Paper presented at the seminar on ***'CRZ – 2010 Draft: Responses & Challenges'***
Organized by ICG, NIO & GCCI on September 8, 2010
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Setback lines for Coastal Regulation Zone – Different approaches and implications

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1.0 Introduction

The coastal zone of the country supports a dense population and contains sensitive ecosystems such as mangrove forests, breeding grounds of several endangered marine and estuarine species and low lying areas susceptible to sea level rise. It also has many areas of outstanding natural beauty (AONB). Increased development activities due to urbanisation lead to encroachment of coastal areas and reclamation of tidal flats, backwaters and estuaries causing increased pollution and severe damages to the sustainability of coastal systems. Landscaping and ill-planned construction activities drastically change the morphology of the coast which adversely affects its stability and aesthetics. In addition to all these, there is always the threat to land and property due to coastal erosion and coastal flooding. These damages could be controlled, to a certain extent, by regulating high impact activities in the coastal zone. It was with this objective the Coastal Regulation Zone (CRZ) Notification was introduced in the country. The CRZ provides a spatial planning framework for coastal zone management. It effectively controls pollution of the coastal and nearshore systems from landbased activities.

1.1 Setback Lines

A spatial planning framework normally provides setbacks around sensitive zones restricting development and other activities close to it. Setbacks require specific reference lines and boundaries for its meaningful implementation. The High Tide Line (HTL) forms the cardinal reference line for determining the setbacks for CRZ. The Low Tide Line (LTL) forms the seaward setback while 200m and 500m CRZ lines are the landward setback lines in the context of CRZ.

A new setback line called hazard line has been introduced in addition to the HTL and LTL in the recent pre-draft CRZ Notification 2010. This could replace the 200m and 500m CRZ lines in certain cases.

2.0 High Tide Line & Low Tide Line

It is well known that the High Tide Level is dependent on lunar cycles. Tide is the periodic rising and falling of water level that result from gravitational attraction of the moon and sun and other astronomical bodies acting upon a rotating earth. A tide with one high water and one low water every day is the diurnal tide and the tide with two high and two low waters everyday is the semi-diurnal tide. Different tide levels like Mean High Water Springs, Mean Low Water Springs, Lowest Astronomical Tide, etc are defined and successfully used for navigational purposes and sea surveying. These are values averaged over a long period of 19 years. The usually defined high sea level connected with tides, is the Mean High Water Springs (MHWS) which is the average of heights of two successive high water springs. Another high sea level is the High Tide Level which is the water level at which the high tide intersects with the vertical plane.

The above definitions given in the literature are not in commensurate with the objectives of demarcating the HTL which is to regulate the activities on the land. The experience of Naval Hydrographer while demarcating the HTL in Goa way back in 1992-93 was an eye opener bringing out the limitations in assigning the usual definitions for the HTL. The HTL demarcated in this case for Goa was found to be in the sea during the next monsoon.

Tide levels are normally defined for navigational purposes. Different heights such as significant wave heights, mean wave heights, etc are defined for gravity waves which are much more varying and dynamic than tides, and being widely used for coastal engineering designs. Likewise a functional HTL is defined in the notification with the sole objective of protecting a given stretch of coastal strip from environmental degradation. Hence an approach different from the ones followed for navigational purpose, is necessary for demarcating HTL, in tune with the definition given in the Notification and for the practical purpose of implementing the CRZ Notification.

Unlike the High Tide Level, the High Tide Line (HTL) in the CRZ notification is the reference line specifically defined as a reference line on the land, exclusively for the purpose of CRZ. The HTL is defined 'for the purpose of the notification' as *"the line on the land upto which the highest waterline reaches during the spring tide"* which is different from the well known and widely accepted definition of High Tide Level. The above definition of HTL takes into consideration not only the level of inundation due to maximum tide (spring tide) but also the wave set up (having a seasonal periodicity). The sea level thus formed due to the combined effect of spring tide and wave set up give the line of maximum reach of water on the land.

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There is a similarity between the HTL thus defined and the High Water Line (HWL) given in Survey of India (SoI) toposheets. Both are lines drawn on the land. But the HWL and HTL are different that the former gives the fair season shoreline during spring tide while the latter accommodates the rough season (monsoon) shoreline oscillations due to monsoon wave set up in addition to spring tide inundation.

Unlike the HTL the Low Tide Line (LTL) has not been defined for CRZ. The HTL required specific definition since the 200m and 500m setback lines are defined with respect to the HTL. The conventional definition of lowest low water line during spring tide (averaged over 19 years) may be taken as the LTL.

