Island topography and Water resource assessment for South Andaman Island, India

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Abstract

Andaman and Nicobar Islands are the largest archipelago system in the Bay of Bengal. Geological factors that control surface and sub surface hydrological conditions of these islands. South Andaman Island topography is hilly terrain with coastal tract of fallow lands. Aster DEM data and topographic contours were processed using ArcGIS 10 software to study the hydrological setting of this island. Due to the undulated nature of island enormous number of low order streams and some of high order streams are running throughout the island. Average rainfall of the island ranges from 3000 to 3500mm which act as an important source of water. Even though the rain water source is abundance which is only persist in monsoon season. Due to limited capacity of Reservoirs in respect to the population and Land usage, water scarcity arises in the month of February to April. In the southern part of the island Dhanikari dam is the major water source for the settlements in Port Blair and surrounding region. Another dam situated in Chouldari which provide water for local irrigation. After December 2004 tsunami and earthquake results to salt water intrusion in ground water which is the major problem in many parts of island. This sea water intrusion is common in the fault zones which are identified by geophysical instruments and by chemical analysis. Dense hills and ranges of the northern part of the island results to high order streams but having limited number of population, absence of reservoir and no consumption of ground water. Since there is imbalance condition of water resource utilization persists in this island.

***Keywords:** South Andaman, Water resources, GIS, Remote Sensing, Seawater intrusion*

1. Introduction:

Water is one of the most vital and limiting factor in life supporting system on earth and is expected to be one of critical natural resource in 21st century [1]. It is a unique resource that essential for sustaining all forms of life, food production, economic development, and for general well being. Steady growth of Population, land usage and urbanization results to significant demand of water need for domestic, agriculture and industrial purposes [2]. Since maintaining this resource is essential need for bode well. Techniques such as Remote Sensing and Geographical Information System (GIS) provides wide variety of applications in assess, monitor and management of the water resources [3]. Water resources of a country constitute one of its vital assets that plays significant role in health, wealth and economy of nation.

1.1. Indian scenario:

Water resources of India are quantitatively large but their occurrence, distribution and utilization are significantly divergent from place to place [4]. India occupies geographical area of 3.29 million km^2 only, which forms around 2.4% of the world's land area but it having 1/25th of world's water resources [5]. The average annual precipitation of about 4000 km^3 but it is uneven which leads to flood and drought in very high spatial and temporal variability [6].

The Andaman and Nicobar Islands are the largest archipelago system in the Bay of Bengal, consisting of 345 islands and 206 rocks and rocky outcrops [7]. The major rain water source is rainfall most of which is lost by runoff in the sea and evaporate. Less than half is feasible to store in lakes, tanks, ponds and reservoirs [8]. Water resource

management for island scenario is difficult and it is important to study the resources for sustainable island management.

Study Area

The study area South Andaman (SA) Island is surrounded by Bay of Bengal in the west and Andaman Sea in the east, which is located between 11°56'51''N to 11°28'10''N and 92°47'53''E to 92°27'46''E which shown in the figure 1. The islands lie approximately 1200 km away from the mainland of India. The urban area Port Blair is located in the SA island where the Harbour and Airport which connects the mainland. The population of SA Island was 133337 as per 2001 census [9].

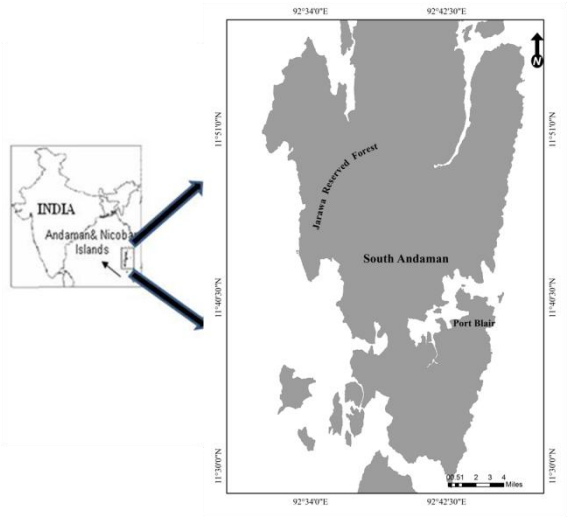


Figure 1: Shows study area map of South Andaman Island

2.1. Climate:

The SA archipelago is situated in the equatorial belt which has a tropical climate, warm, moist and equable. The average annual temperature ranges from 18 to 35°C. Average annual Rainfall ranges from 3000 to 3500mm. This island is surrounded by ocean since the maximum humidity persist which varies from 66 to 85% [10].

