Morphometric Analysis on Tectonic Events Based on Geomorphological Indices Using Remote Sensing and GIS-a Case Study of Andaman Island

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Abstract

An important component of neotectonics is tectonic geomorphology, which is considered to be the backbone of the study. Aside from being tectonically active, the Andaman and Nicobar Islands comprise one of the most active groups globally due to the collision of the Indian and Eurasia plates. Tectonic geomorphology of the South-Andaman Island is primarily addressed in the present study by incorporating geomorphological indices in order to analyze the tectonic activity and landscape evolution of 13 sub-basins. For the purposes of this study, the following indices were used: Asymmetry Factor (AF), Hypsometric Index (HI), Mountain Front Sinuosity (SMF), Longitudinal Profile (L), Transverse Topography Symmetry (T), and Basin Elongation Ratio (Bs). There has never been a study of this kind conducted in this region before. Tectonically active subbasins were observed in all the sub-basins with SMF values < 1.4. The Bs values indicate that basins are most often elongated and have trellis drainage patterns, indicating tectonic control. It can be concluded that the sub-basins are tilted at either end of the plane, as both Af values are < 50 and > 50 as well as T values approaching one (1). HI greater than 0.60 is indicative of tectonically unstable and actively raising subbasins such as Colinpur and Miletilek. The subbasins of Beodnabad, Burmanallah, Dhanikhari and West Jarawa showed HI values > 0.30 and < 0.50, indicating relatively stable landscapes, however still under development. According to longitudinal profiles of all streams, disequilibrium

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conditions were responsible for uplift along the active fault. Burmanallah sub-basin was the only one without much irregularity in slope because the rock types were homogenous.

Keywords: *Geomorphic Indices, Neotectonics, ASTER-DEM, Basin Analysis, GIS, South Andaman Islands*

1. Introduction

According to Keller and Pinter (2002), tectonic geomorphology studies the origin and the shape of landforms that have been formed as a result of tectonic processes or uses the principles of geomorphology to determine the magnitude, history, and degree of the process. In this article, the emphasis is placed on the difference between geomorphological features and topography that has been formed as a result of tectonic forces and erosion resulting from surface processes (Burbank and Anderson, 2001). There is a wide spectrum of effects that tectonics can have on a landscape's geomorphology, ranging from minutes to thousands of years. It is important to note that these effects are largely determined by the type of bedrock underneath. Andaman and Nicobar Islands have a very complicated tectonic setup, because they are located at the center of the Burma-Sunda- Java subduction belt, a 5000 km long belt (Allen et al., 2007). The north of the 90° E ridge is connected in a north-south arc that separates the Sunda and Indian plates (Curray 2005; Dasgupta and Mukhopadhyay 1993) (Figure-1). A study by Malik et al. (2006) concluded that the Andaman spreading zone, which lies between the latitudes of 10° N and 12° N, is enclosed by the Sunda fault system in the eastern part of the archipelago. It has been often referred to as the Burma micro plate since it plays an important role in the evolution of minor tectonic plates (Dasgupta and Mukhopadhyay, 1993; Ortiz and Bilham, 2003; Kayal et al., 2004). There have been various active strike-slip and thrust faults formed since the Cretaceous period due to deformations caused by subduction along trenches either irregularly or continuously (Tapan pal, 2003; Malik et al. 2006 and Chakraborthy, 2009). In Northern Sumatra-Andaman, an oblique subduction was created, which resulted in a strike-slip movement, which also caused the development of a sliver plate between the right-lateral fault system and the subduction zone (Chakraborthy, 2009). During the late Paleocene, the collision between Asia and greater India had a more or less normal convergence, which caused the Northern and Western Sunda arc to rotate and bend in a clockwise direction.

In the Eocene period, a sliver fault may have been initiated offshore of Sumatra and may have spread up to the present regional extent of the Sagaing fault within the Andaman Sea.

Since the strike-slip motion and back-arc extension were united due to oblique convergence, the rate of strike-slip motion was amplified by rotation. This resulted in the oblique opening of an array of extensional basins. An oblique motion between the Burma-Sunda plate and the Indo- Autralian plate appears to have been initiated with the help of existing strike-slip motions in the Andaman Sea, thrust motions in the Sumatra-Andaman trench, ridge-arc systems in the Sumatra faults, and back-arc movements in the southern region (McCaffrey, 1992; Sieh and Natawidjaja, 2000). A section of the Andaman-Sumatra trench lies at the western end of the Andaman-Nicobar ridge and is filled with sediment flowing from the Bengal fan. The Andaman-Nicobar Ridge is believed to have formed during the Late Eocene or Oligocene period and is composed of either seabed ophiolites or sediments from the Indian plate covered by sediments from the shallow water forearc region (Allen et al., 2007; Curry, 2005). This region has been classified as zone V in the recent seismic map of India, as a result of its complex tectonic setup and frequent earthquakes of a mild to moderate severity. Furthermore, this entire chain of islands is also susceptible to other natural disasters, such as tsunamis resulting from both large earthquakes and massive shock waves from afar. This is due to the fact that the earthquake database in India is still incomplete, particularly for earthquakes that occurred prior to the historical period (prior to 1800 AD) (Figure 1.1).

The objective of this study is to morphometrically analyze South Andaman Island in order to address landform evolution and tectonic intensity. This is the first study to apply geomorphic indices, namely mountain front sinuosity (SMF), transverse topography symmetry, asymmetry factor, basin elongation ratio, longitudinal profile, and hypsometric index. All measurements have been determined by manually calculating the values of the above indices, since they are the benchmark for any seismic activity (Bull and McFadden, 1977 and Silva et al. 2003). A topographic map was used to measure the valley height, and then these values were compared with the values from the field in order to evaluate their consistency and accuracy (Bull, 1968, 1977a, 1978, and Bull and McFadden, 1977).

