SALIENT GEOMORPHOLOGICAL FEATURES OF THE SOUTH WEST COAST- SRI LANKA

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INTRODUCTION

The southwest coastal area of Sri Lanka covers a diversified tract of coastal environment. It exhibits a high degree of geomorphologic complexity. In order to study this classification of landforms in the area was made using aerospace survey techniques. The available black and white (panchromatic) aerial photographs of the scale 1: 20, 000 were interpreted.

The Geomorphological units were interpreted first on the basis of landsat images in the laboratory and then the details were identified and analysed, using aerial photographs.

GEOMORPHOLOGICAL UNITS OF THE SOUTH WEST COAST OF SRI LANKA

South West Coast of Sri Lanka could be divided into several coastal zones based on the methodology as described above.

(1) Nearshore zone
(2) Foreshore zone
(3) Backshore zone
(4) Coastal plain

Major geomorphological units of those zones were identified as follows

1 Nearshore zone	(a) Near shore Sandbars
	(b) Rock outcrops
	(c) Beach rocks
2. Foreshore zone	(a) beach types
	(b) Cusps
	(c) Spit bars
	(d) Headlands
3.Backshore zone	(a) berms
4. Coastal plains	(a) beach ridges
	(b) Tidal flats

1 Near shore sandbars

According to the interpretation of aerial photographs of the southwestern coastal areas, such bars can be identified only at the Kalutara and Panadura river mouths. Such bars are not seen at other river mouths in the southwest coastal area. Even at the mouth of the Kalu ganga and Panadura Ganga , these bars reflect the characteristics of seasonality. Bars are specially formed during the North East monsoon period and disappear during the South West monsoon period. This phenomenon occurs mainly due to the monsoon and the longs sediment transportation. The sediments from the areas which face the monsoon directly are carried northwards along the study-area,and possibly start accumulating from the mouth of the Kalu Ganga onwards. The sediments coming along the rivers too contribute to the formation of such bars. Therefore, the formation of these bars can be explained in terms of the interaction between rivers oceanographic factors. The near shore bar at the mouth of the panadura Ganga is located about ¼ km seawards from the river mouth and is about ¼ km in length. It lies in a North South direction. The seaward side is quite irregular in shape while the landward side is very smooth.

The near shore bar at the Kalu Ganga is located in front of the river mouth and about 1/8km into the sea. Its is quite different when compared with that near the Panadura Ganga. The Kalu Ganga bar is curved in shape. Its direction is north-south like the one at Panadura. Local fisherman call it "Weligediya" a term which describes it as an obstruction to the rivermouth due to the accumulation of large volume of sand.

1.1. Rock outcrops

A large number of rock outcrops and other comparable features which can be described as islets or islands are located the South West coast of Sri Lanka .The rock outcrops as well as the other small identified features are all located within the 5-fathom contour line. With the exception of Barbarin island near in size. All rock outcrops and islets found within this limit are quite small. Barbarin island and Parei Duwa have average surface area of approximately 1,000m^2. All other rock outcrops and island are less than 200m^2 in size.Among the rock outcrops located within the study –area, Debagala, Galgoda, Godagala, Pittaniya rock and Debaha rock can be considered as comparatively large in size. Each averaging about 100m^2 in area while most have an area less than 50m^2.

Lithologically, the rock of these island and rock outcrops belong to the Archian group. The surface appearance and their structure of these island and rock outcrops show that they are the results of changes in sea-level and have survived as remnant rocks. Thus the formation of these features can be attributed mainly to coast line retreat and marine erosion. Most of these features can therefore, be classified as erosional remnants.

2. Foreshore zone

2.1 Beach rock

A beach is composed of beach sand consolidated in place by interstitial cement, chiefly calcium carbonate. Typical beach rocks seem to develop best along tropical and subtropical coasts,"indurated beach material, usually with a carbonate cement, but sometimes with one including iron, are beach rocks,"(Swan 1983)

Beach rock occur in many places along the South West coast of Sri Lanka and many have been identified at Matara ,Gall, Beruwala, Akurala, Kaikawala, and Colombo. Their outwards are generally of variable extent and size and occur as discontinuous

foreshore or offshore masses of cemented beach sand or sandstone. They have previously been described as "coastal sandstone"(Coates 1935)."littoral sandstone" (Wadia 1940) and "sandstone reefs" (Cooray 1967).

