WINDMILL SITE SELECTION USING REMOTE SENSING AND GIS – A CASE STUDY IN NORTH PASSAGE ISLAND, ANDAMAN

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ABSTRACT

Windmills are a major source of renewable energy. Electricity generated through windmills are profitably operated in the state of Tamil Nadu where more than 1340 MW of electricity are generated. Erection of windmills promotes development of industry, tourism and other coastal infrastructure facilities. Predominant wind direction noticed in Andaman Group of Islands such as North Andaman, Middle Andaman, South Andaman, Little Andaman and Teressa Island is Southwest and the wind power density noticed at Minyuk, Chukmachi, South Bay, Barkath line, Phoenix bay, Pokkadero and Ramakrishnagram ranges from 55.30 to 106.60 W/M^2 observed at the elevation of 20m. In order to sustain the environment in an eco-friendly manner, windmill site selection is carried out in North Passage Island. This island is located near the four major inhabited islands of North Andaman, Baratang, Strait and Long. Electricity generated in North Passage Island could be transferred to these islands. Erection of Windmills involves investing both government and private revenues. So in order to select suitable site for windmills coastal geomorphology, wind action and landuse studies were carried out and integrated using remote sensing and GIS techniques. Site specific locations for erecting windmills were demarcated using Arc overlay techniques. The advantage of erecting windmills in this island has also been discussed.

KEYWORDS

Andaman, North Passage Island, 3d Elevation Model, Landuse, Slope, Windmills, Remote Sensing and Geographical Information System.

1. INTRODUCTION

The Andaman and Nicobar Islands are the summits of a submarine mountain range lying on the great tectonic suture zone that extends from the eastern Himalayas to the Arakan along the Myanmar border and finally to Sumatra and lesser Sundaes. This archipelago consists of a group of 572 islands, islets and rock outcrops, but there are a total of 352 important islands comprising the main chain of Andaman and Nicobar, Ritches Archipelago and the out laying volcanic islands of Narcondam and Barren. The islands are spread over an area of 8,249 sq.km, of which 6,408 sq. km of area is occupied by the Andaman group and 1,841 sq.km by the Nicobar groups of Islands. The Andaman group consists of 324 islands of which 24 are inhabited while the Nicobar group includes 28 islands of which 12 are inhabited. Undulating topography and intervening valleys characterize the physiography of this Archiepelago. There are several rain-fed streams, which dry up during summer. All the major islands support a luxuriant growth of evergreen, semi evergreen, moist deciduous and littoral forests from the water edge to the mountain top depending on the topography and nature of the soil. For administrative purposes, the Islands are divided into two districts, namely Andaman and Nicobar. There are a total of 204 revenue villages of which 197 are in the Andaman District. The Andaman and Nicobar is having a good economic turnover through Tourism Industry because of its rich natural scenic beauty and natural resources. At the same time these islands are facing problems such as population growth, commercial development etc and inturn facing acute power shortage.

The ever increasing energy needs of the islands will have to be taken into account in the long term Master Plan even at this state. Dependence should be entirely on the

local resources – biomass and other resources of the islands as well as the vast renewable resources of the ocean and atmosphere. In this respect, it is possible that the technology that could be developed and perfected for the islands could be a path-breaker for the national program also. Bio-mass production could be undertaken on an accelerated scale under highly favorable conditions. Solar, tidal and wind resources could be of great importance. Resources from the ocean pose new challenges to our scientist and technologists. When agricultural production, industrial development and economic exploitation of oceanic resources go hand in hand, the energy problem is likely to be a constraint if timely steps are not taken in that direction (Qasim 1998).

