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TOPOGRAPHIC ANALYSIS OF THE DUNE FIELD AT TAMBALDEG, SINDHUDURG DISTRICT, MAHARASHTRA

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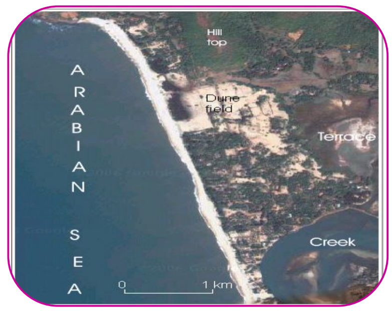
ABSTRACT



The topographic analysis of the dunes in complex dune systems can now be attempted by generating their 3D models and converting the models to achieve various mathematical attributes. Elevation Data base can be created by leveling and geodetic instruments and attesting it to locational references.

Such a topographic analysis was undertaken for a unique dune field at place called Tambaldeg on Sindhudurg coast of Maharashtra near village Mithbav (16° 4′ N latitude and 73° 26′ E longitude). Area comprising of dune field, has an average length of about 5 km and has maximum width of 1.4 km. Maximum dune height in the field is 16 m. The dune field consists of series of fore dunes and back dunes with frequent embryo and shadow dunes. The dune field proper is located between 16° 16.4′ N latitude and 16° 33′ N latitude, 73° 24′ E longitude and 73° 25′ E longitude. It has a length of 2980m and has maximum width of 900 m. The settlement of Tambaldeg is situated right in to the dune field and on the northern bank of Mithbav creek.

The topographic analysis of the dune field was attempted by creating 3D models. The data collected by GPS and theodolite was used. The characteristic features of the topography were extracted by converting the models to their first and second derivatives. Profile curvature, plan curvature, tangential curvature and slope maps were also used. The liner and point features such as dune crest, ridges and peaks could be identified on digital elevation models. The models could not provide the information on volume change but they could be used for the measurement of horizontal migration and peak elevation change.

The dune migration could be effectively studied by identifying peaks, slip faces, windward ridges and surfaces. Slip faces and dune crest were extracted from the slope maps and the profile curvatures. The first and second order derivatives were used to identify the peaks, crests and the tangential curvature to identify the surfaces.

KEY WORDS: *topographic analysis , horizontal migration and peak elevation change.*

TAMBALDEG DUNE FIELD

The beach at Tambaldeg is an open and exposed beach that is dominated by pronounced variations in energy conditions in monsoon and fair weather. There is a striking adjustment between energy conditions in both the seasons. There appears a definite control of wave conditions on the state of the beach. The beach erodes rapidly in monsoon. The accretion in post monsoon season is however a slow process. In monsoon beach face erosion is intensified. In fair weather berm and bar migrate landward.

Fig. 1 Dune system elevation (m) in monsoon

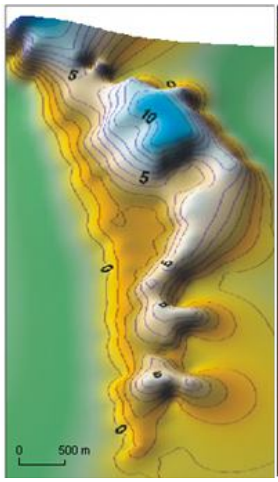
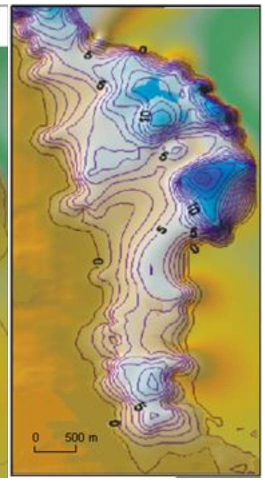


Fig. 2 Dune system elevation (m) in fair weather season



DUNE MORPHOLOGY

Dunes generally begin to develop around the drift line above spring high tide. Here the tidal litter (sea weeds and drift wood) forms an obstacle to the wind promoting the formation of shadow dunes, which are developed near tide line.