The best exposed beach rock occurrence is near Beruwala,where sandstone is seen an the low-watermark, forming a platform of about 100 to 200 meters wide between Barberin island and the mainland., and extending southwards beyond Halwegoda. The beach rock at Athuruwella occurs on the foreshore near the levelcrodessing at the 40.5 Mile stone on the road from Colombo to Galle. At Kaikawala sandstone is exposed on the beach for about 50 m in the middle of the bay south of the Kaikawala headlands. Between Galle and Matara, a number of beach rocks occurm, mainly at Yakinigeduwa, Mirissa, Talaramba and Polhena.

2.2. Beach

Beach along the south western coast can be classifeld on the basis of shape, material composition, ongoing processes, genesis, chronology and stability.The average width of the southwest coastal beach is about 50m, but it varies from 0 to 110m. The average beach angle is 12^0, but it varies from 0 to 30^0.

2.3.Beach shape

The contemporary beaches of the South West coast of Sri Lanka comprise of three segments:

i. Straight coasts,
ii. Irregular shaped coast
iii. Curvy coasts.

Straight coastline predominate the sector from Colombo to Aluthgama while the beaches from Aluthgama to Galle are mostly irregular in shape. This is due to severe erosinal processes and the fact that the coast directly faces the South West monsoons. Curvy beaches are found mostly along the coast between Galle and Mathara, where embayment features are common

2.3.1. Material composition

The beaches of the South West can be classified into 3 types according to their material composition

(a) Sandy beaches
(b) Coral sandy beaches
(c) Boulder/cobble beaches

Sand is the dominated constituent of most beaches of the Southwestern region.However the beaches from Akurala to Seenigama and Kumbalgamas to Polhena can be classified as coral sandy beaches,because coral fragments predominant in these beaches.

2.3.2 Processes in operation

Beaches can also classified according to the processes that were active as erosional or depositional. Most of the beaches, along Moratuwa,Panadura,Kalutara, Akurala,Hikkaduwa and Weligama can be classified as erosianal beaches. The beaches which are not being eroded can be identified as depositional beaches Induruwa , Aluthgama, Ambalangoda, and Polhena have beaches identified as depositional beaches.

2.3.3. Genesis

Beaches can further be classified according to their locations on the coast.

(a) Bay beaches
(b) Lagoonal beaches
(c) Estuarine beaches

While Weligama and Galle beaches can be identified as bay beaches, Moratuwa, Ratgama,and Koggala beaches can be described as lagoonal. Estuarine beaches, associated with river estuaries can undergo changes within a short period due to sudden changes of the bedload of the river and or due to sudden changes of the river processes. Materials brought by the river are deposited at the river mouth directly,sometimes they can be carried out to off-shore.This happens due to sudden changes in the flow of river.Bay beaches are composed of equal proportions of sand and silt. The lagoonal beaches are distinguished by a higher percentage of silty materials

2.3.4. Minor features of beaches, beach cups

The Southwestern coastal area also displays certain minor features which are subject to daily change. The most common in this category is beach cups and ripple marks. Beach cups develop parallel to the wave motion, and evolve as a series of crescent shaped undulating structures along the upper beach, with an intermediate "horn" facing seaward. The range in height from a few centimetres to several meters. Guilcher reported that the wavelength also varies from 5m to 77m (Russell and MC entire (1965). Mineral deposits concentrated in beaches due to wave action are as "heavy sand" beach ores and beach placers".

