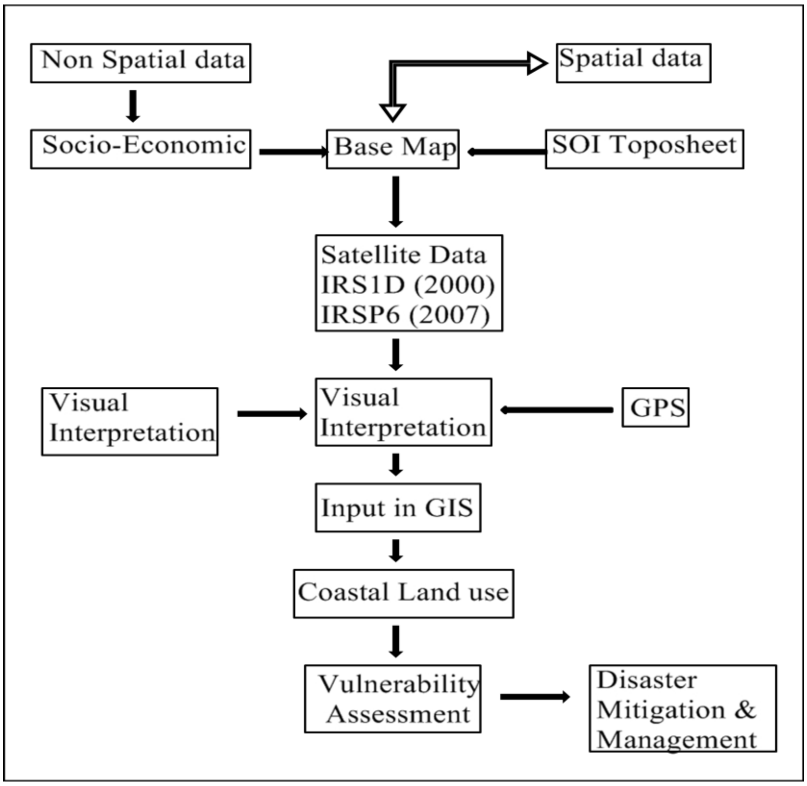


Fig 2: Methodology adopted for disaster studies for the study area

The accuracy error matrix was prepared to know the accuracy of interpretation using IRS P6 LISS IV(February, 2007). The accuracy was calculated to be 89%.

The area statistics of the maps based on IRS 1D LISS IV (February, 2000) and IRS P6 LISS IV (February, 2007) is given in Table 4and 5. A comparison was made in the landuse/landcover changes between 2000 and 2007 (before and after tsunami).

The objective of this study is to mitigate the impact of disasters in the form of Tsunami and earthquake and cyclone for the Car Nicobar Island. Remote sensing and Geographic Information System (GIS) are important tools to prepare thematic maps by incorporating the elevation data, to delineate the extent of tsunami inundation and the areas to locate potential hazard zones of Car Nicobar Island. Preparation of inundation maps of coastal areas helps to identify regions from tsunami attack. Tsunami risk analysis helps to manage the evacuation planning and to diminish the loss of the life by tsunami. Preparation of land-use pattern is relevant for rehabilitation management and to reduce potential damages. From the past source, it is very clear that the Car Nicobar was most affected by seismic induced tsunami. The study is carried out to sort out the risks of potential inundation area due to the tsunami along heavily populated coast line and provides demarcations of suitable sites for rehabilitation and tools to generate the evacuation plane to mitigate disaster happening.