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery was the primary source of Digital Elevation Models (DEMs) as well as an input for the analysis of other digital data. Various interpretations of DEM images are very popular for assessing motion within tectonically active regions (Grygar and Jelnek, 2003; Wojewoda, 2004, 2005b, 2006b, 2007b; Jordan et al. 2005; Kervyn et al. 2006 and Grohmann et al. 2007). An important method for morphotectonic analysis is the DEM analysis. In the present study, a new approach has been employed in order to confirm movement within the areas of tectonic activity by using a digital method combining multiple layers of geographic data, satellite imagery, and digitized calculations of a number of geomorphological indices. To determine tectonic activity along the mountain fronts of the South Andaman Island, this study aims to transition from traditional morphometric analysis to digital morphometric analysis. In the present study, six basins have been named after nearby localities: Beodnabad, Burmanallah, Colinpur, Dhanikhari, Miletilek and West Jarawa.

2. Study Area

The current study examines six sub-basins of South Andaman Island (Figure 2), which is part of the southern group of the Andaman Islands, namely Beodnabad, Burmanallah, Colinpur, Dhanikhari, Miletilek and West Jarawa. This study area comprises Andaman Flysch, Mithakhari, and Ophiolite rock types, as illustrated in Figure 3, and is characterized by a number of trench parallel and trench perpendicular structures. Further, a number of faults in compressional, tensional, and shear regimes run through it in the N-S, NE-SW, and E-W directions. There are mainly trellis and dendritic drainage systems in the study area, which are governed by local faults and fractures.

3. Methods

3.1 Mountain Front Sinuosity Index (SMF)

The Mountain Fronts are the foremost fault-bounded topographic ridges that have measurable relief, surpassing one contour interval of 20 meters. A measure of SMF is the extent at which erosion has modified the tectonic structures (Bull, 1977a, 1978; Bull and McFadden, 1977; Rockwell et al. 1984; Wells et al. 1988; Keller and Pinter, 2002; Silva et al. 2003). The method is used to assess tectonic activity along mountain fronts (Keller and Pinter, 2002; Silva et al., 2003). Using the following formula, it can be calculated.

SMF = LMF / Ls

Specifically, SMF represents the mountain front sinuosity, Ls represents the length of the mountain front along the top of the mountain, and LMF represents the length of the mountain front along the bottom (Bull and McFadden, 1977; Keller and Pinter, 2002).

3.2 Basin Shape Index (Bs)

Geotectonically active mountain ranges typically have elongated basins that are parallel to their slopes on a topographical level. A reduced amount of tectonic activity and topographical uplift over time result in the elongated structures being replaced with rounded basins (Bull and McFadden, 1977). As tectonically active regions have narrower drainage basins along the mountain front, the force of the stream is directed primarily in the direction of downcutting. It is usually possible to determine the planimetric or horizontal shape of a basin using the elongation ratio or basin shape index, Bs (Ramirez-Herrera, 1998), which is calculated a†s follows:

$$B_s = \frac{Bl}{Bw}$$

Where, Bl is the length of a basin measured from the headwaters point to the mouth, and Bw is the width of a basin measured at its widest point. Higher values of Bs indicates elongated shape of the basin which can be associated to comparatively higher tectonic activity. Lower values of Bs indicate a more of a rounded-shaped basin representing relatively lower tectonic activity. Thus, it can be concluded that the Bs value signifies the rate of tectonic activity.

3.3 Drainage Basin Asymmetry (AF)

An index such as this can determine tilting from basin scales to larger areas as a result of tectonic activity, and is particularly sensitive to tilting which occurs perpendicular to the trunk stream. The calculation can be expressed as follows:

$$AF = 100\ (Ar|At)$$

Here, AF represents the asymmetry factor, Ar represents the area of the basin on the right side of the stream trunk, and At represents the total basin area. In stable conditions, most networks of streams have an AF of 50. When a value exceeds 50 by a significant amount, it indicates the influence of tectonic activities, such as the slipping of bedding plains by streams in the course of time (El Hamdouni et al. 2008). In the case of relatively few or slight tilts that are perpendicular to the stream trunk, a value near 50 can be inferred. Considering that active tectonics has tilted the drainage basin to the left, tributaries adjacent to the left side of the main stream will be shorter than those adjacent to the right side by an asymmetry factor greater than 50 and vice versa (Hare and Gardner, 1985; Keller and Pinter, 2002).

3.4 Transverse Topographic Symmetry Factor (T)

The Transverse Topographic Symmetry Factor (T) is calculated by using the formula below

$$T = {}^{Da}/_{Dd}$$

Here, Da indicates the proximity between the midpoint of drainage basin and the midpoint of active meander belt, while Dd indicates the proximity between the midpoint of drainage basin and the basin divide. Consequently, the T value indicates the direction in which the streams migrate perpendicular to the drainage basin axis. Therefore, this index provides a medium for calculating the magnitude and direction of change that may be found between 0 and 1 (T = 0 to 1), which corresponds to a perfectly asymmetrical basin or a tilted basin (Cox, 1994; Cox et al. 2001; Burbank and Anderson, 2001; Keller and Pinter, 2002). It is evident that T values increase and approach 1 as the streams migrate laterally away from the basin center and toward either of the two margins. The main stream of the subbasin was segmented into 1 km long stretches for the calculation of the T index in this study. Then, a two-dimensional vector was created based on the T value calculated for each segment. There is a proportional relationship between vector length and the ratio Da / Dd, and the direction of migration is perpendicular to the segment of the stream. Vector direction reflects the direction in which a segment moves with respect to the midpoint of the basin. The AF index as well as the T index can be used quantitatively to identify tilting of the ground (Cox, 1994; Cox et al. 2001; Keller and Pinter, 2002).