The tails of the shadow dunes stretch out in the down wind direction. Occasionally they can reach elevations higher than the obstacles. Accretion occurs following the establishment of pioneer dune plant species such as Ipomoea, Sphinifex and Marram grass. These plants have higher tolerance to salt. They have elaborate root system and can thrive even on being buried by fresh sand as long as vertical accretion does not exceed 0.5m / yr.

The shadow dunes have good sand trapping ability, which helps them to grow upward, and outward in the embryo dunes at a height of 1 to 1.5 meters. Shadow and embryo dunes are low vegetated mounds of sand. Given good sand supply and sufficient time they can even grow further, coalesce and form the fore dunes.

As soon as the shadow dune reaches the height of the obstacle, deposition ceases since the wind velocities here are unaffected by the now buried obstacle. In order that the deposition can continue to build a true dune the obstacle to wind velocities must keep pace with the deposition rate. The dunes formed lie on the upper slopes of the beach. They are initially an unconnected series of low mounds up to 1 or 2 meters high and are known as embryo dunes (Photo 1). In most environments these embryo dunes are the first stage in the development of true sand dune ridges.(Pethic 1984)

A 40 to 50 m wide zone stretching for about 380 m in the north south direction at Tambaldeg is characterized by number of shadow and embryo dunes. These sand mounds are not more than 1 m height. Embryo dunes are covered with Ipomoea creeper and Sphinifex grass.

Fore dunes are sand heaps of not more than 4 m in height. They run parallel to the beach and immediately back of it. These are mostly discrete mounds of sand. These dunes are north south running discrete lines parallel to present shore. Their relative height ranges from 2 to 4 m. There shoreward face is steep and that towards land is gentle, obviously due to erosional mechanism of wind. Most of the fore dune tops are covered with vegetation. Dense Casurina plantation patches in the northern, middle and southern part cover the fore dune areas.

Back dunes occupy the zone of 1450 m inland from high water mark in northern part and 400 m inland in the southern part of the dune field. These are high dunes that attain a height between 6 to 14 m throughout the dune field. Back dunes essentially suggest a landward limit of sand transport in the study area. The area beyond back dunes is a wide 6 m high littoral terrace, part of it being reclaimed by the construction of a Kharland bund.

The area between back dunes and fore dunes is an undulating surface 2 m above sea level. This is an area covered by Ipomoea, Casurina and Cashew nuts.

There is always an association between beach and fore dune sand budget and the dune formation (Woddroffoe 2002,short & Hesp 1982, Psuty 1992) In a positive beach budget situation with moderate wind energy and ineffective vegetation cover hammocky dunes are developed. Transgressive sand sheets usually favour large dunes. The entire sand sheets are covered by scanty vegetation.

The dunes in the northern part of the study area resemble hammocky dunes and those in the back dune zone resemble transgressive dunes. The interdunal area is a jumble of transverse dunes. These dune types also show a relation with the speed of wind. In the area transgressive dune fields show a tendency of landward migration (Masselink and Hughes 2003).

Study of highly dynamic coastal features like dune requires an understanding of their evolution. Modern geospatial technologies such as GPS and 3D GIS provide necessary tools for acquisition of required data, feature extraction and quantification of change. Such techniques were applied in the study of dune field at Tambaldeg.

Photo 1. A complex of shadow, embryo and fore dunes

Photo 2. Well-defined dune ridge

Photo 3. Dune mounds near the southern tip

The morphological features and changes in the morphology were identified by creating elevation models of the dune field in 2004 and 2005. GPS point data and theodolite tacheometric data were used to compute the models.