Considering the impact made by disaster like tsunami, it is important to take necessary mitigation plan to protect the coastal people life and shift to safer places. From the above map, suitable sustainable development measures were prepared for the protection of people, property and environment. (Fig 2)

III. Result

Disaster Mitigation

Mitigation means minimizing the risk from the disaster. For reducing the risk need proper plan for that measures are evacuation route, coastal plantation, sea wall, artificial reef, sand dune etc. Various thematic maps like contour map, DEM, vulnerability map, transport network were prepared for the for the mitigation measures. The details are given below:

Contour Map

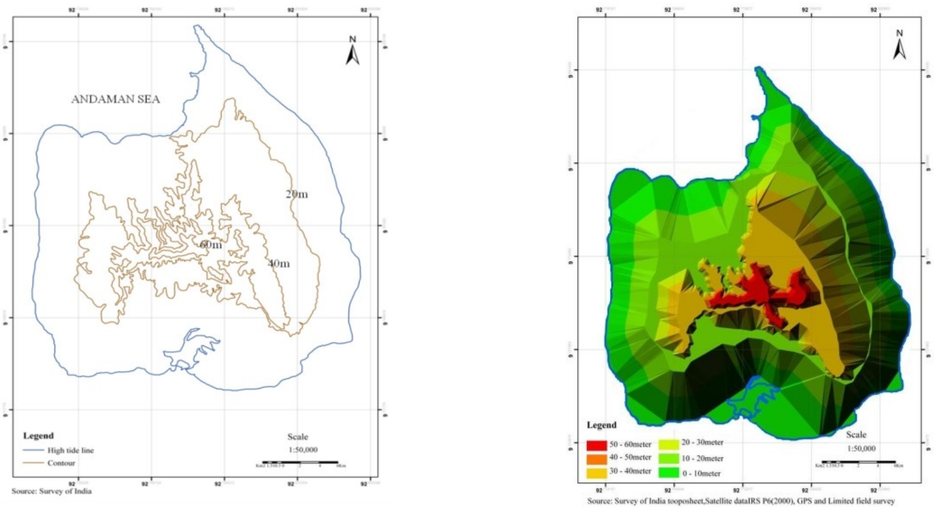


Fig 3: Contour map & Digital Elevation Model

Contour map was digitized from the toposheet at the interval of 20m from mean sea level. It is starts with zero value and end at value of 60m. The highest height value is 67m. From the contour map, it is observed that most area is fall under 20m height (Fig 3) DEM (Digital elevation Model) was prepared from the contour map. It was prepared using 3D analyst software of ARCGIS (Fig 3) the 3D view of the island show the gently sloping area and low lying area. After analying these maps vulnerable area was identified. Since it is the island, the area between High Tide Line and 20m contour was taken as a vulnerable area (Dharanirajan et al 2007). The villages like Malaca, Perka, Teetop, Mus, Kimos, chuccucha, sawai, Arong, Aukchang and Tapoming ware under vulnerable area.

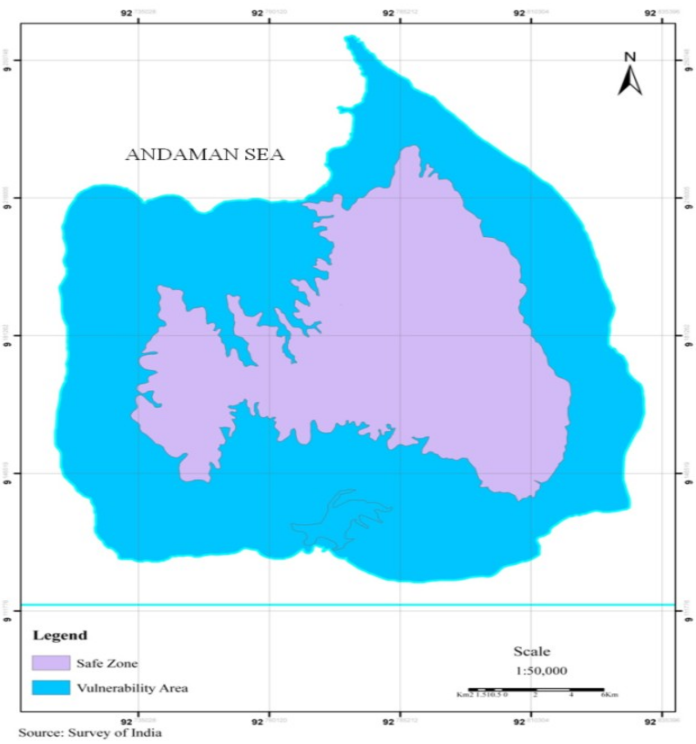


Fig 4: Vulnerability map

IV. Other Mitigation Measures

The following two mitigation measures are highly useful for the protection of tsunami. They are
Hard options –eg. Seawalls, Artificial reefs (Expensive)
Soft options –eg. Coastal Plantation, Sand dunes, Coastal Wetlands and Coral reefs (Less costly).