3.5 Hypsometric Integral (HI)

In general, the Hypsometric Integral index is calculated for a specific drainage basin, and its composition is unaffected by the basin's size. An elevation index illustrates the pattern of elevation distribution in a landscape, particularly in drainage basins (Strahler, 1952). It is defined as the area below the hypsometric curve, which is a measure of the volume of the basin that has not been eroded. Calculating HI is done by directly obtaining the minimum and maximum elevations of the topographic map (Mayer, 1990; Keller and Pinter, 2002). Using a point sampling method on a grid, the mean elevation value of the basin is determined by taking into account at least fifty values of elevation (Pike and Wilson, 1971; Keller and Pinter, 2002; Luo, 2002; Luo and Howard, 2005). According to Davis W.M. (1899), a value of less than 30 indicates "tectonically stable", "mature", and "denuded" basins, whereas a value above 60 indicates "unstable", "young", and "actively uplifting" basins. Higher values of HI usually indicate that very little of the landscape has been eroded, which suggests that the landscape may be young or immature as a result of active tectonic activity. It is generally accepted that lower values are associated with mature landscapes that have undergone more erosion and have a smaller impact from active tectonic movements.

$$H_i = \frac{Mean\ elevation - Minimum\ Elevation}{Maximum\ Elevation - Minimum\ Elevation}$$

3.6 Longitudinal Profile

It is widely accepted that longitudinal profile analysis is an effective method of identifying how rivers respond to active tectonic activity (Sinha, 2001). As it shows distance on the x-axis and elevation on the y-axis, its effectiveness is determined by the fact that irregularities in channel slope can be seen in disequilibrium conditions, which indicate uplift along active faults. A profile that is upwardly concave indicates mature basins and channel degradation resulting from a longer period of time since the basement was lowered, whereas an upwardly convex profile indicates less down-cutting of channels and continuous lowering of the base level and/or shorter time since the base level fell (Wells et al. 1988).

4. Results

4.1 Mountain Front Sinuosity Index (Smf)

For each of the six sub-basins, mountain front sinuosity was calculated (Figure 5). After evaluating all mountain fronts, the average of all values obtained was calculated (Figure 5.1). Based on SMF values of Colinpur, Dhanikhari, Miletilek, and West Jarawa, all are classified as Class One (SMF 1.0 -1.4, Tables 1 c, d, e, and f, respectively), indicating that all mountain fronts are tectonically active. As the SMFs for the remaining two subbasins, Beodnabad and Burmanallah, were > 1.4 (Tables 1 a and b, respectively), they were classified under Class Two, indicating a relatively low tectonic activity.

4.2 Basin Shape Index (Bs)

Using the drainage basin shape equation, each sub-basin was calculated (Figure 4). An increase in the ratio of Basin shape index (Bs) indicates tectonically active basins (Cannon, 1976), and similarly, in this study, the Bs of three sub-basins (Colinpur, Dhanikhari, and Miletilek) indicate elongation (Figure 6 c, d, and e, respectively), whereas an increased ratio of Bs (Figure 6.1; Table 2) indicates that these basins are tectonically active. Beodnabad, Burmanallah, and West Jarawa were found to have circular shapes (Figures 6 a, b, f), suggesting they are tectonically less active (Figure 6.1; Table 2).

4.3 Drainage Basin Asymmetry (AF)

The Asymmetry Factor (AF) calculated for each of the six sub-basins and the ratio are shown in Table 3. Colinpur, Dhanikhari, and Miletilek subbasins are tilted towards the right (Figure 7 c, d, and e, respectively) as the ratio is less than 50 (AF < 50), whereas Beodnabad, Burmanallah, and West Jarawa subbasins are tilted towards the left (Figure 7 a, b, and f, respectively), as the ratio is greater than 50 (Table 3).

4.4 Transverse Topographic Symmetry Factor (T)

For each of the six sub-basins, the Transverse Topography Factor was calculated. Table 4 shows the ratio of transverse topography symmetry. Transverse topography ratios were calculated for all segments at 1 km intervals transversely for each subbasin, as shown in Figure 8, and the values were averaged (Table 4). As a result, the ratios of the sub-basins - Beodnabad, Colinpur, Dhanikhari, and Miletilek - have been calculated to be approximately one (1), suggesting that these sub-basins are tilted. Burmanallah and West Jarawa have T values approaching 0, thus they are not considered tilted in the sense shown in Figure 8.

4.5 Hypsometric Integral (HI)

For all six selected sub-basins, the elevation/relief ratio factor (HI) was also calculated. Table 5 shows the ratios of the hypsometric index for all the subbasins. In the Colinpur and Miletilek subbasins, the HI is greater than 0.60, indicating that they are tectonically unstable and actively uplifting. As a result, the sub-basins namely Beodnabad, Burmanallah, Dhanikhari and West Jarawa, exhibit HI values > 0.30 and < 0.50, indicating that these sub-basins are relatively less stable tectonically, but still undergoing development. Landscapes or sub-basins with HI less than 0.30 are considered stable. The HIs of all the sub-basins in the study area, however, were greater than 0.30, indicating their tectonic instability.

