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GEOLOGICAL ASPECTS FOR THE KONKAN COASTAL BELT AREA, AROUND MAHAD, MAHARASHTRA

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Abstract- Various areas of this belt have studied by number of workers with respects to geology, geomorphology and tectonics (Dikshit, 1976, Srinivasan, 2002 &Dikshit and Patil, 2003). In recent years geomorphic studies have become a part and parcel resource management or planning studies. An attempt has been made in this paper to prepare the geomorphology and its applied aspects for the Konkan Coastal Belt Area, around Mahad (Savitri River) Maharashtra using Indian remote sensing data. The geomorphic studies are carried out using survey of Indian topographic data products. By applying visual interpretation techniques to the false color image the geomorphic map on 1:50,000 scales are produced. The parameters worked out include the linear aspects using methodology adopted by the geomorphologists. The study area is around Mahad which is part of KCB from Raigad district of Maharashtra. The present investigation geomorphic and tectonic features of this region by using remote sensing data and topographic maps and followed by field work. These studies will be undertaken with respect to the social and academic interest of region, such as land instability, seismicity and land use. The three physiographic regions from west to east in Maharashtra are: 1. The Konkan Coastal Belt, 2. The Western Ghats and 3. The Maharashtra plateau. The Konkan Coastal Belt (KCB) is narrow and elongated strip of land whose average width is about 40 km. most of this region is covered by basaltic lava flows of the Deccan Trap of upper cretaceous to Eocene age. Remote sensing studies, morphometric studies & field studies are helped to investigate main geomorphic zones, lineaments, Neo-tectonic feature & landforms
Keywords- Bifurcation, Lineament, Landforms, Neo tectonic, fractures.

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Introduction

The three physiographic regions from west to east in Maharashtra are: 1. The Konkan Coastal Belt, 2. The Western Ghats and 3. The Maharashtra plateau. The Konkan Coastal Belt (KCB) is narrow and elongated strip of land whose average width is about 40 km. most of this region is covered by basaltic lava flows of the Deccan Trap of upper cretaceous to Eocene age. It is traversed by several easts - west trending ridges and west flowing rivers and their tributaries with steep to moderate gradients. Summer and rainy are two major seasons and hence whether is hot and humid. It receives 2000 to 3000 mm rainfall per year. Most of this belt is under forest and soil cover of varying density and thickness respectively.

Study Region

The Mahad region is part of Konkan Coastal Belt from Raigarh district of Maharashtra. This region is traversed by westerly flowing Savitri River and its tributaries. The major tributaries of Savitri are Kal River, Gandari River, Ghod nala, Kal nadi, Negeshri nadi. The width of coastal belt in this region is about 50 kms. The average rainfall is more than 600 cms. The study area is bounded between 17° 55' North to 18° 25' North Latitude and 73° 05' East to 73° 40' East Longitude and includes about 2000 sq.km.area. The area is covered by Survey of India topographic maps numbers of 47 G/1, 47 G/5, 47 G/9, 47 F/4, 47 F/7, 47 F/8, 47 F/11, 47 F/12 of 1:50,000 scale.

Objectives

The main objectives of the research work are

- To recognize geomorphic and tectonic features.
- Remarket areas of landslides
- Impact of new tectonic activity in the area.

Methodology

To achieve above mentioned objectives following methods of study are used.

- Remote sensing analysis
- Physiographic analysis
- Morphometric analysis

Field work analysis

Discussion and Analysis

Remote Sensing Analysis

To demarked and recognize physiographic features, geomorphic features and tectonic features, Land sat TM satellite remote sensing data was used. The most common methods of digital image analysis used are i. Contrast stretching ii. Sobel filtere iii. High band pass image iv. Flase colour composite image v. 3 DEM image vi Slope mapping.

Drainage and Lineament Analysis

Fig. 1 represent Land sat TM band 7 image. This shows Savitri river basin and its tributaries, location of Mahad, part of the Sahyadri upland and Western Ghat scarp. Figure 2 and 3 shows two types of drainage patterns, namely a trellis and second dentritic.