2.2. Geology

The Arakan Yoma Range of western Myanmar in North east Himalayas and Irrawadi in south rises as Andaman and Nicobar Ridge [11, 12]. The main ridge of Andaman and Nicobar exposes flysch sediments of paleogene age with occurrence of ophiolites and metamorphic of late cretaceous to early paleogene age [13].

2.3 Soil

Soil cover is more or less varying between 2 to 5 meters in the hilly tracts. The alluvial soil is found on the top of the ridges and dialluvial soil covers the blocks of ridges and valleys. Thick alluvial soil range from 30 to 50m forms along the river courses which allows percolation. Since it plays important role in ground water recharge. Coastal flats are admixture of sand silt clay and dialuvial material, together with fine fragments of coral lime. The soil in general is mud to moderately acidic with appreciably high humus on top [14].

3. Materials & Methodology:

ASTER DEM Image (2010), IRS R2 (Resource SAT 2) satellite image 2013, Survey of India Toposheet (1979) and Rainfall data from Indian Metrological Department. Software such as ArcGIS 10 and ERDAS 11 were used for this study. Ground Penetrating Radar (GPR) and Garmin Ertex GPS was used for field survey.

Digital Elevation Model was created using Aster DEM data and topographic contours and spot heights. Due to finer resolution ASTER DEM was taken for further analysis. Using ArcGIS 10 software Slopes, Aspect, Flow Direction, Flow Accumulation were generated by its tools for studying the landscape and water resources [15]. Drainage pattern refers to spatial relationship among streams or rivers which may be influenced by slope, soil, structure and geology of the region. [16]. Slopes control flow pathways of the surface water and influence the subsurface flow pattern substantially. Using GIS technology and available ASTER DEM slope aspect was generated. The drainage pattern over an area and hydrological parameters such as flow direction and upstream flow accumulation can be modelled from the slope map and aspect map [17]. Water availability is mainly governed by the runoff available in the basin. Runoff is the most important hydrological variables used in many water resource applications [1]. In addition other water resources also identified and mapped with existin information, satellite image and field survey. Finally the above maps are interpreted and water resource for SA Island was mapped. Risk assessment was made based on the availability of water resources like streams, ponds, lakes and ground water. The tsunami inundation caused salination of ground water in the study area [18]. So GPR survey and water

analysis was carried out to identify the ground water risk.

4. Result and Discussion:

4.1. Island Topography

The topography of the SA Island is the hilly terrain with the coastal tracts of fallow lands [19]. The elevation ranges from 0 to 460m, Mount Koyob is the highest peak present in the north part of SA Island. The slope map shows highly elevated areas occur mostly in the northern part of the Island and southwest of the southern part have hilly regions (Figure: 2). Slopes in the northern part of the island results to continuous undulated hills resemble to mountain ridge region comprises dense forest and flat lands in the foot hills. Whereas in the southern part west side having undulated hills, remaining areas with ledges and flat lands. Vegetation extended on the flat lands and plantation in the foothills. The aspect map shows the direction of the slope (Figure: 3) which mostly faces eastwards that results most of the rivers flow towards east.