4.6 Longitudinal Profile (L)

Stream profiles were plotted along the longitudinal axis for each sub-basin in order to identify irregularities in channel slope in the form of Knick points, which are ascribed to active tectonics. As seen in Figure 9, Beodnabad, Colinpur, Dhanikhari, Miletilek, and West Jarawa show irregular slopes indicating disequilibrium conditions along the fault line. The Burmanallah subbasin, however, did not exhibit much irregularity in slope due to its homogeneous rock type. There is evidence of upward concavity in the longitudinal profiles of the sub-basin streams, indicating that the headwater area is highly active tectonically (Figure 9).

5. Field Evidences on Active Faults and Interpretation

In the current study, field investigations have been conducted on selected and possible sites. There are several major faults in the South Andaman region, including Jarawa Fault, Bathubasti Fault, Beodnabad Fault, Jogger's Park Fault, Carbyn Fault and South Point Fault (Figure 10). A field investigation was conducted at the Beodnabad and Burmanallah sites in order to collect geological and geomorphological evidence that confirmed the active nature of the faults (Figure 11). As an initial step, the tectanogeomorphic landforms in Quaternary deposits are mapped, including fault scarps, pressure ridges, shutter ridges, sag ponds, river deflections, compressed meanders, and Knick points. It is challenging to conduct field investigations and validations at the other sites in the current study because they are in a reserve forest area.

6. Discussion

subbasins were examined based on geomorphic indices (SMF, Bs, Af, T, HI, and L). As shown in Table 1, Colinpur, Dhanikhari, Miletilek, and West Jarawa sub-basins have Mountain Front Sinuosity (Smf) values between 1 and 1.4, which indicates they are tectonically active (Figure 5). Beodnabad and Burmanallah are slightly tectonically active, with Smf values greater than 1.5 (Figure 5.1). Colinpur, Dhanikhari, and Miletilek have elongated drainage basin shapes and an increased ratio of Bs, which indicates tectonically active drainage basins (Figure 6 c, d, and e, respectively; Table 2). On the other hand, the sub-basins Beodnabad, Burmanallah, and West Jarawa, which are circular in shape, have a low Bs ratio, indicating that they are less tectonically active (Figures 6 a, b, and f, respectively; Table 2). It can be seen from Figure 7 that the Drainage Basin Asymmetry (AF) for Colinpur, Dhanikhari, and Miletilek sub-basins is less than 50 (Table 3), which indicates that there is active tectonic activity (Figure 7 c, d, and e, respectively). There is an AF ratio greater than 50 in the sub-basins of Beodnabad, Burmanallah, and West Jarawa (Table 3), indicating that these basins are also tectonically active (Figure 7 a, b, and f) and due to tilting, the drainage system changed direction and course. According to Table 4, Beodnabad, Dhanikhari, Colinpur, and Miletilek exhibit a close to 1 Transverse Topography Factor (TTF), indicating they are tilted and tectonically active (Figure 8). On the other hand, Burmanallah and West Jarawa had nearly zero TTF values (Table 4), indicating that they were moderately tilted and slightly active (Figure 8). Colinpur and Miletilek have a Hypsometry Index (HI) greater than 0.6 (HI > 0.6), indicating that they are tectonically unstable and are actively rising (Table 5). Beodnabad, Burmanallah, West Jarawa, and Dhanikhari have HI > 0.3 and 0.5, which indicates a relatively less stable tectonic environment (Table 5). Figure 9 depicts disequilibrium conditions that suggest uplift along active faults at Beodnabad, Colinpur, Dhanikhari, West Jarawa, and Miletilek. The Knick point in the river profile is clearly visible as a result of faulting. Burmanallah sub-basin (Figure 9) is the only exception, which shows no irregularities in slope due to the homogenous nature of the rocks. By analyzing current river/stream patterns and drainage basins, we can gain insight into past deformations (Friend et al., 1999).

7. Conclusion

In this study, morphometric analyses of drainage subbasins in Bumanallah, Colinpur, Dhanikhari, Miletilek and West Jarawa were conducted based on the following geomorphic indices: Mountain Front Sinuosity (Smf), Drainage Basin shape (Bs), Drainage Basin Asymmetry (AF), Transverse Topography Factor (T), Hypsometry Index (HI) and the longitudinal profile of the faulted fronts. As a result of the study, it has been concluded that landscapes have continuously evolved under the influence of tectonic activity throughout the sub basin region of South Andaman. While the bulk of the topography seems to have developed under compressional tectonics, the analysis provides ample evidence about how the landscape has evolved along active faults within the region.

Table 1 (a) Mountain Front Sinuosity (Smf) of Beodnabad. BEODNABAD

No.	Lmf	Ls	Smf = Lmf/Ls	INFERENCE
1	0.904	0.799	1.13	Tectonically Active
2	1.444	0.792	1.82	Slightly Active
3	1.713	1.106	1.54	Slightly Active

Table 1 (b) Mountain Front Sinuosity (Smf) of Burmanallah

BURMANALLAH				
No.	Lmf	Ls	Smf = Lmf/Ls	INFERENCE
1	1.248	1.018	1.22	Tectonically Active
2	0.553	0.480	1.15	Tectonically Active
3	0.660	0.474	1.39	Tectonically Active
4	1.004	0.787	1.27	Tectonically Active
5	1.962	1.022	1.91	Slightly Active

6	1.693	0.988	1.71	Slightly Active
7	1.235	0.740	1.66	Slightly Active
8	1.261	0.765	1.64	Slightly Active