V. Hard Option

In order to protect the ecosystem the hard engineering options like revetments, seawalls, groined fields, gabions, piles, and breakwaters (surface piercing and submerged can be used. Some of the option is studied using remote sensing and GIS technique, which are given below.

Sea Wall

A seawall is a form of hard and strong coastal defence constructed on the inland part of a coast to mitigate the effects of strong waves. Sea wall is an important parameter of protection measures. Well-built seawalls have long been used as an inexpensive way to control coastal erosion. Seawalls are associated with reduced aesthetic value and increased erosion at the ends and in front. The seawall is in the high tidal zone above a sandy beach environment. Expected erosion will reduce the sandy environment near the wall causing the ecology to shift from sandy shore to rocky shore ecology. The main impact of the seawall will be economic, but the true value to the property and ecology should be considered before building such structures. Sea wall protects the coast from the erosion by the sea wave. With the help of GIS and remote sensing some of the areas were nearer to the coast ware identified. Sea wall can be constructed in these places to mitigate the tsunami. The villages like Mus and Teetop were identified as the highly vulnerable area and sea wall can be constructed here to protect the people, property and environment. The location identified in the field survey and the GPS reading were taken. The location and the length of the sea wall are shown in table 1.

Table 1: Length of Sea wall

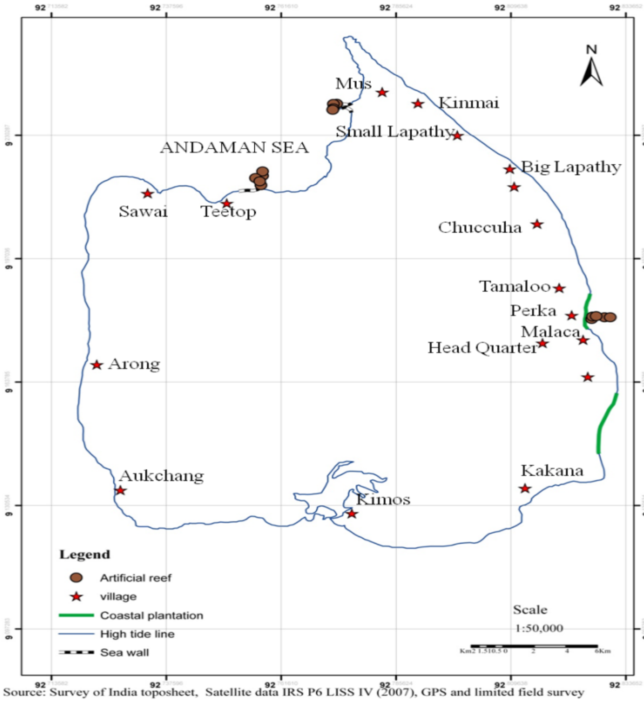
Area	Location	Length of sea wall
Teetop	9^0 12' 42"N 92^0 44' 50"E	1km
Mus	9^0 14' 20"N 92^0 46' 72"E	1.5km

Artificial Reef

An artificial reef is a man-made, underwater structure, typically built for the purpose of promoting marine life in areas of generally featureless bottom. Artificial reefs may also serve to improve hydrodynamics for surfing or to control beach erosion. Artificial reefs can be built in a number of different methods. Many reefs are built by deploying existing materials in order to create a reef. This can be done by sinking oil rigs (through the Rigs-to-Reefs program), scuttling ships, or by deploying rubble, tires, or construction debris. Other artificial reefs are purpose built (e.g. the reef balls) from PVC and/or concrete. Historic or modern shipwrecks become unintended artificial reefs when preserved on the sea floor. Regardless of construction method, artificial reefs are generally designed to provide hard surfaces to which algae and invertebrates such as barnacles, corals, and oysters attach; the accumulation of attached marine life in turn provides intricate structure and food for assemblages of fish.
Artificial Reefs serve for two functions
Harbor aquatic life
Help in breaking waves