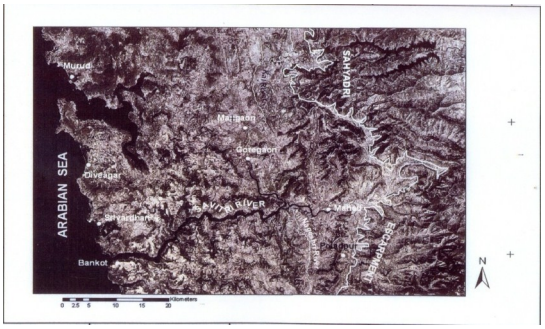

Fig. 1-

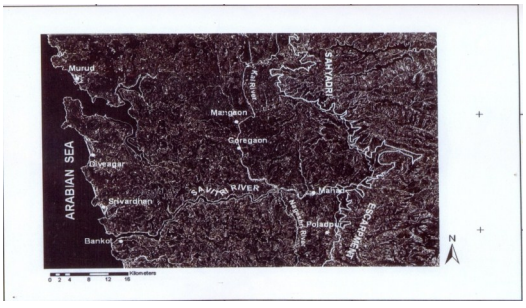

Fig. 2-

Dendritic drainage pattern is mainly seen in the most eastern part of the savitri river basin. This is located east of Mahad. The trellis drainage pattern dominantly seen in the central region of coastal belt, which is located west of Mahad. The major streams of trellis pattern are in the North - South direction. Trellis drainage pattern in this region indicates structurally controlled drainage. Thus the major tributaries of Savitri River which are in North - South direction are controlled by major weak plains which are trending nearly in the North - South direction. Drainage pattern in the upland region is dendritic and major streams seen to flowing towards east.

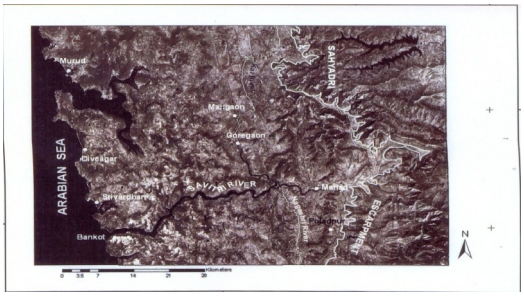

Fig. 3-

Table 1 represents the azimuth frequency of lineaments, where as figure - 6 represents Rose diagram of azimuth frequency of Lineaments. Lineaments map 5 and Rose diagram (Figure - 6a) indicates that most of the Lineament is trending in

Table 1- Azimuth Frequency of Lineaments (Mahad and Upland Region)

Direction of Degree	Lineament no	Percentage	Direction of Degree	Lineament number	Percentage
NE-0-15	09	14.75	NE-0-15	12	23.52
16-30	04	6.56	16-30	03	5.82
31-45	03	4.91	31-45	03	5.82
46-60	02	3.28	46-60	02	3.92
61-75	05	8.20	61-75	04	7.84
76-90	02	3.28	76-90	02	3.92
NW-0-15	13	21.31	NW-0-15	04	7.84
16-30	10	16.39	16-30	02	3.92
31-45	06	9.84	31-45	01	1.96
46-60	05	8.20	46-60	07	13.72
61-75	01	1.64	61-75	09	17.64
76-90	01	1.64	76-90	02	3.29
Total	61	100	Total	51	100

Source- Based on field survey Compiled by Author

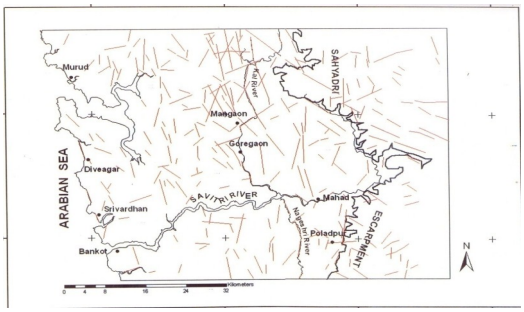

Fig.4 -

NW - SE to NNE - SSW directions.

Lineament map also shows the trend of lineaments in the Upland region located east of the study area. Figure-6 b Rose diagram of the Lineaments from the region of upland locating east of Mahad coast belt (KCB). The lineaments in the upland region are mainly

trending in NW-SE and NNE-SSW directions. The difference in the trend of Lineaments and drainage pattern in the study area. Suggest difference in tectonic activity of Mahad region in comparison to that of upland region.