Power is likely to become a serious constraint. Unless resources are discovered on the island, thermal power stations using coal or diesel oil are likely to be extremely expensive. Also the pollution arising out of the fuel could spoil the natural resources of the island. Possibilities for hydropower are limited due to non-perennial nature of rivers. In this context, it might be necessary to vigorously explore alternative sources of energy. Three approaches which are likely to prove fruitful are geothermal energy, wind energy and ocean thermal energy conversion (OTEC). Due to the volcanic origin of the main islands it is possible that suitable geothermal sites for fairly large scale power generation might be available. OTEC is already planned for Lakshadweep Islands. Possible OTEC sites should be explored for the Andamans also. Moreover, very little attempt has been made to explore the usage of wind energy. Appropriate sites of good wind energy could be targeted using satellite technology to promote wind mills (Qasim 1998).

In order to relieve the pressure on available land and water resources due to increase in population on presently inhabited islands possibility of shifting a part of this

population to uninhabited islands after creation of necessary facilities needs to be examined. On some of these islands both solar and wind energy is available at exploitable levels. Use of Photovoltaic solar cells and wind mills for generation of power will go a long way in their development. The generating capacity of wind power systems ranges from 100 watts to 4 megawatt. The systems require the installation of a generator with rotor, tower, battery bank and control unit. A generator with an average capacity of 500 W with a 5-m diameter rotor and a life span of 10 years can cost Rs. 10,00,000 (TEDA 1999). These systems may benefit coastal resorts as these areas are generally exposed to wind. An average wind speed of greater than 4m per second is necessary if wind energy is to be economically feasible. In this case, wind generators are often cheaper than solar PV and diesel generators. Skilled technicians are required to install and maintain the system. Maintenance requires regular checking and access to new parts (Huttche et.al. 2002).

Because of the important relationship between the available power and the wind speed, turbine should be suitably located as to allow free movement of the wind. Wind energy is particularly appealing way to generate electricity because it is essentially pollution-free. More than half of all the electricity that is used in India is generated from burning coal, and in the process, large amounts of toxic metals, air pollutants and greenhouse gases are emitted into the atmosphere. Development of 10% of the wind potential in the 10 windiest Indian states would provide more than enough energy to displace emissions from the nation's coal-fired power plants and eliminate the nation's major source of acid rain; reduce emissions of carbon dioxide (the most important greenhouse gas); and help to contain the spread of asthma and other respiratory diseases

aggravated or caused by air pollution in this country. If wind energy were to provide 20% of the nation's electricity, a very realistic and achievable goal with the current technology, it could displace more than a third of the emissions from coal-fired power plants, or all of the radioactive waste and water pollution from nuclear power plants. Table 1 shows the state wise installed wind power in India.

Any development plan of islands should be based on long term need, taking note of natural resources both living and non living, ecological status, natural beauty and the present state of development of the region. This requires reliable and upto date database about the natural resources and their distribution over space. With the conventional methods the data obtained are often time consuming and less accessible. The remote sensing technology with its uniform and unbiased data collection system has the capability of providing the much needed information on large areas in single synoptic view, in short time, and at periodic intervals. For inaccessible areas this is the only source of data collection. Hence in order to identify sites for wind mills as a pilot project for North Passage Island, Remote Sensing and GIS techniques were used.

For proposing suitable sites for windmills using Remote Sensing and GIS the following criteria were adopted:

- Flat plain region and the slope less than 5°
- Minimum canopy cover with the trees height should be less than 40m
- Surrounding regions should have less than 60m elevation
- Windward side is most suitable than leaward side
- Open shoreline as a mountain gap which produces wind funneling effect
- ‘U’ shaped valley regions with good wind speed