Artificial reef is an important parameter to prevent the wave action and protect the coastal ecosystem. In Car Nicobar Island Malaca, Mus and Teetop are chosen for the construction of artificial reef. Areas are Malaca (9^0 10' 03"N 92^0 50' 00"E), Teetop (9^0 12' 42"N 92^0 44' 50"E) and Mus (9^0 14' 20"N 92^0 46' 72"E) during the field study, GPS location were identified

Fig 5: Proposed sites for the development of artificial reefs



VI. Soft Option

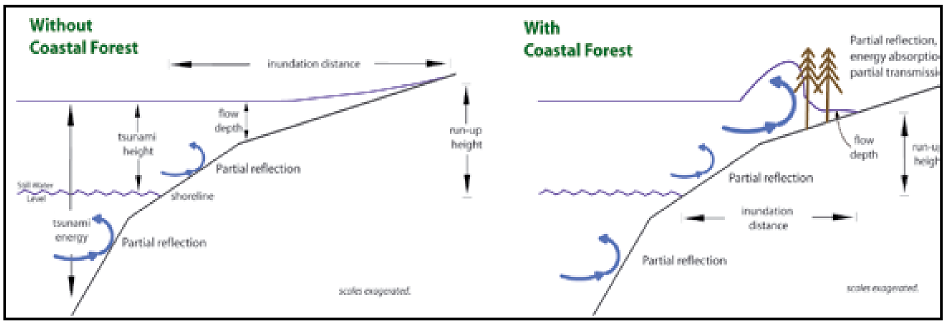
The soft options currently applied within the existing framework include: 1) the use of vegetation or revegetation of areas; 2) the use of vegetative matting on bluff faces to aid in bluff face stabilization; and 3) the enforcement of coastal related legislation specifically for the use of building setbacks, the protection of some vegetation species and the prevention beach sand mining. Some of the soft options are coastal plantation, coastal wetland, and sand dunes.

Coastal Forest

There is considerable evidence that coastal forests can reduce the force, depth and velocity of a tsunami, lessening damage to property and reducing loss of life (Keith Forbes (2007). The reductions in the degree of damage to trees with distance from the leading edge of a coastal forest, implying that the force of the tsunami is reduced by the forest and areas to the rear are afforded protection in areas like Teetop in the study.

In the case of mangroves, for any particular elevation or distance from the sea front, tsunami hazard is consistently lower for areas behind mangroves. Furthermore, plantations Arong have proved effective against various tsunamis. Many casuarina shelterbelts in India, Sri Lanka and Thailand, established to protect coasts from cyclones, tsunami and other coastal hazards were effective against the 2004 Indian

Fig 6:



sunami wave run-up with and without coastal forest barrier. (Source: Keith Forbes (2007)

Ocean tsunami as well (Keith Forbes 2005). Natural beach forests and plantations of tree crops, such as cashew nut with their low, widely branching canopies or pandanus with mangrove-like stilt roots and dense foliage (Kimos), have also protected coasts in many instances. Kimos where coastal forests failed to protect coastlines from a tsunami. Rather than an indictment of coastal forests in general, however, these failures can be attributed to a rare, massively large tsunami or insufficiency of one or more forest attributes such as forest width, density, age or some other parameter important in providing protection. In these places degraded or altered beach forests was observed with widely spaced trees, replacement tree species susceptible to breaking, or sparse undergrowth. The (Fig 6) shows the how coastal forest can protect the coast from the disaster.

Less dense forest around Malaca and IFA base were identified using satellite image (2007) for the development of forest to protect from future disaster. It covers an area about 2km can be developed for increasing the density of the forest.