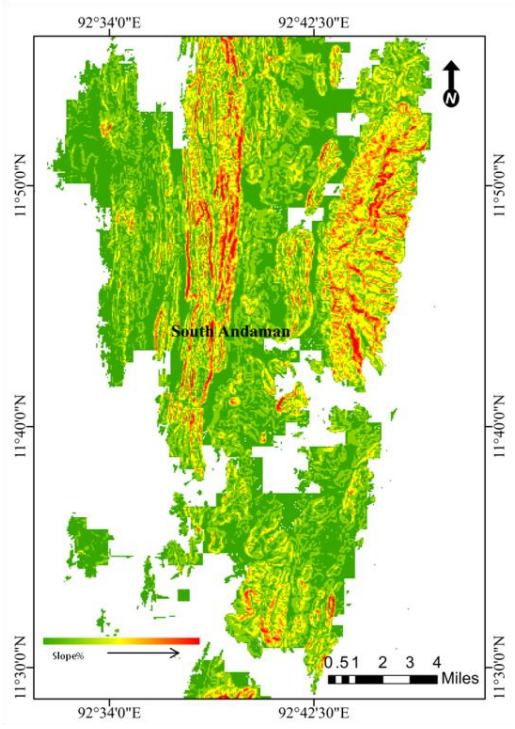


Figure 2: Slope map extracted from ASTER DEM

Since the topography defines the pathway of surface water flow which use to identify the stream orders and water shed. Flat terrains exist in smaller portion of this island which found on Sippighat, chouldari, mithakari and tusanabad. The flat lands exist near the coastal regions are low lying lands some of the areas are submerged during tsunami inundation except in tusanabad.

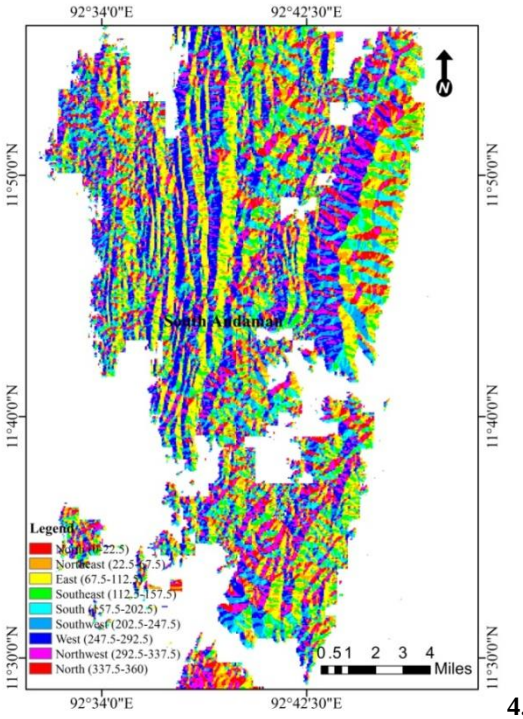


Figure 3: Aspect Map extracted from ASTER DEM shows direction of slope

4.2. Water Resource Assessment:

Water resources for the Andaman and Nicobar Islands from extensive rainfall, Rivers and streams with water storage reservoir and check dams, ground water

4.2.1. Rainfall:

The Island gets the rainfall from South West monsoon during the month of May to July with early downpour from the April. North East Monsoon during september to November. In addition to this downpour also occurs except during December to March. The island gets the maximum rainfall from the South West monsoon. The rainwater harvesting system is time being in this island, since the development of rainwater harvesting methods is needed to reduce the water scarcity

4.2.2. Rivers and Streams:

Rivers and streams flow unrestrictedly to downstream were studied using Flow direction tool in the ArcGIS 10 software. Due to undulated topography many of the streams are seasonal and some of the streams are perennial. The maximum stream order of

upto sixt in northern part and five in the southern part of the island (Figure: 4a). The higher order streams are delineated by the flow accumulation tools which are mostly perennial as shown in figure 4b.