The dune field under the study belongs to the class of large, isolated coastal dunes with a meager growth of vegetation. The back dunes are asymmetrical with gentle seaward and steep landward slopes. The dune field is a complex, comprising of three distinct dune zones, namely embryo dunes, fore dunes and back dunes. Each zone exhibits a special morphology and behavior. Wind records the dominance of southwesterly winds in monsoon. Based on the data collected in the field (Table 4.2) the maximum wind speed in the monsoon was 0.47 m/sec in southwesterly direction and 0.3m/sec in westerly direction. It was observed that the dominance of southwesterly wind in monsoon has a definite scouring effect on the dune system. Dune system elevation in monsoon (Figure 3.1) shows the development of 10m high dune crest in the northern part of the dune field. The morphology of the dune system is thus dominated by the effect of strong winds and development of dune crest in the monsoon. In fair weather the system exhibits development of dune crest at number of places caused by a slight drop in the wind speed (Figure 3.2).

Evolution of the dune field over the research period (2003-2006) has been accompanied by a distinct change in the land cover in the area (Figure 3.5). Most of the sand flats and small dunes have been replaced by building construction and cashew nut plantation. As a result a sand supply has diminished and has also contributed to the loss of elevation of the dunes.

The favorable conditions leading to dune development in fair-weather are getting disrupted day by day, by increasing building constructions and an overall change in land use pattern. These activities are causing significant reduction in sand supply to the dune field today. It is also likely that there will be complete transformation of the dunes to other than transverse type, probably parabolic due to reduction in sand supply as seen today, due to rapidly changing land use in the area.

Topographic analysis of the dune field

The topographic analysis of the dune field was attempted by creating 3D models. The data collected by GPS and theodolite was used. The characteristic features of the topography were extracted by converting the models to their first and second derivatives. Profile curvature, plan curvature, tangential curvature and slope maps were also used. The liner and point features such as dune crest, ridges and peaks could be identified on digital elevation models. The models could not provide the information on volume change but they could be used for the measurement of horizontal migration and peak elevation change.

The dune migration could be effectively studied by identifying peaks, slip faces, windward ridges and surfaces. Slip faces and dune crest were extracted from the slope maps and the profile curvatures. The first and second order derivatives were used to identify the peaks, crests and the tangential curvature to identify the surfaces.

Peaks

This feature is relatively easy to identify from the points with the highest local elevations. The first and second derivatives of the dune field in monsoon show that the elevation of peaks on the foredunes is relatively higher as compared to those in fair-weather, this is due to the monsoon cutting of the beach. In fair-weather however the back dunes and the peaks in the interdunal areas show relatively higher elevations (Figure 3, 4, 5, 6, 7).