Coastal Wetland

A wetland is an area of land whose soil is saturated with moisture either permanently or seasonally. Such areas may also be covered partially or completely by shallow pools of water. Wetlands include swamps, marshes, and bogs, among others. The water found in wetlands can be saltwater, freshwater, or brackish. It is playing an important role at the disaster because it consists of mangroves that work as a barrier for the interior of the land. Coastal wetlands such as salt marshes, mangroves, coral reefs, oyster reefs and sea grasses can help to mitigate these hazards by reducing the intensity of waves and creating natural barriers. The villages like Aukchang is showing newly developed mangroves and it should be well protected, so that it can be use full for the future disaster.

Sand Dune

A dune is a hill of sand built by alluvial processes. Dunes occur in different forms and sizes, formed by interaction with the wind. Most kinds of dunes are longer on the windward side where the sand is pushed up the dune and have a shorter "slip face" in the lee of the wind. The valley or trough between dunes is called a slack. A "dune field" is an area covered by extensive sand dunes. Large dune fields are known as ergsDunes form where constructive waves encourage the accumulation of sand, and where prevailing onshore winds blow this sand inland. There need to be obstacles e.g. vegetation, pebbles etc. to trap the moving sand grains. As the sand grains get trapped they start to accumulate, starting dune formation. The wind then starts to affect the mound of sand by eroding sand particles from sand dunes.

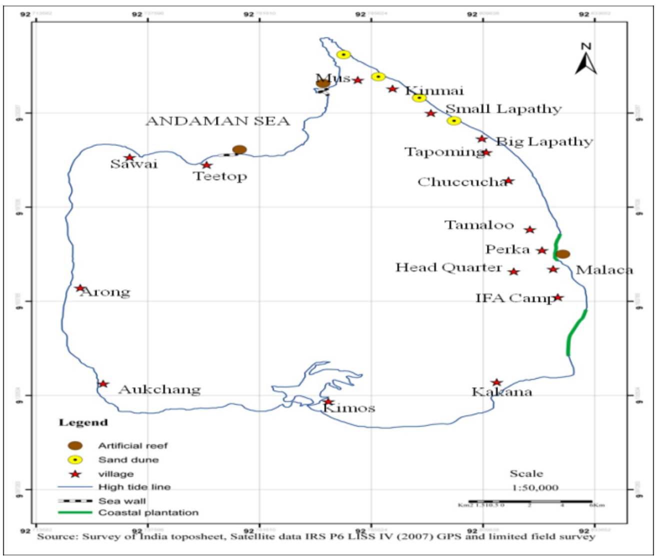


Fig 7: Proposed sites for the development of sand dune

These dunes provide protection from various disasters like storm surge cyclone and tsunami. These sand dunes provide natural barrier for interior coastal land. But these sand dunes are absent in the study area. So the Artificial sand dunes can be developed along the coast. The areas like Mus (92^0 48' 12"E 9^0 14'33"N), Small Lapathy (92^0 48' 34"E 9^0 14'23N) and Kinmai (92^0 48' 19"E 9^0 13'24N), sand dunes can be developed in these areas to protect the coastal village (Fig 7).

VII. Other Option

Evacuation Routes

Minimizing risk of the disaster is very important in disaster mitigation, for that Evacuation routes is on if the important path. In Car Nicobar all roads are well connected with each other. The total length of main road before tsunami was around 100.8Km (Directorate of Economics and Statistics 2008). Many roads are aligned parallel to the coast, which isobserved in the village like Malaca, Perka, Tamaloo, Big Lapathy and Arong. The evacuation map was prepared from the transport network mao. The roads running perpendicular to the coast were identified and evacuation route map was prepared. It is shown in the (Fig 8). The roads near Malaca, Perka, Tapoming, Tamaloo villages are identified as the evacuation route.

Sing Board

Sign symbol can play an important role at time of emergency. It shows the road to people to escape from emergency and save their life and even their property also. The sign boards can be fixed along the evacuation route, so the people can be guided to escape. The sign boards (Fig 8) can be fixed in the places like Malaca, Big Lapathy, and Small Lapathy so that it could be useful for the mitigation measures. Areas are Malaca ($9^0$10' 03"N $92^0$50'00"E), Big Lapathy ($9^0$13'39"N $92^0$48'06") and Small Lapathy ($9^0$14'39"N $92^0$47'27"E) reading are taken with the help of GPS.