NW-SE trend of Lineaments is the upland region coincides the Dharwarian trend. (Joshi et al, 1996). Thus, it can be concluded that NW-SE trend of Lineaments is pre-Deccan trap age while those of NNW-SSE to NNE-SSW are post-Deccan trap.

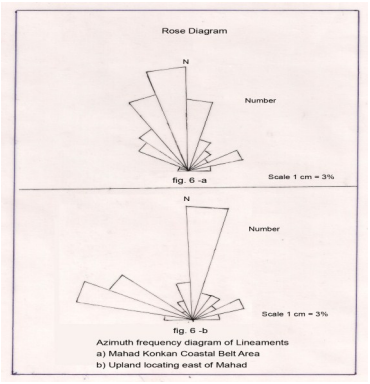

Fig. 5-

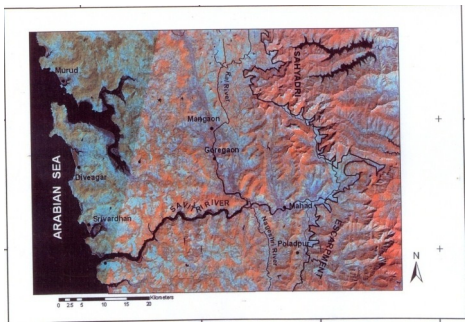

Fig. 6-

Physiographic and Geomorphic Analysis

Land sat TM digital data has used to prepare False Colour Composite (FCC) and 3DEM map. FCC has been prepared by superimposing TM bands of 1,2 and 3(Fig-7) 3DEM map (Fig-8) has been prepared by using digital contouring method. Both of these images are very useful to study and analysis physiography and major geographic features.

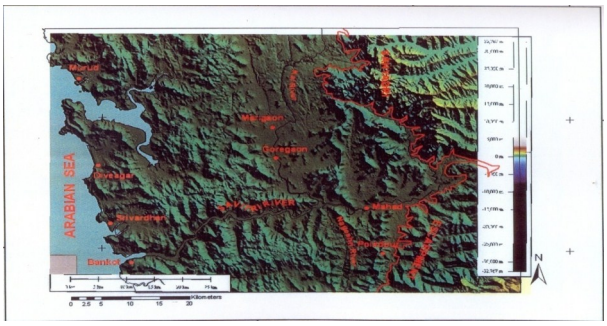

Fig. 7-

Major physiographic features are distinctly seen in the FCC images where as major and minor physiographic features are clearly seen in 3DEM map Based on these two images, it is easy to demarcate major drainage, upland, crest of scarp and scrap, ridges, low lands, hilly terrenes etc. 3DEM map images of the Mahad region shows two distinct physiographic features-

- Hilly terrain and
- Oval shaped depression.

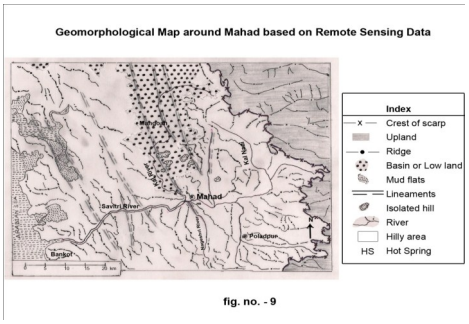

Fig. 8-

The 3DEM images show the Mahad region is highly hilly and traversed by numerous ridges. The trends of these ridges are N-S, NW-SE and E-W. These ridges are dissected by numerous 'V' shaped valleys. The oval shaped low land area in the Mangaon region is surrounded by hilly terrain. The Mangaon basin is distinct lineaments which are trending NWW-SSE. This association strongly indicates that this basin is bounded by faults and the Mangaon basin is result of Neotectonic activity.

Geomorphic Map

Based on FCC images and 3DEM image geomorphological map has been prepared (Fig.9). Various parameters is used are scarp, crest of scarp, upland, ridge, hilly area, isolated hill, basin or low land, mud flats, river and streams, beaches, Lineaments etc.