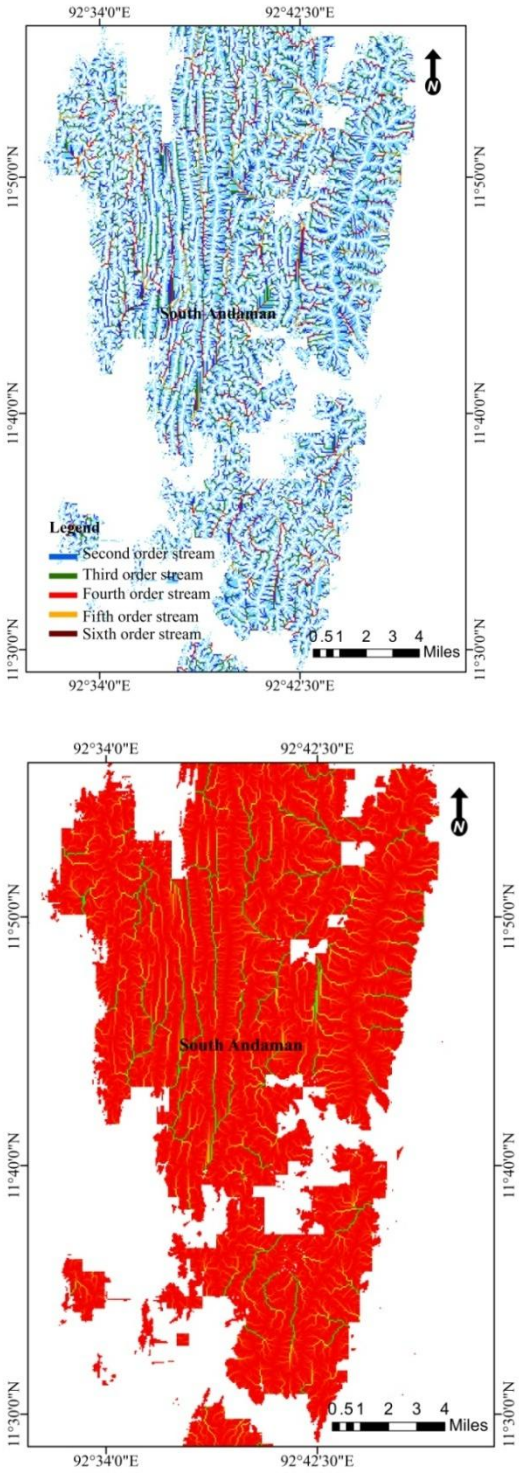


Figure 4: a) Stream Order map b) Flow accumulation map shows perennial rives of South Andaman

Even perennial streams also dry rarely during the summer. Dahnikari dam is the major source of water which provides water for domestic and irrigation facilities in Port Blair region. Chouldari dam have less capacity and provides water for the irrigation and local domestic purposes. Further few check dams are constructed in the streams significant for nearby settlements and vegetation.

4.2.3. Ponds and Wells:

Ponds and open wells are mostly used to water storage for irrigation purposes and some of the domestic purposes in the rural area. According to Ratan in 1990 [8] 56 ponds present in SA Island presently there are more than 75 ponds exist which indicates increase of pond water irrigation. Most of the ponds are connected with adjacent brooks and streams. Open wells mostly present in the flat areas and foot hills. Bore wells are mostly in the urban areas for the domestic purposes.

4.3. Resource and Risk Assessment:

Rain water plays sufficient role all around the SA Island but due to lack of storage capability it runoff to sea. The urban area lacks the water resource and insufficient streams and lake water source. So the municipality regime the charge of supplying water from Dhanikhari reservoir to the urban area Port Blair. Most of the areas in the southern part also depend on municipal water with some addition source of ground water. Dhanikari River also provides water to sippighat and nearby settlements (Figure: 5).

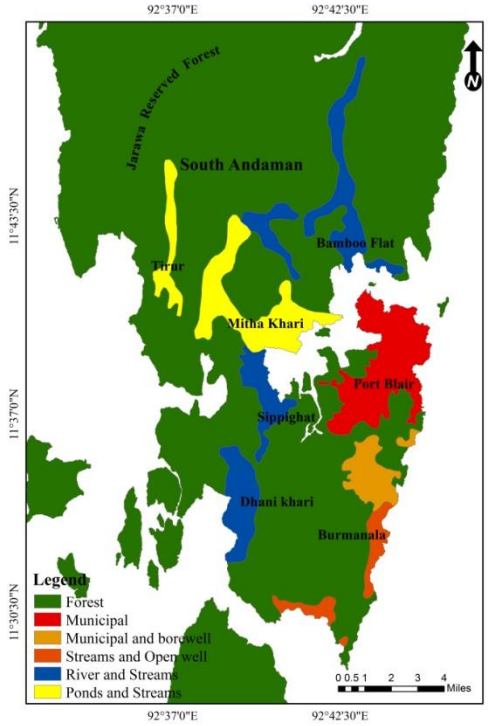
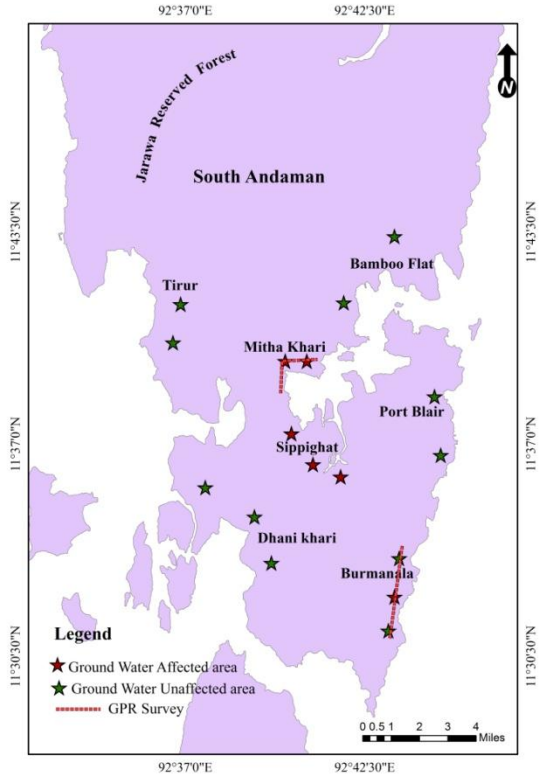