Beach cups are located at several places along the southwest coast. Mostly on wide and steep beaches. No beach cups occur in segments where groynes and revetments have been building. Therefore the segments of the beaches from Mount Lavinia to Ratmalana, From Kalutara to Maggona, Ambalangoda, and from Mirissa to Matara are prominent beaches for beach cusp development. The average distance between two cups in the southwest coastal area is 25m. The average length of a horn is 10m. Ripple marks area a category of features which from on the beaches due to oscillatory nature of winds and waves. Oscillatory (symmetric) ripples are rare, being characteristic of standing water. Most common are transitional ripples (asymmetric) which develop normal to the current direction and also rhomboid ripple marks (interference type). Most of this ripple can be seen in those parts of the Southwest coastal area where the beaches are wide and covered with loos sand.

2.3.5. Spits and barriers

Spits and barriers are outstanding coastal features that can be identified in the foreshore. The Encyclopedia of Geomorphology (Fairbridge 1983) describes a spit as "a cliffed headland projecting onto a shallow offshore shelf, which generates waves in the basin so that they approach the headland perpendicular to the shoreline."Due to this process, another spit develops on each side of the headland. Shaped uses the term"cuspate spit" to the development of "compound spits" or bars by progradation of a barrier bar or island. In Sri Lanka spit-bar features can be seen mostly at mouths of rivers as these are formed due to the combined action of sea and rivers. In the Southwestern coastal area,these spit features can be found mostly at the mouths of the Kelani Ganga,Nilwala Ganga, Bentota Ganga and at the Polwatta Ganga near the Weligama bay. These spits are always connected and extend parallel to the coast

A barrier is partly an emergent bar like ridge of sand or coarser sediment lying off a shore or shoal, and usually sub-parallel to the shore. Projecting from the flank of a headland or connecting two headlands. A barrier is usually cut by one or more tidal inlets, Forming a barrier chain a succession of barrier peninsulas and barrier island or simple, narrow beaches.

Barriers have also been called 'sandbanks" offshore bars" are narrow barriers near headlands of changeable shoreline positions and or the updrift sides of migrating inlets where they grow longitudinally (Armstrong, price,1980). Longstanding barriers as well as barriers of resent can be found in the study area. All of them are formed at rivermouths. These barriers have been formed under the influence of wave action and the rivers. It is a bar blocking the river estuary and connecting both sides of the river. The main difference between a barrier and a rivermouth bar is the seasonal nature of the latter. River mouth bar can be seen clearly at Panadura, Balapitiya and Ginganga if the season is fovourable. They developed during the North East monsoon seasonal are formed due to the low velocity of the river mouth bars begin to disappear with the onset of the South West monsoons when the bed-load and the flow velocity increases and ,simultaneously the wave activity abates under the effect of land winds. The height of the waves and the energy generated by them in height of the waves and the energy generated by them in combination with the flow characteristics of the river thus are the two main cause of alimentation of these bars. These factors explain the essentially seasonal character of these river mouth bars of south west Sri Lanka.

The effects of barriers and rivermouth bars are quite different from those produced by spit bars.Barriers and rivermouth bars cause changes in their adjoining areas and the environment in the upper reaches of the river. The main effect of these bars is a decrease in the velocity of the flow. Barriers and rivermouth bars also create water-logged areas, cause the accumulation of bed-load in the lower reaches of the river closes to the rivermouth and further lead to the raising of the river-bed.

2.3.6 .Headlands

Headland features are not limited to the foreshore unit. Sometimes they extend into the headland through the backshore and the coastal plain. They may extend up to the nearshore zone and also seawards from the foreshore. Headlands are discussed under the foreshore unit because they are most significant for this particular segment.

A headland can be described as a portion of the earth's surface composed of parent rock which extends seawards through the foreshore in a coastal unit. Therefore, the origin of a headland is not strictly marine in character, but may be described as a sub-aerial landform as a result of certain marine processes.

Swan (1974) , classified the headlands in the South Western coast on the basis of their efficiency and stability or instability. Headland efficiency means "the potential of the seaward protrusion of the land for acting as a beach retaining barrier" (Swan, 1974). In other words the situation of the beach determines its efficiency. Headland stability means "the ability of a headland physical destruction by wave action (Swan, 1974)

2.4. Backshore zone

The "back shore" is that portion of the beach which lies between the high-water and the low-water marks. Consequently the backshore zone is in the first place influenced by tides and waves. The "backshore" is the belt which starts from the berm crest and extends to the cliff foot, dune or first vegetated beach ridge (R.W.Fairbridge 1983).