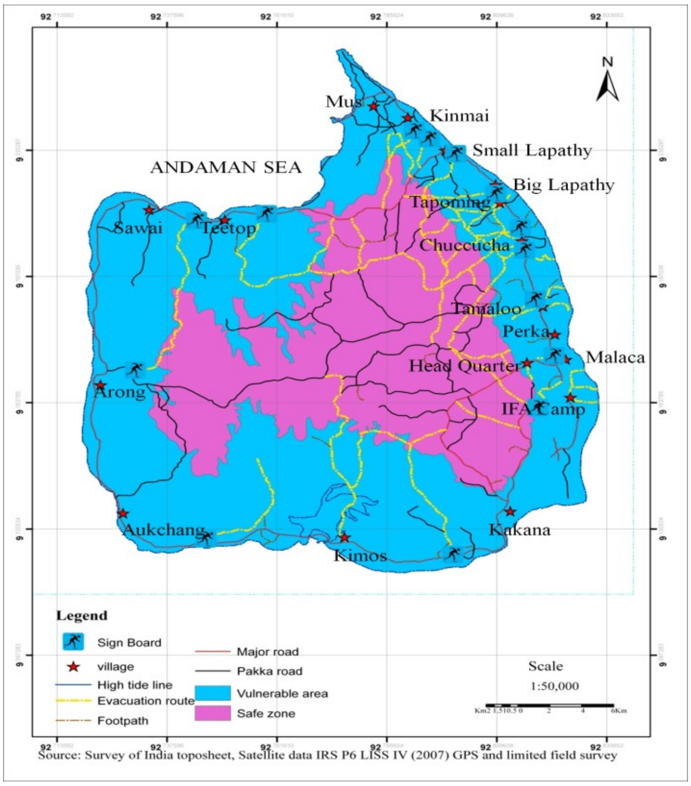


Fig 8: Evacuation route with Sign Board

House Design

Car Nicobar Island is tribal area, where the peoples are living in traditional way. There houses are round in shape and constructed with wood and jungle leaf with the height from ground is about 5-7 feet and attached with movable ladder. These houses are traditionally constructed so that it is very much safe from the dangerous animal and also from disaster. But 26th Dec, 2004 Indian Ocean earthquake and tsunami destroy these traditional household because it was constructed by wood and jungle leaf that does not have that much potential to withstand mega wave of tsunami. It was fully washed out and because of this losses of life and property were increased. So that it is very important to construct houses in such a way that it should stand with any kind of disaster. The concrete and well reinforced elevated structure can be constructed in the study area. Such houses are observed in very few places like Malaca, Perka, Tamaloo etc. These houses can be useful to protect the people from future disaster.

VIII. Conclusion

Disaster likes tsunami, cyclones are one of the catastrophics of the world coastal regions, moving with enormous kinetic energy and dissipating it on the coast. They cannot be prevented but the impacts can be reduced and human life can be saved by having monitoring system. Proper understanding about the integrated disaster management practices, research, monitoring and communication are the hopes for future disaster mitigation in the region. The remote sensing and GIS technologies can be exploited in creating a wealth of relevant information about various components of small island developing states and generating an integrated decision support system (DSS) to assist inland/coastal zone managers in making informed decisions. It is expected that developing an integrated decision support system would enable policy makers/managers to better understand the linkages between local, regional and global processes, take effective management decisions, and achieve the goal of mitigation of Small Island developing states/union territory such as the Car Nicobar Islands. The damage over highly sensitive critical habitats can be easily identified by remote sensing and GIS technology. Settlement, mudflat, mangrove, sparse mangrove, and sandy beaches can be identified using this technique. Various mitigation measures like hard option and soft option can be easily identified using remote sensing and GIS technique. This mitigation measures will be helpful to protect the people, property and environment from future disaster.

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