Table 1 (c) Mountain Front Sinuosity (Smf) of Colinpur. COLINPUR

No.	Lmf	Ls	Smf = Lmf/Ls	INFERENCE
1	0.913	0.866	1.05	Tectonically Active
2	1.114	1.077	1.03	Tectonically Active
3	1.276	1.181	1.08	Tectonically Active
4	0.848	0.782	1.08	Tectonically Active
5	1.779	1.742	1.02	Tectonically Active
6	1.743	1.674	1.04	Tectonically Active
7	1.585	1.549	1.02	Tectonically Active
8	1.155	1.123	1.38	Tectonically Active
9	1.376	1.349	1.02	Tectonically Active
10	1.617	1.466	1.10	Tectonically Active
11	0.687	0.671	1.02	Tectonically Active
12	1.448	1.389	1.04	Tectonically Active
13	1.197	1.164	1.02	Tectonically Active
14	1.175	1.156	1.01	Tectonically Active
15	0.845	0.816	1.03	Tectonically Active
16	1.650	1.577	1.04	Tectonically Active
17	1.640	1.385	1.18	Tectonically Active
18	1.000	0.995	1.00	Tectonically Active
19	0.784	0.768	1.02	Tectonically Active

20	1.586	1.493	1.06	Tectonically Active
21	1.136	1.069	1.06	Tectonically Active
22	2.009	1.965	1.01	Tectonically Active
23	1.170	1.137	1.02	Tectonically Active

Table 1 (d) Mountain Front Sinuosity (Smf) of Dhanikhari

DHANIKHARI				
No.	Lmf	Ls	Smf = Lmf/Ls	INFERENCE
1	3.004	2.916	1.03	Tectonically Active
2	1.046	0.970	1.07	Tectonically Active
3	1.378	1.291	1.06	Tectonically Active
4	0.824	0.791	1.04	Tectonically Active
5	1.120	1.112	1.00	Tectonically Active
6	1.492	1.338	1.11	Tectonically Active
7	1.623	1.552	1.04	Tectonically Active
8	1.540	1.437	1.07	Tectonically Active
9	1.218	1.074	1.13	Tectonically Active
10	1.195	1.134	1.05	Tectonically Active

Table 1 (e) Mountain Front Sinuosity (Smf) of Miletilek

MILETILEK				
No.	Lmf	Ls	Smf = Lmf/Ls	INFERENCE
1	1.730	1.655	1.04	Tectonically Active
2	1.430	1.314	1.08	Tectonically Active
3	1.765	1.510	1.16	Tectonically Active

4	1.793	1.588	1.12	Tectonically Active
5	1.139	1.040	1.09	Tectonically Active

Table 1 (f) Mountain Front Sinuosity (Smf) of West Jarawa

WEST JARAWA				
No.	Lmf	Ls	Smf = Lmf/Ls	INFERENCE
1	1.426	1.422	1.00	Tectonically Active
2	0.977	0.954	1.02	Tectonically Active
3	0.999	0.857	1.16	Tectonically Active
4	1.283	1.102	1.16	Tectonically Active
5	0.988	0.828	1.19	Tectonically Active
6	0.847	0.844	1.00	Tectonically Active
7	1.745	1.597	1.09	Tectonically Active
8	0.905	0.812	1.11	Tectonically Active

Table. 2 Basin Shape Ratio of all the six sub-basins of South Andaman

BASIN SHAPE RATIO					
NAME	LENGTH	WIDTH	RATIO	SHAPE	INFERENCE
BEODNABAD	5.2	3.5	1.48	Circular	Tectonically Less Active
BURMANALLAH	4.7	5.17	0.92	Circular	Tectonically Less Active
COLINPUR	15.3	2.9	5.27	Elongation	Tectonically Active
DHANIKHARI	14.2	2.9	4.89	Elongation	Tectonically Active

MILETILEK	6.9	2.1	3.28	Elongation	Tectonically Active
WEST JARAWA	8.2	6.5	1.2	Circular	Tectonically Less Active

Table 3. Asymmetry Factor Ratio of all the six sub-Basins of South Andaman

NAME	Ar	At	RESULT	INFERENCE
BEODNABAD	3.65	5.85	57.54	LEFT SIDE
BURMANALLAH	6.77	11.05	61.26	LEFT SIDE
COLINPUR	10.28	29.25	35.14	RIGHT SIDE
DHANIKHARI	7.80	24.88	31.35	RIGHT SIDE
MILETILEK	3.00	12.11	24.77	RIGHT SIDE
WEST JARAWA	11.35	19.56	58.02	LEFT SIDE

Table 4. Transverse Topography Ratio of all the six sub-basins of South Andaman

NAME	RESULT	INFERENCE
BEODNABAD	0.29	Tilted
BURMANALLAH	0.15	Less Tilted
COLINPUR	0.39	Tilted
DHANIKHARI	0.40	Tilted
MILETILEK	0.51	Tilted
WEST JARAWA	0.07	Less Tilted

Table 5. Hypsometric Index of all the six sub-basins of South Andaman.