2.1 Setback lines of 200m and 500m

The 200m and 500m setback lines are drawn landward of the HTL. Once the HTL is well defined and demarcated, the above 2 setback lines could be drawn without any ambiguity following planimetric methods.

2.2 Advantages of HTL and associated setback lines

Sustenance of coastal ecosystems and morphology is vital for coastal stability and livelihood security. All the intertidal regions such as tidal flats with and without mangroves both on the seacoast and in estuaries/backwaters/creeks and seasonal beaches are brought within the CRZ by the definition of HTL in the CRZ. Since the 200m and 500m CRZ lines are measured with respect to the HTL thus defined, all the coastal morphologies like cliffs, beaches, spits and dunes are included within these regulation lines thus offering protection from uncontrolled construction and other activities.

Limiting the LTL as the seaward setback line and the conventional definition of lowest low water line during spring tide for LTL have caused the exclusion of waterbody part from the CRZ. Control of degradation of coastal systems due to various activities on the land part alone would have been intended through CRZ.

3.0 Different approaches to demarcate the HTL and associated setback lines

The accuracy of delineation of HTL will have a bearing on fixing the boundaries of CRZ. The HTL being the cardinal reference line on which all setback lines like 200m and 500m for CRZ depend, it is important that implementing agencies like local bodies have access to maps on which the HTL is demarcated with sufficient number of easily identifiable field control points for proper and error free field implementation of CRZ. It is therefore important that reliable data on HTL along with other details, which can be represented on the scale of survey, be collected to meet the requirement of CRZ regulation. Highest level horizontal positional and spatial accuracy in mapping and presenting the HTL becomes necessary for such field uses. Agencies responsible for implementation of CRZ rules are looking for a planimetric accuracy approaching zero error.

The methodology should be scientifically acceptable and inexpensive and which can be done within a reasonable time frame. A decentralised approach entrusting the responsibility with different organisations spread over the coastal states will help to ensure a reasonable time frame which is imperative in the present circumstances. The methodology should also be simple enough to copy it easily in the field.

The different approaches now practiced in the country to demarcate the HTL are:

- tide level projection
- using morphological signatures
    - field methods
    - satellite data

3.1 Tide level projection to the beach profile for HTL

Elevation profiling perpendicular to the shore and with reference to chart datum is carried out. Highest range of spring tide and its horizontal run up on the beach is projected on the beach profiles. The horizontal run up of breaking waves and the seasonal cyclicity of beach changes are not accounted in tidal records which could result in significant oscillations in the HTL.

3.2 HTL using morphological signatures

This could be done by field methods and using satellite data.

3.2.1 Field method

HTL has to be fixed with respect to certain reference points on the land. These reference points at sufficiently close intervals (preferably 1 km alongshore) have to be marked with respect to lat-long and known points in the base map. Known reference/control points are very important since it is not always feasible to carry GPS/DGPS to reoccupy the control points by a Govt official during the implementation stage. Geomorphologic features like berm crest, cliff, headland, line of permanent vegetation, etc are indicators of the reach of sea water into the land. Stable coastal protective structures like seawall also limit the intrusion of seawater. Hence High Tide Line (line of maximum reach of seawater into the land during spring tide) can be fixed in the field, with respect to these features and tied to the reference points, as detailed below.

Landward (monsoonal) berm crest in the case of sandy beaches

In all the well-formed wide beaches, one or more berms (which are nearly horizontal part of the beach formed by the deposition of sand by wave action) are usually observed. The seaward end of the berm, which shows a sudden downward slope is called the berm crest. When there is only one berm, it normally gets eroded during the monsoon. But when there are two berms the landward berm is the monsoonal berm, which normally do not get eroded. Or else we can say that the erosion reaches only to the second berm crest. Since the tidal waters do not reach the coast beyond this landward berm crest, it can be taken as the HTL. The distance to this point from the reference point is measured using the beach profile to fix the position of the HTL.

Seawall/revetments/embankments

In highly erosion-prone areas, there are no landward second berms. Such locations will be protected by seawalls. During the monsoon season majority of these are devoid of beaches. The waves impinge upon the seawall during the monsoon season, especially during the high tide. Thus they are the artificial barriers stopping the waves/tides at the coast. Since the seaward part of the seawall in most cases is defaced due to erosion, the landward toe is taken as the HTL boundary in such locations. There are some locations with two or three lines of seawall, particularly in the accreting areas (eg. Purakkad, Puthuvaipu, etc. in Kerala). The seaward seawall is considered here for the purpose. On the other extreme, in the case of continuously eroding sites there are lines of sea wall which are now in the sea (eg. Panmana, Alappad, etc in Kerala). In such cases the landward seawall is taken. In order to facilitate the demarcation of HTL at seawall locations, the latter has to be clearly marked in the beach profile during coastal surveys.