For the present study “backshore zone is taken as” the zone extending from the upper margin of the beach face towards the island, up the seaward margin of the creeping vegetation and subject to daily and seasonal changes due to coastal processes.

The width of the backshore zone of the South West coastal area varies to a great extent. As the mean width of the backshore here, is the amount of the extension from the face to the margin of the creeping vegetation zone, the width of the backshore narrows down in areas where active emotional processes of no erosion. The backshore zones in the South West coast can be charactericed on the basis of width:

i. Zones of wide backshores
ii. Zones of moderately wide back shores
iii. Zones of narrow backshores

Backshore zones extending to more than 10m are regarded as wide backshore zones. Those between 5m and 10m are classified as moderately wide, and those less than 5m as narrow backshore zones.

The main characteristic of back shore zones is being subject to seasonal changes. The width of the back shore zone begins to reduce gradually from commencement of the South West monsoon. The average rate of reduction observed is 3.5m per day. The behavior of waves has a direct effect on the reduction of the width.

When the uprush becomes higher and higher during the SW monsoon period due to the increase of wave and the strengthening of wave energy, the backwash velocity also increases. As a result of the increases, of the velocity of the backwash, large volemes of beach materials from the backshore are carried to the sea. As a result the width of the backshore gets less and less.This process goes on uninterruptedly throughout the season. This varies, however and at places may be as much as 5m per day. The slope of the backshore too undergoes changes. During the South West monsoon the gradient from the highest part of the backshore zone to the sea level increases from 5 to 15. The height also varies : from 2m to 7m from the sea level. During the North East monsoon period the behavior of the backshore is reversed. Due to the comparative calmness of the sea, The wave height and wave energy become reduced. Therefore , the processes described from the South West monsoon are now reversed. The load brought to the sea by backwash is reduced and as a result, the gradient and the height of the backshore are reduced. The gradient is lowered from 5 to 2 and the height decreases from 5m to 2m.As the backshore is composed of material. Its composition may very from one locality to another due to other influences such as river action and weathering processes.

2.4.1. Berms

Berms, miniature sand dunes, sand ripples and beach scarps are the most prominent morphological features that can be identified in the backshore of the southwest coast. These features are subject to seasonal changes or are fully seasonal in character. The changes are brought about by physical features such as winds, and waves. At the upper edge of the beach face wherever a micro-tidal is found , a berm may never be located. Berms are near horizontal portions of the beach on backshore formed by wave born deposits (Swan 1973)

The seaward limit of the berm is called the beach face and is defined as the escarpment notched into the beach profile by solution or wave action.

The formation of berms in the southwestern coastal area depends on two factors, mainly :The site and the season. Wide beachers and straight coasts are among the important factors that are favorable for the formation of berms. Sometimes features such as beach slope also affect the formation of berms, because the volume of sand which can be washed away from the backshore is dependent on it. In addition to the nature of the site, the seasonal factor also affect the formation of berms. During the monsoon period when the waves are high. the seasonal factor also affect the formation of berms. During the monsoon period when the waves are high, the beach becomes flattened, During the calm season, the up rush of the smaller waves is strong enough to carry sand to the upper regions of the beach and the weak backwash cannot transport into two categories, namely; single berms, and multiple berms

Multiple berms are created by wave action. Calm and low-waves gradually deposit sands along the backshore at different levels and this seaward deposition leads to the formation of multiple berms.

The swash zone and single berms occur parallel to each other. Here too waves cut into sand dunes or the backshore area. More powerful waves during the stormy season carry the sediments creating a single berm at one level. Three zones of berms can be identified in the Southwestern coast, On the basis of their frequency of occurrence:

(a) The zone where many berms occur
(b) The zone where few berms occur, and
(c) The zone without berms.