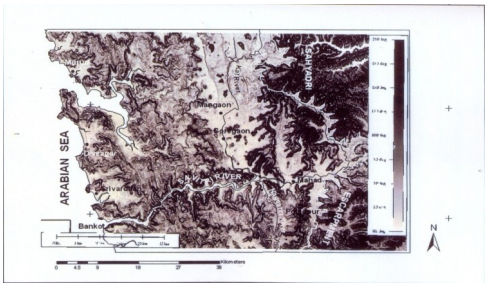

Fig. 9-

The scorce of Savitri River is crest line scarp located east of Mahad. This river flows towards west and meets to the Arabian Sea near Bankot. It is interesting to note that it has few sharp bends. The drainage pattern around Mahad is trellis. Most of the tributaries join the Savitri River nearly at 90° in the Mahad region. One of the abnormal drainage characters is that of Kal River. This river flows from North to South and shows barbed drainage pattern indicate drainage reversal and possibly due tilting of the region during tectonic activity. The Basin of Kal River is within the Mangaon depression or basin. The trellis pattern in the Mahad region is also indicative of structurally control and neotectonic activity.

The Geomorphic map of the Mahad region shows three major Geomorphic zones, such as i) scarp, ii) hilly area and iii) basin or low land. Most of the area shows hilly area. The major basin or

lowland is that of Mangaon depression through which Kal River is flowing. It is bounded by N stending lineaments. In this area there are few isolated hills. The hilly area has numerous ridges and 'V' shaped valleys. It is interesting to note that most of the ridges are trending NNW-SSE.

Slope Analysis

Land sat digital TM data has been used to analyze slope characters of the study area. Digital contouring has been carried out to prepared 3DEM map (Fig.8). From this contouring, slope map is prepared (Fig.10). Slope values determined are in the range of 20° to 0°. Most of the slope angle values are in the range of 17° to 2°. The scrap region and sides of plateau in the coastal belts are of higher slopes. The slopes of ridges are in the range 15° to 10°. Undulating terrain has slope angle in the range of 7° to 2°. Some of the regions are leveled ground which has slope angle from 2° to 0°. It is interesting to note that the Mangaon depression has low slope angles in the range of 5° to 2°.

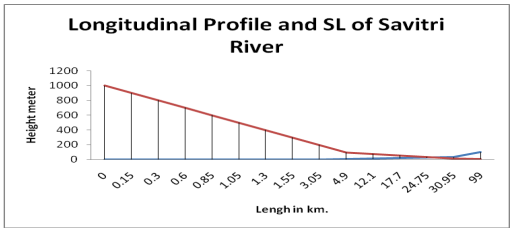

Fig. 10(a)-

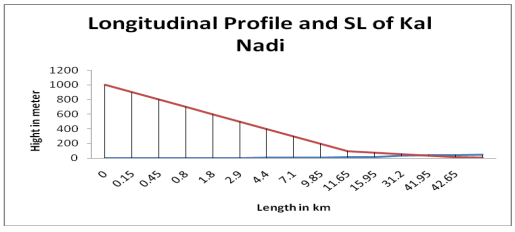

Fig. 10(b)-

Morphometric Analysis

Three parameters namely longitudinal profile, stream length gradient indices (SL), and bifurcation ratio have been determined for Savitri river and its tributaries, such as Kal river, Kal nadi, Nageshri river.(Table 2,3,4 and 5).

Table 2- Savitri River

Height in Mts	ΔH in Mts.	Length in Km ΔL	Cumulative Len. in Km.	L Δ -- 2	L	SL
1000	-	0	0	0	0	0
900	100	0.15	0.15	0.075	0.075	50
800	100	0.15	0.3	0.075	0.225	150
700	100	0.3	0.6	0.15	0.45	150
600	100	0.25	0.85	0.125	0.725	290
500	100	0.2	1.05	0.1	0.95	475
400	100	0.25	1.3	0.125	1.175	470
300	100	0.25	1.55	0.125	1.425	570
200	100	1.5	3.05	0.75	2.3	153.33
100	100	1.85	4.9	0.925	3.975	214.9
80	20	7.2	12.1	3.35	7.25	20.14
60	20	5.6	17.7	2.8	14.9	53.21
40	20	7.05	24.75	3.525	21.225	56.6
20	20	6.2	30.95	3.1	27.85	89.83
10	20	68.05	99	34.05	64.975	19.1