Fig. 3 First Derivative map showing Peaks in monsoon

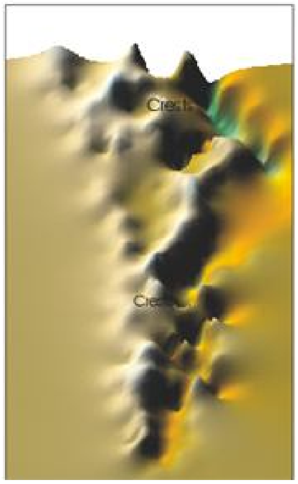


Fig. 4 Isolines of constant slope by First Derivative

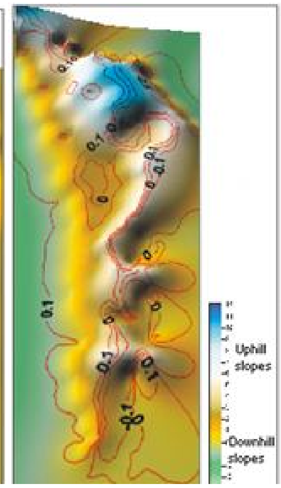


Fig. 5 First Derivative map showing Peaks in fair weather

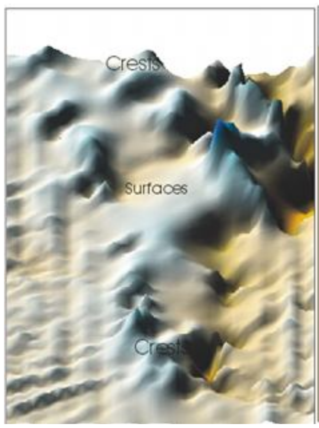
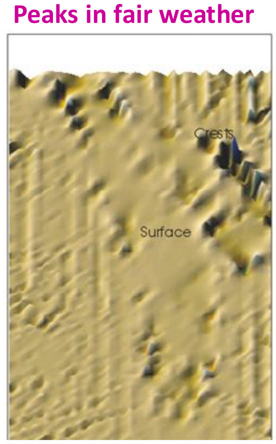


Fig. 6 Second Derivative map showing Peaks in monsoon

Fig. 7 Second Derivative map showing Peaks in fair weather



Profile curvature determines the downhill or uphill rate of change in slope in the gradient direction (opposite of slope aspect direction) at each grid node. Grid files of profile curvature produce contour maps that show isolines of constant rate of change of steepest slope across the surface. This operation is comparable to the Second Directional Derivative but is more powerful because it automatically determines the downhill direction at each point on the surface, and then determines the rate of change of slope along that direction at that point. The profile curvature map for monsoon clearly shows the fore dunes in the form of discrete mounds of sand. These dunes are north to south running discrete lines parallel to present shore. These fore dunes are backed by flat interdunal surfaces. Profile curvature map in fair weather season distinctly shows dune crests of high back dunes where the interdunal area between fore dunes and back dunes can easily identify (Figure 8, 9, 10, 11).

Dune ridges and surfaces

In general ridge and surfaces can be identified by using tangential curvature. The tangential curvature map for monsoon clearly shows the development of low dunes without distinct ridgeline, which is probably the effect of strong winds and the moist air (Figure 8, 9, 10, 11). The map for fair-weather shows a distinct development of dune ridges, interdunal surfaces. Seasonal variations in slip faces (slopes) and plan curvature could be detected both in monsoon and fair-weather (Figure 12, 13, 14, 15).

Fig. 8 Seasonal variation in Profile Curvature (Monsson)

Fig. 9 Seasonal variation in Profile Curvature (Fair weather)

Fig. 10 Seasonal variation in Tangential Curvature (Monsson)

Fig. 11 Seasonal variation in Tangential Curvature (Fair weather)

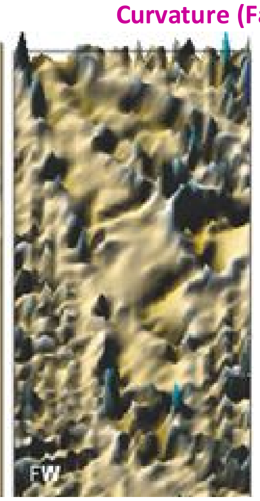


Fig. 12 Seasonal variation in Slip Faces (Monsson)

Fig. 13 Seasonal variation in Slip Faces (Fair weather)

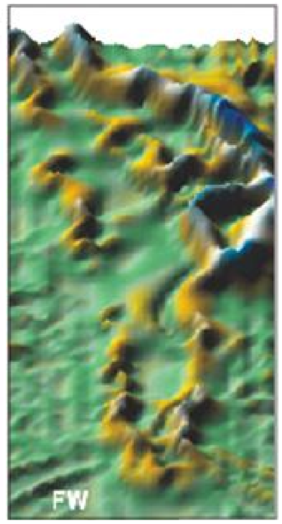


Fig. 14 Seasonal variation in Plan Curvature (Monsson)

Fig. 15 Seasonal variation in Plan Curvature (Fair weather)

The dune migration could be effectively studied by identifying peaks, slip faces, windward ridges and surfaces. Slip faces and dune crest were extracted from the slope maps and the profile curvatures. The first and second order derivatives were used to identify the peaks, crests and the tangential curvature to identify the surfaces.

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