The coastline extending from Mount Lavinia to Ratmalana,from Induruwa to Aluthgama, and from Dodanduwa to Bussa, are the coastal zones where multiple berms are commonly observed. The width of the berms varies from 10m to 75m, while the gradient varies 0 to 3. The average height of the berms may from 1m to 3m.Multiple berm features are mostly developed during the calm season. However during the SW monsoon period, these multiple berm formation turn into single berm formation, due to the creation of powerful waves which then cut onto the backshore.

2.5. Coastal plains and their sub-units

"Geomorphologically coastal plains are regional features of low relief bounded by the shore and landward by highlands"(Freeman and Morris 1958).Another definition of a coastal plain is as follows: geomorphologically, coastal plains are the present products of continuing emotional and accrational processes through time" (Donald,O.1984). coastal plains are bounded landwards by highlands, and to the seawards by the continental and of marine origin formed both at the present time and in the geological past.

The coastal plains of the southwest coast of Sri Lanka is a comparatively narrow stretch of land as a result of the severe coastal erosion that has occurred in the past. This can be observed between Kalutara and Weligama. The coastal plain from Colombo to Panadura, and from Weligama to Matara is comparatively wide as compared with former. The following are the main characteristics of the southwestern coastal plain:

(i) The major rivers of Sri Lanka such as the Kalu ganga, Bentota ganga, Ginganga and the Nilwala Ganga cut through the southwestern coastal plain.

(ii) The landward margin is bounded by the ridge underlain by Vigayan and pre-Cambrian rocks of the hill series. More structurally controlled features therefore exist along the highland margin.
(iii) Nearly the whole the coastal plain is underlain by quaternary wind blown sand except for a few areas like Dehiwela, Beruwala, Bentota, Ambalangoda mainly what lateritic caps occur. The following specific features can be identified in the southwest coastal plain:
(i) beach ridge
(ii) lagoon and lakes, and (iii) tidal flats.

2.5.1. Beach ridges

The encyclopedia of geomorphology has defined beach ridges as "sub-parallel ridges of sand or pebble, warying in amplitude from a few inches to many feet and varying defined as follows, "beach ridges are built where the beach face angle appropriates to the beach materials and most significant wave type is steeper than the overall shore profile" (Savage 1959). Generally a beach ridge can be defined as a low elongated ridge of sand generally lying on the beach parallel to the present beach line.

The identified beach ridges could be classified into two categories according to their ages as follows: (a) younger beach ridges, and (b) old beach ridges.

2.5.2. Younger beach ridges

The Younger beach ridges are morphological features that developed parallel to the beach during the Holocene period. These beach ridges can be seen from Colombo to Matara close to the contemporary beach and parallel to it. The Colombo -Matara highway,at certain places has been built on the crest of one of these beach ridges. The Younger beach ridges from north to south can be identified in three areas.

(a) the northern part, extending from Ambalangoda to Colombo ;
(b) the middle part extending from Ambalangoda to Galle;
(c) the southern part extending from Galle to Matara.

In the case of beach ridges, the most outstanding characteristic in the northern and southern parts are their continuous longitudinal and irregular shapes. The beach ridges in the middle section to the quaternary era longitudinally discontinuous and are irregular in plain as a result of more severe erosion. Moreover, some of the beach obliterated as a result of human settlement and land utilization. Yet can be clearly recognized in aerial photographs. While the Younger beach ridges and the swales zone is about 3km wide in the northern and southern portion. Taken as a whole, the Young beach ridge zone is of every gentle relief with slopes varying from 0 to 3.

The average distance between two beach ridges is approximately ½ km and the average height of the ridges is less than 4m.While in the northern and southern parts, beach ridges are parallel to the coast, in the middle part, most of the recent beach ridges are semi-circular in shape due to the semi-circular shape of the beaches. The semi-circular forms of the beach ridges are mainly due to the headlands along the coast. The natural vegetation is off the sandy shore type, but most of the beach ridges are now comprised of settlements, roads, hotels, and homesteads.