Source- Compiled by Author

Table 3- Kal Nadi

Height in Mts	ΔH in Mts.	Length in Km ΔL	Cumulative Len. in Km.	L Δ -- 2	L	SL
1000	-	0	0	0	0	-
900	100	0.15	0.15	0.075	0.075	50
800	100	0.3	0.45	0.15	0.3	100
700	100	0.35	0.8	0.175	0.625	178.6
600	100	1	1.8	0.5	1.3	130
500	100	1.1	2.9	0.55	2.35	213.6
400	100	1.5	4.4	0.75	3.65	243.3
300	100	2.7	7.1	1.35	5.75	213
200	100	2.75	9.85	1.375	8.475	308.2
100	100	2.1	11.65	1.05	10.9	519
80	20	4	15.95	2	13.95	69.75
60	20	15.25	31.2	7.625	23.575	30.92
40	20	10.75	41.95	5.375	36.575	71.36
20	20	1	42.65	0.5	42.45	849
10	10	4.05	47	2.025	44.975	99.94

Source- Compiled by Author

Table 4- Nageshri River

Height in Mts	ΔH in Mts.	Length in Km ΔL	Cumulative Len. in Km.	L Δ -- 2	L	SL
500	-	0	0	0	0	-
400	100	0.15	0.15	0.075	0.075	50
300	100	0.25	0.4	0.125	0.275	110
200	100	0.3	0.7	0.15	0.55	183.3
100	100	0.6	2.3	0.8	1.5	93.75
80	20	0.95	3.25	0.475	2.275	58.42
60	20	1.85	5.1	0.925	4.175	45.14
40	20	7.5	12.6	3.75	8.85	23.6
20	20	2.6	15.2	1.3	13.9	106.92
10	10	12	27.2	6	21.2	17.66

Source- Compiled by Author

Table 5- Kal River

Height in Mts	ΔH in Mts.	Length in Km ΔL	Cumulative Len. in Km.	L Δ -- 2	L	SL
700	0	0	0	0	0	-
600	100	0.15	0.15	0.075	0.075	50
500	100	0.15	0.3	0.075	0.225	150
400	100	0.15	0.45	0.075	0.375	250
300	100	0.15	0.6	0.075	0.525	350
200	100	0.3	0.9	0.15	0.75	250
100	100	3.5	4.4	1.75	1.65	47.14
80	20	5.65	10.05	2.875	7.275	25.75
60	20	7.2	17.25	3.6	13.65	37.91
40	20	4.4	21.65	2.2	19.45	88.4
20	20	10.25	31.9	5.125	26.775	52.24
10	10	10.2	42.1	5.1	37	36.27

Source- Compiled by Author

Longitudinal Profile

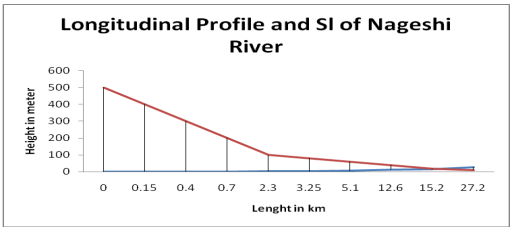

Fig. 11(a)-

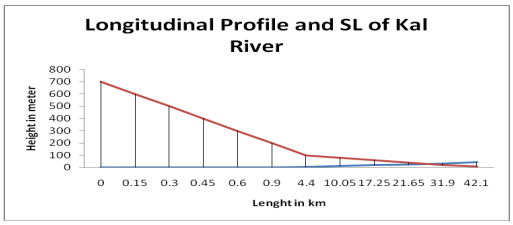

Fig. 11(b)-

Elevation versus distance for the Savitri River and its tributaries has been measured from to topographic maps of 1:2, 50,000 scales, from this data. Longitudinal profile for the Savitri river and its tributaries are drawn (Fig.11).

Profiles are steep in the sources region and become horizontal near the mouth. These profiles are useful state whether streams are in the state of graded or upgraded river due to rejuvenation.