State	As on 31.03.2002			As on 31.03.2003			As on 31.01.2004
	Demons-tration Projects (MW)	Private Sector Projects (MW)	Total Capacity (MW)	Demons-tration Projects (MW)	Private Sector Projects (MW)	Total Capacity (MW)	(MW)
Andhra Pradesh	5.4	87.2	92.6	5.4	87.2	92.6	92.8
Gujarat	17.3	149.6	166.9	17.3	155.8	173.1	201.2
Karnataka	2.6	66	68.6	2.6	121.7	124.3	177.5
Kerala	2	-	2	2	0	2	2
Madhya Pradesh	0.6	22	22.6	0.6	22	22.6	22.6
Maharashtra	6.4	392.8	399.2	8.4	392.8	401.2	401.3
Rajasthan	6.4	9.7	16.1	6.4	54.3	60.7	109
Tamil Nadu	19.4	838.1	857.5	19.4	970.9	990.3	1119.7
West Bengal	1.1	-	1.1	1.1	0	1.1	1.1
Others	1.6	-	1.6	1.6	0	1.6	-
Total (All India)	62.8	1565.4	1628.2	64.8	1804.7	1869.5	2117.2
Source: TADA (1999)							

Table 1: State-wise wind power installed capacity in India

2. STUDY AREA

The Andaman and Nicobar Islands are situated in the Bay of Bengal within 6° and 14° N latitude, 92° and 94° E longitude. For administrative purposes, the Islands are divided into two districts, namely Andaman and Nicobar. The former consists of two sub divisions, namely South Andaman and Mayabunder consisting of four tahsils. The Nicobar district is divided into Car Nicobar and Nancowry tahsil. The four tahsils of Andaman district are Diglipur, Mayabunder, Rangat and South Andaman. The South Andaman tahsil is further bifurcated into two tahsils namely, Port Blair and Ferrargunj. At present 36 islands in Andaman and Nicobar Islands are inhabited. The population as per 1991 census is 2,80,661 and as per 2001 census it is over 3,50,000 in Andaman and Nicobar Islands. Of the total population, the majority (90%) is settlers from outside the islands.

3. METHODOLOGY

GIS mapping method was used to identify and map the sites with potential wind power in North Passage Island. Using Arc View GIS software, thematic maps such as landuse, 3-d elevation model, and slope were digitized, rectified, analysed and integrated for identifying suitable sites for erecting windmills.

4. RESULTS AND DISSCUSSION

The fluid (air) that drives the rotor is much less dense than water, and so the diameter of the rotor must be much larger than the rotor of a hydro turbine. A hydro turbine capable of generating one megawatt (MW) of power would be several meters in diameter--a 1-MW wind turbine's rotor would be roughly 54 meters across. Second,

wind energy is available over a much larger geographical range than hydropower according to AWEA 2003.

Good wind speeds are important. The energy that the wind contains is a function of the cube of its speed (Jeyakumar et.al., 2002). This means that a site with 12-mph average winds has more than 70% more energy than a site with 10 - mph average winds.

The wind power produced varies with the cube of wind speed. The mass of air (m) with speed (v) and density (d) flowing per unit time through area (A) swept by the blades of a conventional horizontal axis wind turbine is dAV. Thus the kinetic energy of this mass of air is given by $1/2mV^2 = 1/2dAV^3$. So it is very important to locate windfarms in areas with high average wind speeds. Wind speed increases with height above the ground; it also increases over open areas (sea, large lake, etc). It has been seen that for wind power development, sites with average wind speeds of 6.5 to 8 m/sec are the ideal sites (Suneel 1995). The wind power density observed at Andaman group of islands are within the range from 55.30 to 106.60 W/M^2.

Using remote sensing and GIS for selection of site for windmills have many advantages such as it reduces time, cost and manpower for locating wind monitoring stations, it provides predefined knowledge to locate wind monitoring stations, inaccessible areas could be identified, integrated and a perspective study could further enhance the scientific research potential for windmill site location. Table 2 shows the island-wise data of wind monitoring stations for potential sites in Andaman & Nicobar Islands. One of the best possible sites for locating wind machines is the top of a smooth, well rounded hill with gentle slope lying on a flat plain. A site located on an island in a lake or a sea is usually an excellent site; open plain, an open shoreline as a mountain gap

which produces wind funneling is good. The proposed site of windmills falls in the latitude and longitude extension of 12° 17' 00.50" N – 12° 17' 54.94" N and 92° 55' 53.74" E – 92° 56' 06.62" E (Figure 1). The area of the proposed site is 50 hectares. About 5-MW of electricity could be generated in this area.