2.5.3. Old Beach ridges

The old beach ridges are geomorphological features that have been formed during the early Holocene (Year). Although their shape, forms the locations that are similar to those of the Younger beach ridges. They possess certain unique characteristics which distinguish them from their Younger counterparts .Although no clear regional pattern is discernible in the distribution of old beach ridges, two areas can be demarcated as follows:

(a) the areas where old beach ridges are clearly visible, and
(b) the areas where beach ridges are not clearly visible.

In the above first area, old beach ridges could be seen easily as three-dimensional objects in air photos as well as during field visits. In the second area, however it is not possible to identify or detect them in the field. During the interpretation of air photographs, only a limited number of specific clues could be observed. In Colombo, Mount Lavinia, Kalutara, and Matara, old beach ridges were identified clearly in the field as well as in the air photos. They were not clearly distinguishable in the areas of Akurala, Bussa, Galle. or Weligama, except with the help of air-photos, In these areas, beach ridges exist only in the form of remnants and patches. The beach ridges in the latter areas run parallel to the present coastline. But they have been subjected to various erosional and dispositional processes as well as to the influenced by human interference.

Due to sea level changes that have occurred in the past, the coastal areas were submerged by the sea, and due to the lowering of the sea level in the past, those old beach ridges have been buried under colluvial material transported by streams and river a and wind blown sands. Some section of these ridges have been destroyed by human interference.

Various stages and levels in the formation of old beach ridges could be easily identified through air-photographs of the areas of Matara close to the Nilwala Ganga estuary. The average width of old beach ridges that have been identified varied from 6m to 25m and their height from 1m to 2m. Their average slopes on either side varied from 3 to 10. it is only in the Colombo area, that old beach ridges can still be easily observed. The material composition of the old and young beach ridges also differs. The old beach ridges are composed predominantly of silt and clay fraction while medium and coarse fractions dominated in the composition of the younger counterparts

2.5.4. Lagoons

A lagoon is an elongated, body of water Iying parallel to the coastline and separated from the open sea by a barrier (Stevenson, 1958). Lagoons have been considered as evidence of emergence of low-lying coastal area (Johnson 1919), Since they are most common along coasts bordering lowlands,the formation of lagoons is related to a number of factors such as the formation of embayment as a result of marine transgression, and the development of barriers in front embayment. The waterbeds of Beira lake (Colombo), Bolgoda lake, Kalutara lagoon Ratgama lake, and Koggala lake are prominent lagoons in the southwestern coastal plain. They can be classified

into two categories according to the above definitions: (a) lagoons which were formed due to the downthrown of a part of the land.

These lagoons are affected by seasonal as well as secular changes. The Kalutara lagoon and partly the Bolgoda lake are subject to seasonal changes. The Kalutara lagoon displays very distinct changes compared to the Bolgoda lake because it is closer to the open sea. The other lagoons show less distinct changes. The Beir lake displays minimum seasonal and secular changes.

Another characteristic of these lagoons is the vegetation around them. All the lagoons except the Beira lake and the Kalutara lagoon are surrounded by lagoonal vegetation. The Kalutara lagoon does not have any appreciable vegetation around due to the rapid seasonal changes occurring around it, while the Beira lake is completely devoid of vegetation due to rapid urban development. Lagoon beaches can be observed at the Kalutara lagoon. Mostly they are covered by lagoonal vegetation due to high siltation. The sediment composition of the Kalutara lagoon has a very high wave energy.

2.5.5. Tidal Flats

Tidal flats are not very common in the southwestern coastal plain. They do occur at places such Mahamodara, Galle. Mihiripenna and Weligama. These tidal flats can be divided into two categories according to their geographical characteristics.

(a) The largely barren tidal flats, bounded by the backshore hinterlands and

(b) The mangrove covered tidal flats.

Tidal flats located at Mahamodara and Hihiripenna belong to the first category, while the others belong to the second. The fluctuation in the water level caused by the surges and tides flowing through the tidal creeks, streams and canals cause an influx of water into the adjacent areas and this sustains the process of tidal flat formation. Tidal flats are at some distance from the contemporary beach and thus are protected from wave action.

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