Permanent Vegetation

There are several locations which has only one berm and the beaches undergo severe erosion during the monsoon, and yet not protected by seawall. In such cases, permanent vegetation, particularly well grown coconut trees, which are the main vegetation species prevalent all along the coast, is used as an indicator (Fig.3). The seaward limit of permanent vegetation is taken as the boundary of HTL. In some cases the trees are planted where a beach is found stabilised for one or two years (eg. mudbank sites). Due to repeatability of coastal processes (eg. mudbank migration), these locations get eroded, exposing the permanent vegetation to the sea. During the field surveys, limit of the vegetative cover was marked on the profiles, which helped in demarcating the HTL. In addition, indications of permanent vegetation as obtained from the satellite imageries are used for cross-checking and drawing the HTL between two profile stations.

Deltas and mud flats are formed by fine-grained silts and clays in a medium to large tidal environment. They have a fairly large intertidal zone fringed by vegetation. In such cases the landward limit of HTL can be demarcated as the line of permanent vegetation other than salt marsh vegetation and mangroves of intertidal habitat. Other geomorphic signatures like changes in land forms & sediment characteristics can also be used.

Rocks, Headlands, Cliffs

At the rock outcrops, headlands and cliffs the water is quite deep that there is virtually no spatial displacement in the waterline. Hence, the High Water Line available in the topographical maps (transferred to the base map) can be taken as such (Fig.4). However, at the eroding laterite cliffs (e.g. Varkala, Paravoor, Thalassery in Kerala), the latest position of the toe is taken from the cross section measured at the respective sites. This is to be verified against the satellite imagery and transferred to the base map.

Other geomorphic signatures

Appropriate geomorphic signatures, may be identified for other type of coasts not described above, like mudflats, mangrove coasts, coral fringed coasts etc. For example, in the case of mangroves the landward limit of mangroves (and not associates) be the HTL

Low Tide Line

As mentioned earlier not much importance is given to the Low Tide Line in the notification and is not defined for the purpose of the notification. The LTL also depends on the lunar cycle. The seaward/waterside limit will also depend on the shoreline position.

The Low Water Line available in the topographical maps is transferred to the base map as such. This could be corrected from the satellite imagery by identifying the shoreline position during fair season when the beaches have maximum width. The imageries could be selected for a spring tide low. The land (beach) sea boundary being one of the most distinguishable lines in the imagery, corrections can be done without much difficulty. Inlets (openings of river to the sea) being dynamic features do not conform to their base map positions. All the changes in their position, as obtained from the satellite imageries are to be incorporated. The information obtained during the coastal survey can also be made use of.

200 & 500 m lines

Once the reference points and the HTL are available, it is not difficult to draw 200 m and 500 m line on the map as required in the Notification.

The distance of 200 m and 500 m from the HTL is converted to the map scale at each reference point and demarcated. The 200 m and 500 m lines are drawn parallel to the HTL uniformly all along the coast.

For the use in the field, the distance of LWL, 200 m line and 500 m line from HTL from all the reference points can be given as a table. The location details, including place names, latitude, longitude etc can also be given in these tables

3.2.2 Use of Remote sensing data for HTL

Use of satellite data for one of the key areas of the coastal regulation namely accurate demarcation of HTL / LTL and landuse boundaries for direct field application had been a great challenge. With the availability of high resolution satellite data like Quick Bird, IKONOS, Cartosat and precision GPS, it is now possible to get a mapping accuracy of less than one meter.

The challenge is georeferencing using accurate GPS data at precisely locatable Ground Control Points (GCPs) in satellite images to have improved accuracy level in the identification and demarcation of HTL/LTL. Accurately identifying the positions for HTL with respect to signatures may become difficult when there vegetations like coconuts cover the signatures. The CRZ mapping through remote sensing is ideal for identifying the boundaries of different CRZ categories and ecosystems.

4.0 Hazard Line

A hazard line has been defined in the recent Pre-draft of the proposed CRZ Notification for the purpose of preparing Coastal Management Plans. This has to be demarcated taking into consideration the tide, waves, sea level rise and shoreline change. The limitations in the availability of data on waves, sea level changes, etc on a finer scale, limitations in the level of accuracies in projecting the changes and the inconsistency in shoreline changes may affect the positional preciseness of hazard lines mapped through the above processes. Hence it may be difficult to replace the CRZ boundaries now decided with respect to HTL with hazard lines. But this will be highly useful for developmental coastal management plans for local bodies.