S.No	Latitude	Longitude	Station	Wind power density (W/M^2) at 20m Altitude
1	10° 34"	92° 26"	South Bay	106.60
2	08° 15"	93° 08"	Minyuk	62.60
3	08° 13"	93° 10"	Chukmachi	66.20
4	13° 14"	92° 57"	Ramkrishnagram	55.30
5	12° 53"	92° 54"	Pokkadero	63.10
6	11° 39"	92° 45"	Barkath line	63.00
7	11° 40"	92° 44"	Phoenix bay	68.50
Source: CWET 2000				

Table 2. Island wise wind monitoring station in Andaman & Nicobar Islands

Wind monitoring stations report on places such as Ramakrishnagram, Pokkadero, Phoenix bay, Barkath line, South Bay, Minyuk and Chukmachi reveals that the general wind direction is towards South - SW and its energy varies from 55.30 W/M^2 to 106.20

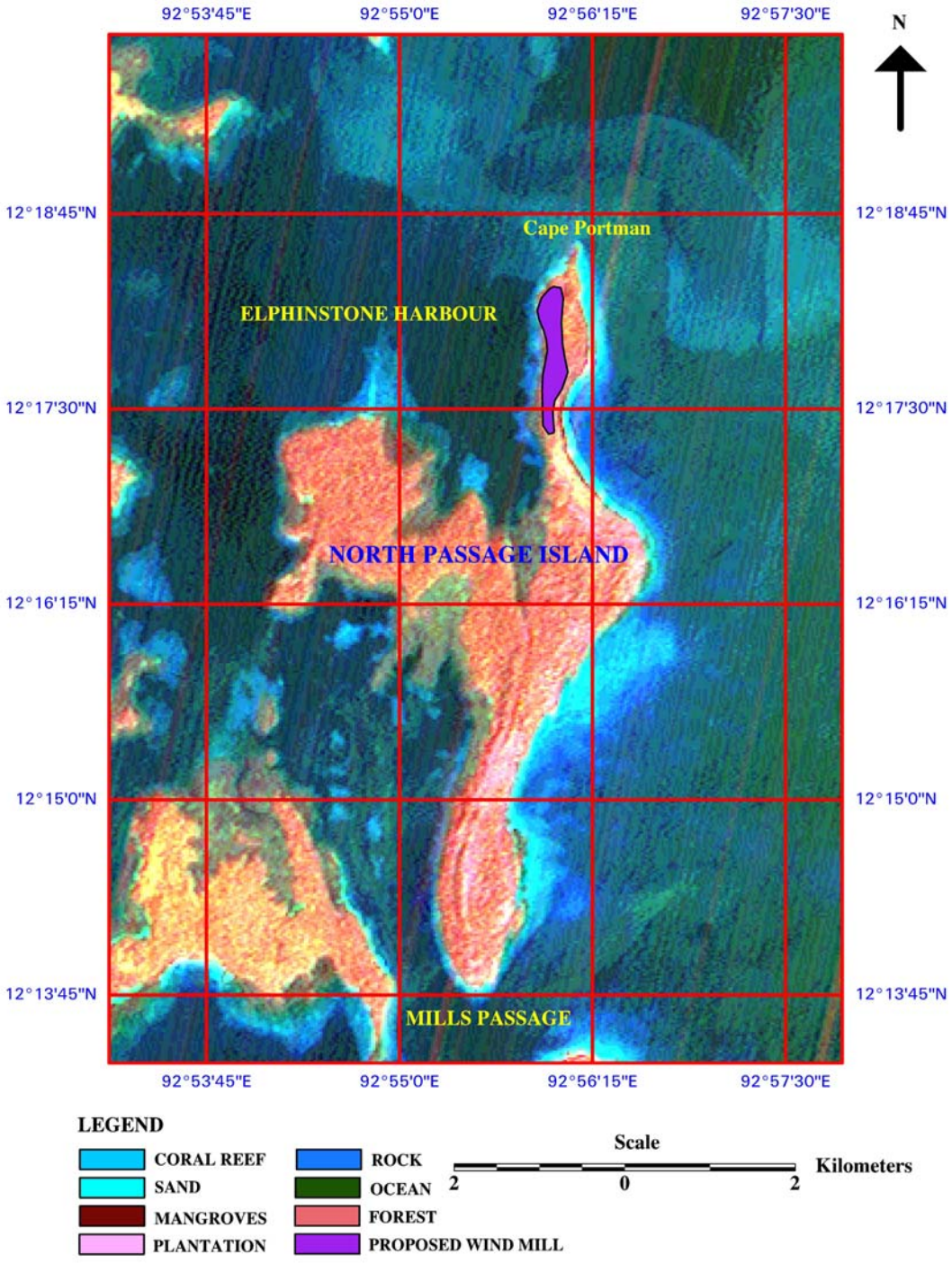

Figure 1. Proposed windmill site using IRS ID LISS III 2003 satellite imagery

W/m^2 (Figure 2). Low wind energy is observed at the mainland whereas at the shore the wind energy is high. Moreover the windward side of the elevation has maximum wind energy whereas at its leaward side wind energy is reduced because of its thick canopy cover and scattering of the winds due to elevated regions.

Generally the small islands situated at the leaward side of the larger islands which has an elevation greater than 60m could not be proposed for windmills because of its elevation and canopy effects. Whereas in the case of North Passage Island it is surrounded by islands such as Baratang in East, Middle Andaman in North and Strait in South. Though it is surrounded by largest elevated islands the geographical location is well suited for windmills (Figure 3). Eastern side of the north passage has got a passage, Homfrey's strait. It acts as a funnel for wind flow. The surrounding elevation of this island is less than 60m and it is about 7 km away from the shore of Baratang island. Hence, this island has got an excellent geographical location for utilizing it for windmill erection.

For North Passage Island the slope analysis is carried out using Arc View GIS software reveals that the majority of the island falls within the slope of 10°. The area proposed for windmill erection is within a 5° slope. This slope is most suitable for erecting wind mills continuously in the terrain. Topography of the study area reveals that there is a U shaped valley found between northern and eastern portion of the island. The peak height of the northern part of the island is 64 meters and the eastern part of the island is 84 meters. This valley region is surrounded by sea and favorable amount of air flow is observed due to this U shaped topography. The continuous wind action makes