BASIN	HYPSOMETRIC INDEX	INFERENCE
BEODNABAD	0.38	Tectonically Less Stable
BURMANALLAH	0.35	Tectonically Less Stable
COLINPUR	0.60	Tectonically Unstable
DHANIKHARI	0.56	Tectonically Less Stable
MILETILEK	0.68	Tectonically Unstable
WEST JARAWA	0.49	Tectonically Less Stable

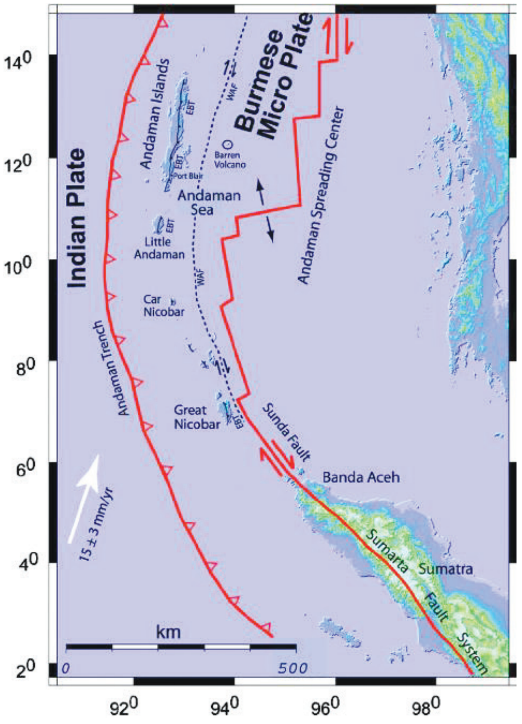

Figure 1: Tectonic setting of Andaman and Nicobar Islands (modified after Malik. 2006) shows very complex tectonic regime with both compression (subduction), expansion and strike-slip movements along Sunda Fault (Sumatra Fault System)

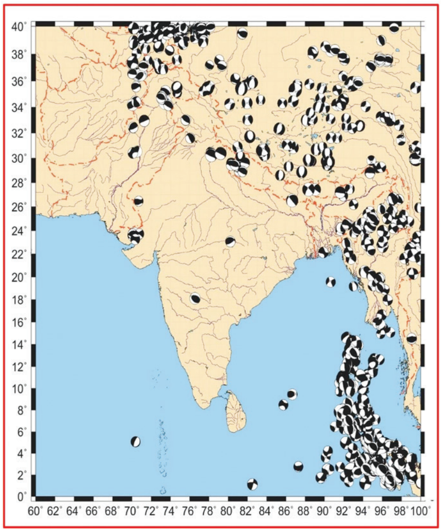

Figure 1.1: Seismotectonic setting of the Indian and Burmese micro Plate and focal mechanism solutions of almost 700 interplate and intraplate earthquakes derived from Harvard CMT solutions from 1/1/1997 – 1/1/2014 and processed in GMT. Dark and blank quadrants show compressional and dilatational fields respectively.