Stream Length Gradient Index (SL)

The stream length gradient index (SL) has been developed by Hack (1973). He defined SL index for a particular segment of stream by following equation,

$$SL = \frac{\Delta H}{\Delta L} \times L$$

Where, ΔH is change in elevation of the steam segment, ΔL is the length of steam segment and L is the total length from the drainage divide to the centre of stream segment.

According to Hack, index is very sensitive to change in slope and useful to evaluate possible to tectonic activity, rock resistance and topography. Anomalously high values of SL index indicate possible location of uplift. Killer (1977) used this method to the San Garbrial Mountain southern California, which has been uplifted to several thousand meters elevation. Fig.11 represents the curves for longitudinal profiles of Savitri River and its tributaries. The SL value have been plotted along there longitudinal profile.

Longitudinal profile for Savitri River and its tributaries show steep initial segment of curve were as very gentle slope for the downstream segment. The profile of Kal nadi and Nageshri River show distinct knick point. In the zone of knick point the SL values are higher than its upstream and downstream segments. Thus, these zones possible represent the fault zones.

Bifurcation Ratio (RB)

Bifurcation ratio is defined as ratio of number of streams of given order (Nu) to the number of streams of the next higher order (Nu + 1) and is expressed with following equ

$$Rb = \frac{Nu}{NU+1}$$

Bifurcation ratio is useful to understand the branching pattern of the drainage network. The difference in the bifurcation ratio between successive stream orders is attributable to variation in the topography, structure and tectonics. According to Horton (1945), it is an index of relief and dissection. Bifurcation ratio values are 2 in flat or rolling drainage basin, while the values between 3 & 5 are for mountain or highly dissected basin and indicate mature topographic surface. Strahler (1952) has stated that this ratio is of a smaller range and bifurcation ratio varies from region to region. The bifurcation ratios are high where tectonic structures are predominating. Miller (1953) has found that the bifurcation ratio does not depend on lithology.

Number of streams for the Savitri river basin has been measured from the topographic map of 1: 2, 50,000 Scale. Table 6 shows the Bifurcation ratios between streams of various orders .Bifurcation ratio values are ranging from 1.63 to 5.22. These values for 3rd and 4th order stream are 5.22 and 4.50 respectively. Thus, the average bifurcation for the 3rd and 4th order streams is 4.86. Such relatively higher bifurcation of youth topographic surface and highly dissected drainage basin and possibly structurally controlled drainage.

Table 6- Bifurcation Ratio for Savitri River Basin

Source-Compiled by Author

Field Work Analysis

Field investigations include collection of numerical and qualitative data regarding structural, erosion and depositional feature. Such studies are considered as ground truths to confirm remote sensing and morphometric analysis, which add more information about lithology, landforms, structural and tectonic characters

Lineament and preliminary geomorphological maps prepared by using remote sensing data and basin morphometric data were considered to plan the field work. Traverses & locations of field visits were planned to study lithology, structure and various geomorphic features. In general, traverses & locations were selected on the topographic maps of 1:50,000 scale. Importance was given to study change in the type of lava flow and their nature of contacts, geomorphic features, and channel characters, type of valleys and associated landforms and sediments. Photographs of significant lithological structure and geomorphic features were taken and similarly sketches have been also drawn for the same. Brinton compass has been used to measure attitude of planer surfaces, such as fractures and any change in the inclination of lava flow contacts.

The area under investigation is bounded by part of Western Ghats segment locating east of Mahad & western coastal line. Both of them represent major lineaments. The study area is part of the Konkan Coastal Belt which is one of the distinct regions recognizable in the western Maharashtra. The study area is covered by basaltic lava flows of the Deccan traps of upper Cretaceous to Eocene age.

Lithology

Lava flows observed are either nearly horizontal or gently dipping toward west. In this region the thickness of lava flows varies. Most of the basalts are either compact or vesicular & they are alternating. Compact lava flows from the top of plateau. Basalts are dark in color, fine grained (Photo 1& 2.). The compact lava flows shows spheroid weathering. The individual lava flows are separated by red bole beds. Red bole beds are dark red in color, fine grained and porous.

Landforms

The most common landforms observed in the field are ridges, hills, mesa, plateau, 'V' shaped valleys, river terraces, pot holes,

waterfalls & cascades etc.
Highly dissected valleys, deeply dissected valleys, terraced landscape, steep slopes are observed in the Western Ghats (Photo 3 & 4). Tops of hills & ridges to from mesas & plateaus. Sides of mesas & plateaus are steep. (Photo 5 & 6).