Figure 5: Water Resource Map of South Andaman Island

The gracious streams and rivers present in the northern part of the Island supplies water for the Bamboo Flat region. Ponds and stream water provides water for domestic and irrigation purposes in Mithakhari and Tirur region.

Most areas in the island, especially in the urban areas drinking water shortage occurs in the months of March and April, in spite of the annual rainfall being almost 3500 mm [20]. Water scarcity persists in the summer season particularly in the urban areas and rural remote areas. The seasonal streams will dry and perennial streams lack the sources which lead to less potential load of water. Harbour and airport transportation to the mainland is located in the Port Blair region of SA Island, since the landuse development was increased in and around the city. The city lacks the source of adequate fresh water source, landuse and urban development vanish water harvesting structures like ponds. Landuse management plan should be develop for the sustainable development of this island.

The exploration of ground water through open and bore well commenced to solve scarcity problem but it is insufficient and some of the areas are affected by tsunami inundation impacts. Water analysis and GPR survey was made in the few places (Figure: 6). Water Samples collected from both the bore and open wells and chemical analysis are made. In Mithakari tsunami inundation impacted the adjacent ground water. In addition the GPR survey indicates the presence of fault zone in the area.



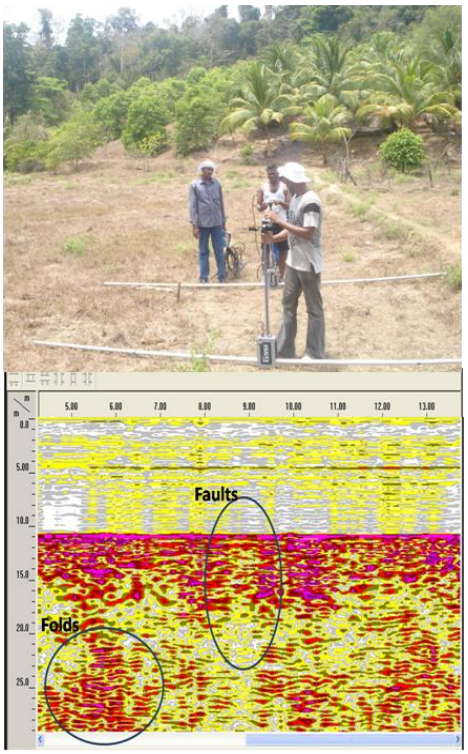


Figure 6: Water analysis for ground water salination and GPR Survey in Study area and GPR Profile shows the fault and folds in the study area.

Conclusions:

Digital Elevation Model of South Andaman used to elaborate the topography and water resources. Slope map shows the presence of hills and ranges in the northern part and undulated hills in southwest part of the island. Aspect map denotes the maximum slope features facing towards east and minimum towards west direction. Further the drainage map derived for identifying the stream order where the SA Island have the maximum stream order of six in northern part and five in southern part. Based on the existing data other water resources are derived and mapped. The water resource map shows the features of water source in the island, ponds plays role in irrigation facilities, rivers and streams in rural domestic purposes and ground water in semi urban areas. Tsunami inundation leads to ground water seepage and salination which is studied and confirmed by GPR and water analysis. From this study it is concluded that the northern part of SA Island having good water source and southern part lacks which leads to water scarcity during summer. It is in need that proper land use plan and resource management techniques for this island ecosystem for the sustainable development.

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