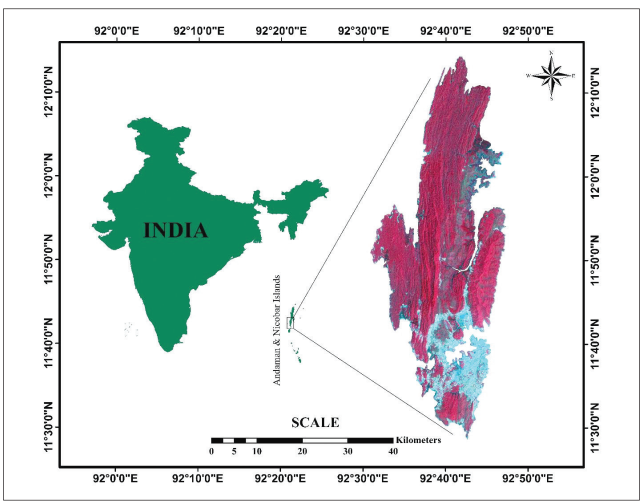

Figure 2 : Map showing the location of South Andaman, India

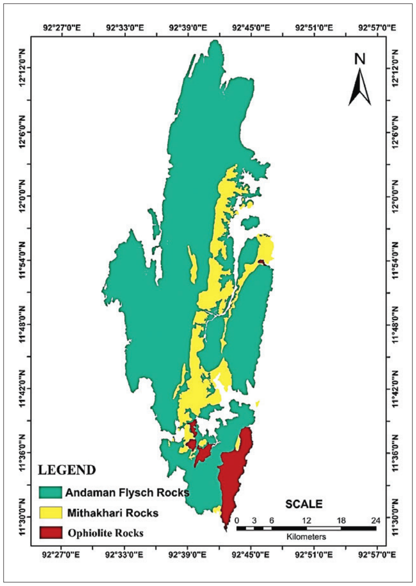

Figure 3 : Lithostratigraphy map of South Andaman, India

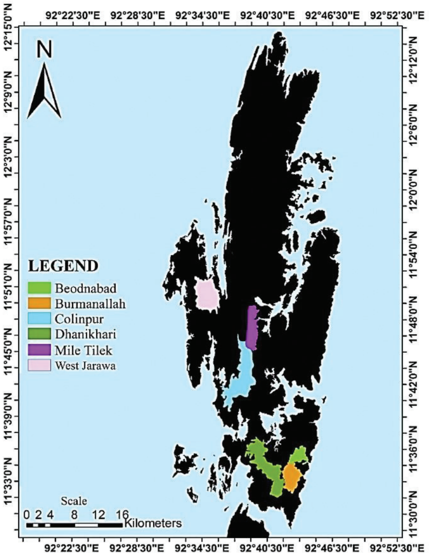

Figure 4 : Six Sub-basins of South Andaman Island were used for current study

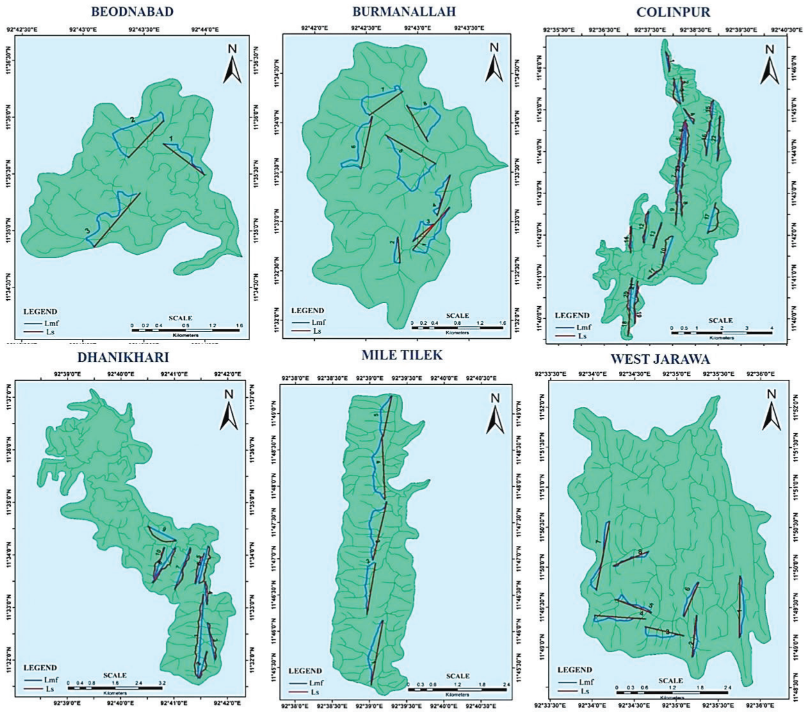

Figure 5 : Mountain Front Sinuosity (Smf) of Six Sub-Basins

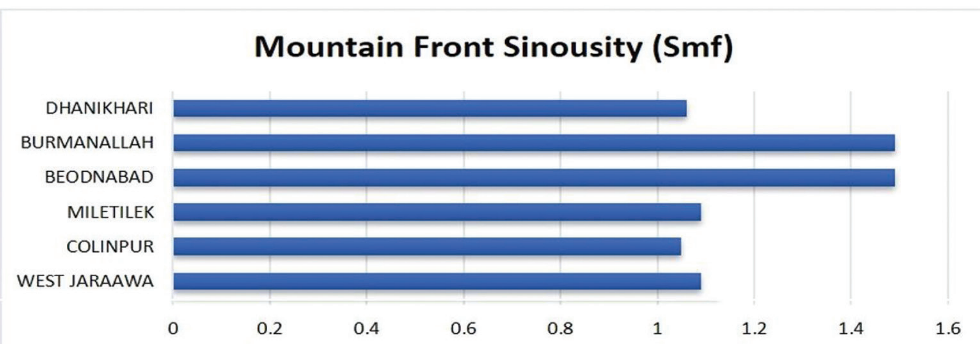

Figure 5.1: Average Mountain Front Sinuosity (Smf) of all the Six Sub-Sasins

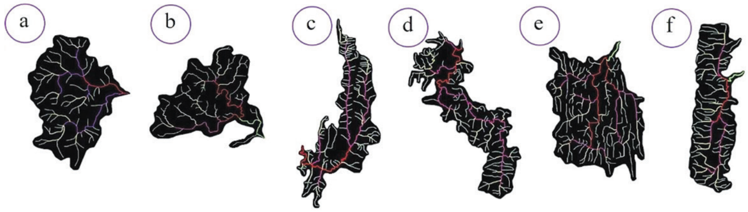

Figure 6 : Drainage Basins Shape (Bs) of six Sub-basins; (a) Beodnabad, (b) Burmanallah, (c) Colinpur, (d) Dhanikhari, (e) Miletilek, and (f) West Jarawa