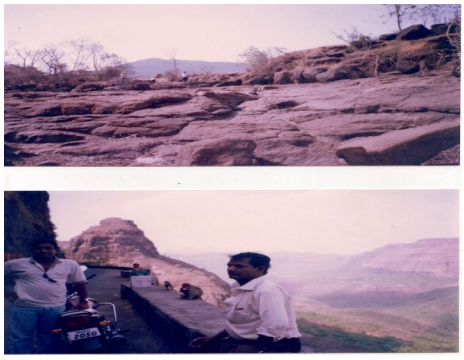

Photo 1&2

Photo 3&4

Photo 5&6

Neotectonic Features
Most common neotectonic features are in the form of the fractures and geomorphic features, such as 'V' shaped valleys, river terraces, pot holes & waterfalls etc. Second and third order streams are 'V' shaped. Sediments along there strims are very course grained, such as large blocks, boulders, pebbles, gravels etc. River terraces are seen at different levels, which are under cultivation. Pot holes are of different dimensions. Waterfalls across the streams are the few meters to 20 meters high (Plate 4).
Two types of weak plains are observed - (1) fractures and (2) shear zones. Fractures are trending in N-S, NW-SE or NE-SW directions. Shear zones constitute closely spaced numerous fractures which are parallel to each other (Photo 5). These fractures are steeply dipping to vertical. Such shear zone is observed near Mahad.

Applied Aspect
Geomorphic studies provide following information which are useful to the society.

Springs & hot springs
There are numerous springs in the area, which are shows on the topographic map of 1:50,000 scale. These are indicative of leakage of sub surface water fractures interacts the topography. One hot spring is the left bank of Savitri River near Mahad. The temperature of this water is about 50°C. This hot spring is indicative of the presence of deeply penetrating week planes. Spring water is useful for source of drinking water.

Agriculture
River terrace areas constitute fertile soil. Thus, these are more useful for cultivation of paddy (Rice).

Landslides
The areas of steep slopes which are traversed by fractures are prone to landslides (Photo 6). Such areas near highways and road are most dangerous mainly during monsoon season (Rainy season). Thus, fracture and slope studies will help us to take the measures so landslides will not take place.

Geomorphological map
Based on remote sensing studies, field studies; final regional geomorphological map has been prepared fig.12. In these map major geomorphic zones, Lineaments, Geomorphic features are shown.

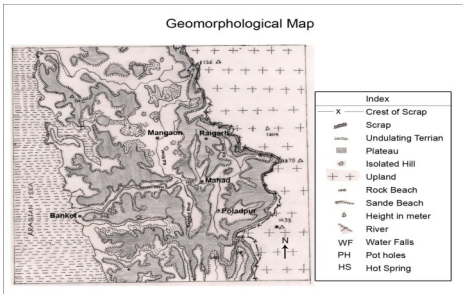

Fig. 12-

Discusssion and Conclusion
Remote sensing studies, morphometric studies & field studies are helped to investigate main geomorphic zones, lineaments, Neotectonic feature & landforms. The study areas are part of the Konkan Coastal Belt which is bounded by segments of Western Ghats & Coastal line. The major geomorphic feature is scrap, hilly terrain & Mangaon basin. The major river is Savitri which is flowing from east to west. The basin area exishibits trellis drainage pattern and number of river/stream bends including structural control. The trend of lineament in the study area is NNW-SSE where as that in the upland region is NW-SE. The fracture observed in the field is also correlate to the trend of lineaments. There are also shear zones. Thus, there are number of faults which are traversing the study along which movements/displacement has taken place. These movements are recent indicating the Neo-tectonic activity

occurred in the study area and because of which numerous geomorphic features are seen along the streams. One of the distinct major geomorphic features is Mangaon basin which is bounded by faults.

Based on geomorphic studies it is concluded that the study area is traversed by numerous fractures & faults, which are trending NNW-SSE to NNE-SSW. Along these weak planes recent movements has taken place. Similarly because of steep slope & numerous fractures there are numbers of regions which are prone to landslide.

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