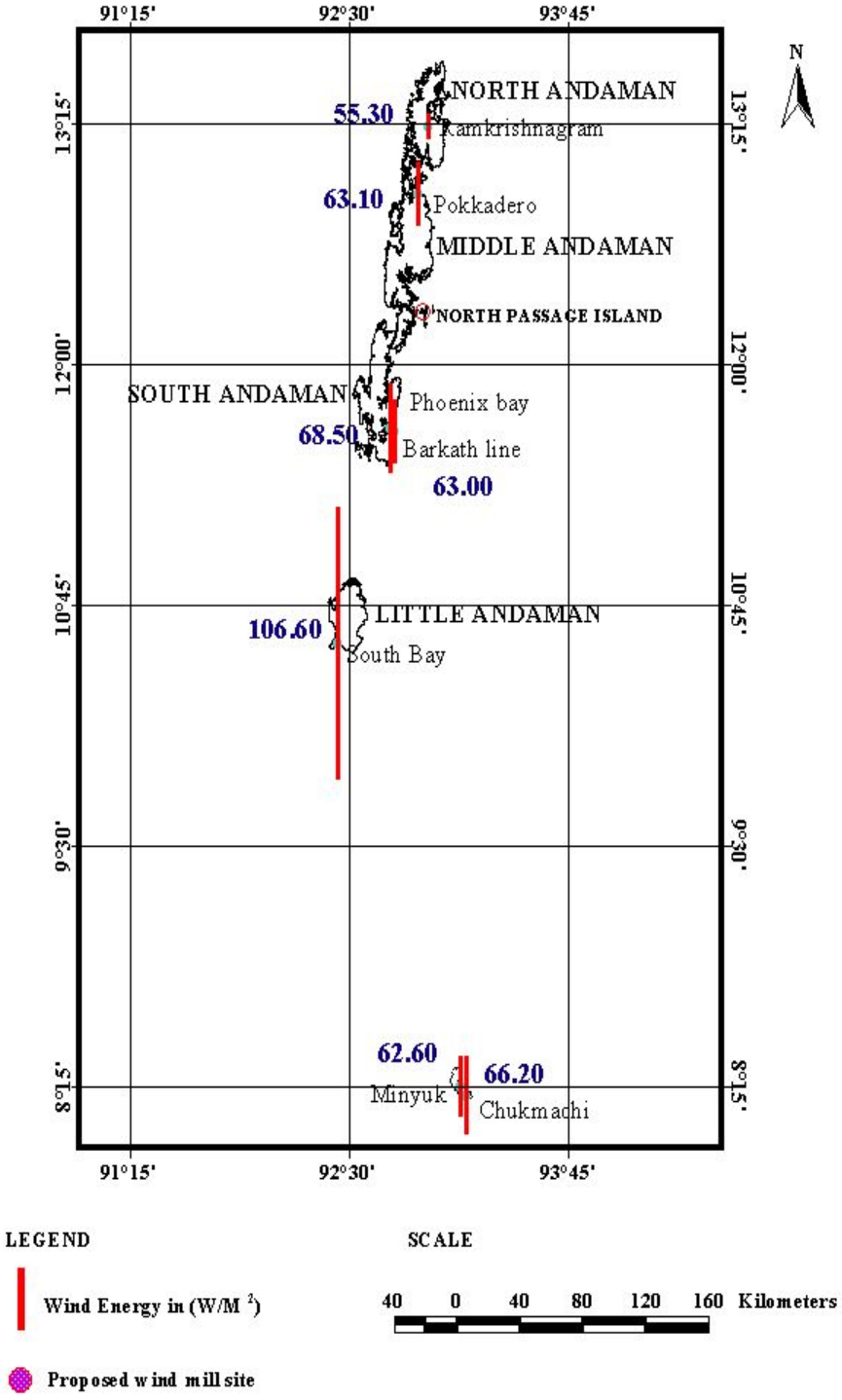

Figure 2. Wind energy noticed in Andaman & Nicobar Island and proposed wind mill site