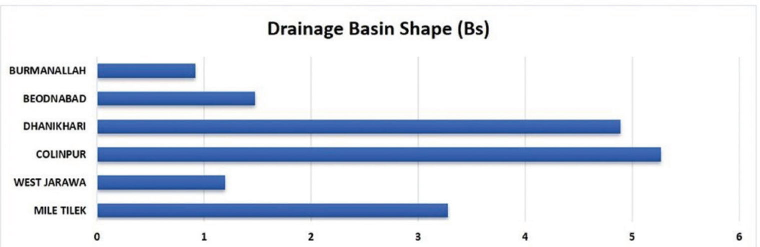

Figure 6.1. Drainage Basin Shape Ratio of Six Sub-Basins

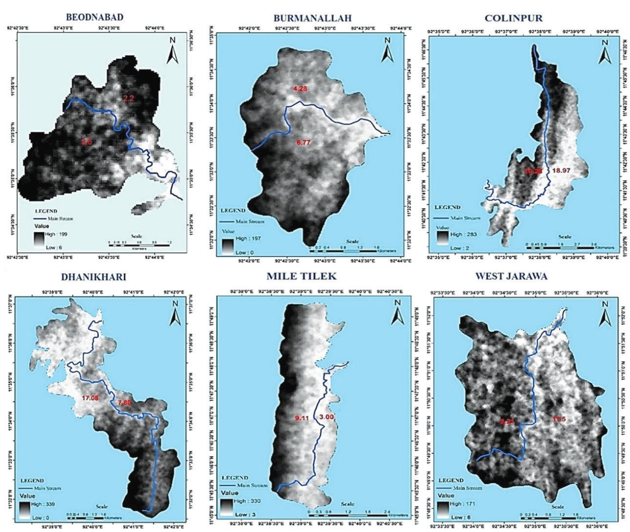

Figure 7. Drainage Basin Asymmetry (AF) of all the Six Sub-Basins

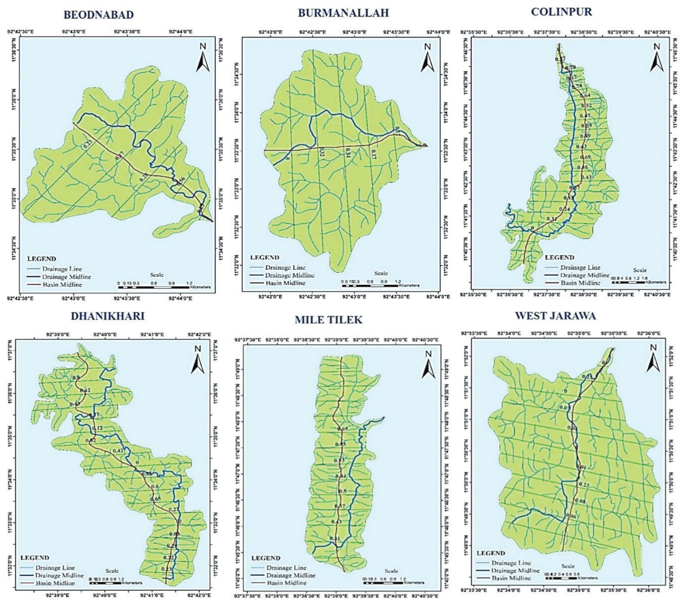

Figure 8. Transverse Topography Factor (T) of all the Six Sub-Basins

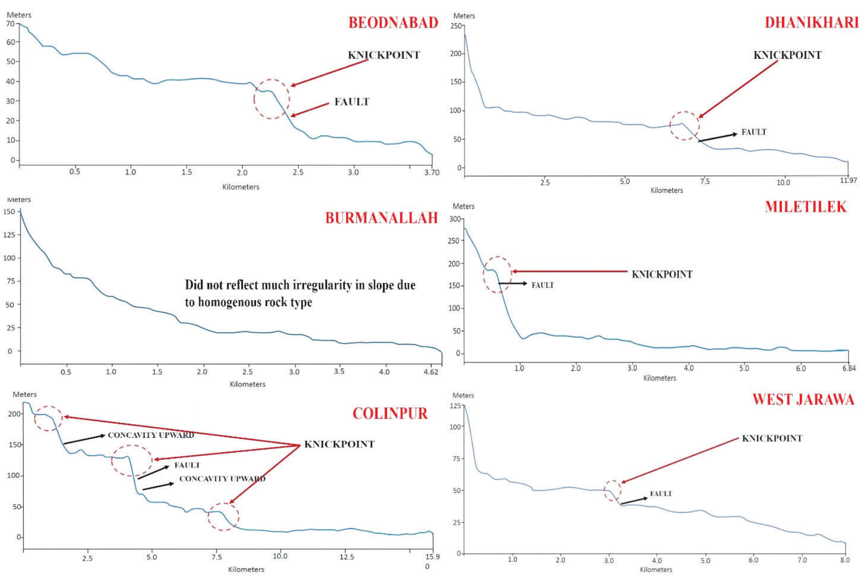

Figure 9. Longitudinal Profile of all the Six Sub-Basins

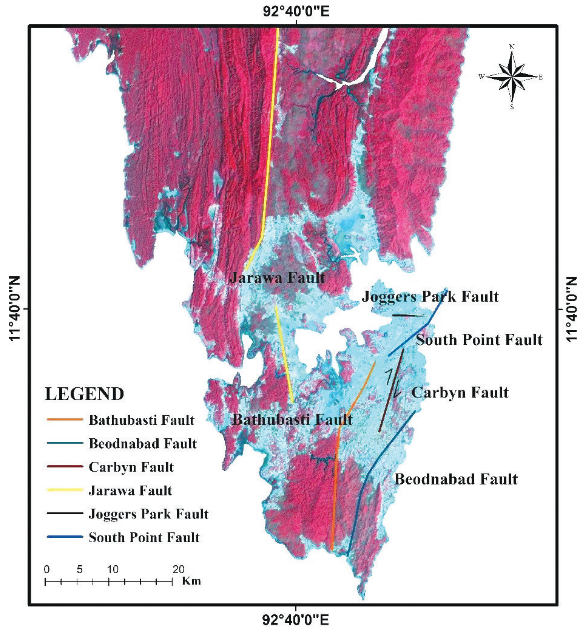

Figure 10. Major active faults of South Andaman Island

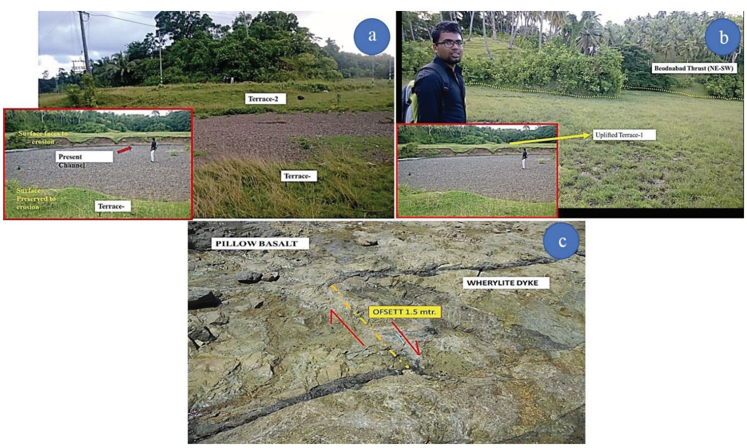

Figure 11. Field investigations in selected sites. (a) Showing river terraces and present channel at Beodnabad (b) Showing uplifted terrace and pressure ridge at Beodnabad (c) Showing offset of Wherylite dyke in Pillow Basalt at Burmanallah.

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