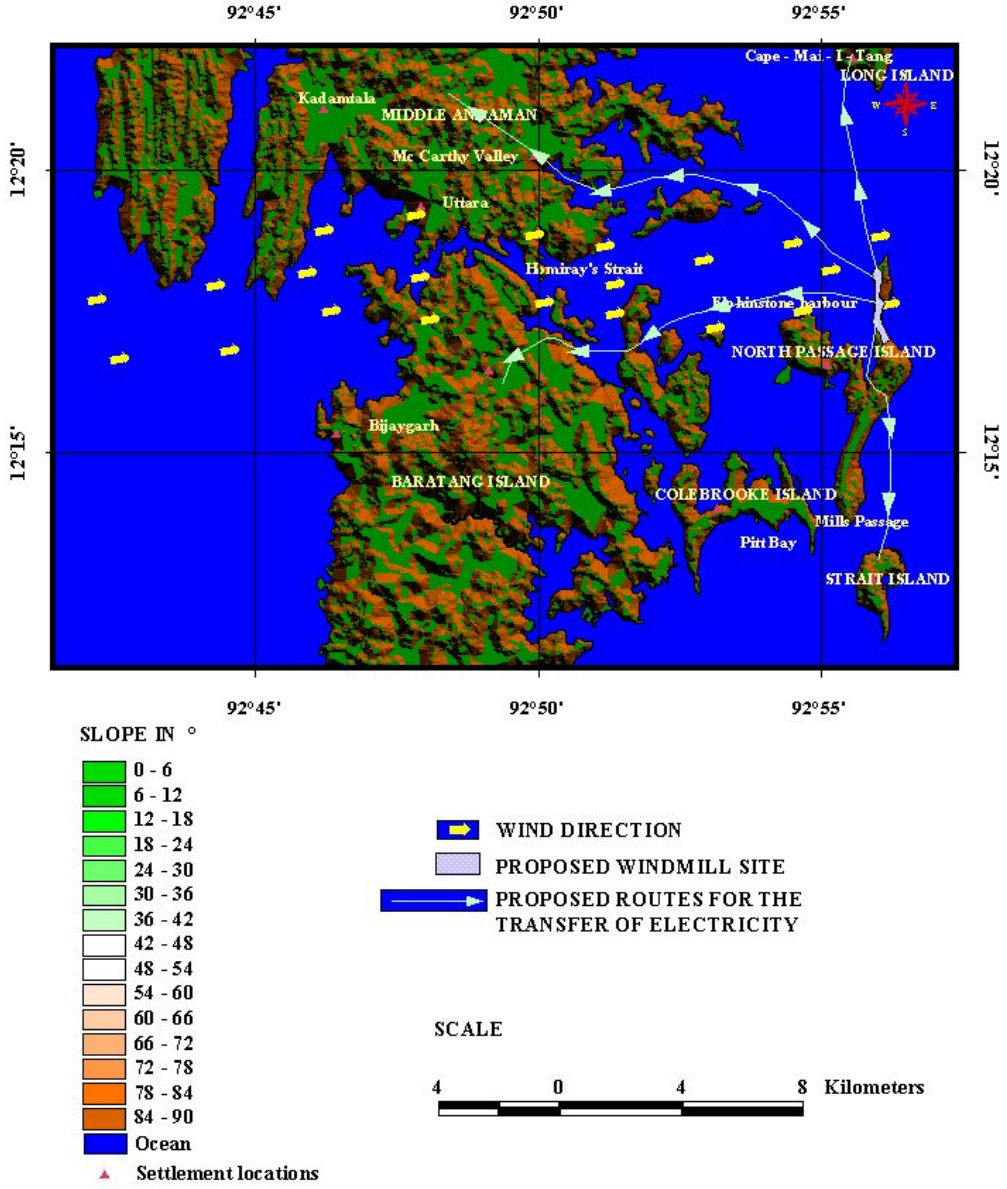

Figure 3. Proposed windmill site and transfer of electircity map using Survey of India toposheet (1969) and IRS LISS III 2003 satellite imagery

this an excellent locality for erecting wind mill. Because of the U shaped valley and proximity to the sea the wind action were found to have good speed (Figure 3).

The electricity generated through this wind mill could be transferred to the nearest inhabited islands also. The following islands were the nearest inhabited islands from North Passage Island (Figure 3). The distance from North Passage to Long Island is 7.8 km, Strait is 8.3 km, Baratang is 15.11 km and North Andaman is 11.9 km. Implementation of this study would be extremely useful to the inhabitants of this island as well as to the nearby neighboring islands.

5. CONCLUSION

This study investigates the potential of satellite technology to identify the site for erecting windmills. The usage of ArcGIS software for the integration of thematic information such as geomorphology, wind, landuse etc through satellite imagery, field survey data and other attribute information enhances the study as well as increases its accuracy. Similar study could be attempted in other parts of the Andaman islands where the air flow is free and probably at the windward side of the island i.e. the western portion of Andaman.

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