Chapter 6

SUMMARY AND CONCLUSIONS
Shore parallel beach ridges with alternating swales and occurrence of strandline deposits on the shelf make the northern Kerala coast an ideal natural laboratory for documenting morphodynamic response of the coast to changing sea levels. To understand the coastal evolution during the Pleistocene to Holocene period, a systematic study along two east-west transects originating from the strand plain and cutting across the beach to the continental shelf domain is attempted.

Plane table mapping of geomorphic units along the two E-W transects namely Punjabi and Onakkunu in 1:2250 and 1:5000 scale respectively were carried out. From the reduced levels, swale and ridge height were determined with reference to the PMSL. Eight sets of beach ridges and swales were identified in Onakkunu transect and seven sets in Punjabi transect. High stand of sea level fluctuation is deciphered from a series of strandline deposits ranging in elevation from +7.73m to -3.91m. The east-west profile drawn by joining the spot heights (with respect to PMSL) of ridges and swales indicate a general seaward slope. The seaward slope of the ridge and swale bottom manifests successive regression during different periods.

Radiocarbon dating of shell samples collected from the Thekkekad island from a core-depth of 6.3 m below PMSL gave an age of 2830 ± 30 YBP. This shows that the deposition of shells associated with regressive phase took place at around 3000 YBP.

Based on the granulometric analysis of subsamples collected from 22 cores varying in depth from 7 to 11 m, various sedimentary facies were inferred, viz., strand plain, beach, estuarine, inner shelf and river. Morphostratigraphy and radio carbon dating of the deposits indicate that sediment accumulation is thicker in Onakkunu than in Punjabi.

Study of heavy minerals is used to elucidate post depositional changes of the coastal plain sediments. In the Onakkunu transect, rarity of unstable ferromagnesium minerals indicates post-depositional transformation of the deposit. Relative enrichment of stable minerals and the reddening of the sand show that the strand plain sediments, after being part of the littoral environment, could have got exposed to sub-aerial weathering during the successive phases of regression, thereby activating the intra-stratal solution processes.
In this process, dissolution of iron from the ferromagnesium minerals and ferric coating on the sand grains could have led to the reddening of the surficial and sub-surface sediments to a great extent.

It has been established from the study that, under humid tropical conditions bright red colours might be attained even within $10^3$ to $10^4$ years. The radio carbon dates obtained from the shell and peat samples in dark gray coloured fine and very fine sands from the Onakkunnu transect at a depth of 3.2 m and 10.4 m gave an age of $5650 \pm 110$ YBP and $>30000$ YBP respectively.

Based on the textural analysis, calcium carbonate and organic matter contents in nine gravity cores and one piston core collected at a water depths ranging from 30.2 to 151 m, the depositional history of the shelf sediments were inferred. The four-segmented cumulative probability curve of the relict sediments at 40-m water depth is found to be quite similar to that of the beach sediments. The shelf sediments are also affected by a series of Quaternary fluctuations, thus resulting in sediments consisting of various proportions of relict, reworked and modern sediments. Intimate relationship that exist between the climate and sedimentation pattern have synergistic effect on the preservation potential of organic matter and CaCO$_3$ in the sediments. Carbonate content of sediments has been found to be a good indicator of glacial inter-glacial stages. Generally high concentration of CaCO$_3$ indicates cooler periods while a lower content indicates warmer period. Silty clay sediment in the inner shelf, sand-rich sediments in the mid shelf and silty clay/sand-silt-clay sediment in the outer shelf represent different episodes of sedimentation that the shelf has undergone during the late Quaternary period.

Sedimentological studies amply demonstrate that a paleo-beach existed off the Kerala coast during the late Quaternary low stand of sea level, which, at present, remain detached from the mainland due to the subsequent transgression. The expanse of sandy sediments at a water depth of 40 m in the mid-shelf has an age bracket of 7000-8000 YBP. Radio carbon dating on shells from the innershelf and outer shelf cores collected at 40 m and 150 m water depths, indicates a sedimentation rate of 0.12 mm/yr for the innershelf and 0.05 mm/yr for the outershelf.
By collating the result from geomorphological, lithological and geochronological studies and other published work, the evolution of shoreline position of the northern Kerala coast from 36 kyr to present is deciphered.

The radio carbon dating of marine deposits located at a distance of 5.79 km from the present beach shows that present land area extending up to 6 km inland was under the sea at about 5650 ± 110 YBP. This result matches well with the general trend of mid-Holocene global pattern. The vertical difference between the elevation of adjacent ridges and swales are considered for locating the then position of the sea level. The ridge/swale elevation at this location indicates that the sea level was around 5 m above PMSL around 6000 YBP.

The chrono-stratigraphy illustrates eight episodes of regressive events corresponding to eight sets of ridges and swales. The inner most ridge event took place around 6000 YBP and the fore dune adjacent to the beach is a morphologic continuum since 1000 YBP. Presuming uniformity in the conditions of depositions, formation of each ridge/swale set took around 500 to 700 years. These ridge/swale set might have been formed by the rise/fall couplet. From these, a sea level fall of around 60 cm on the average per ridge/swale set is found to be a reasonable estimate evolved out of this study.

The marine regressive episode of the coastal plain sequences encountered at deeper level shows an age of >30000 and >40000 YBP. Since, the radiocarbon date can give near accurate dates only up to 30000 YBP the two samples definitely belong to an older marine sequences. This reveals that an earlier period during which sea level crossed the PMSL belongs to the oxygen isotope 5e stage at about 125 kyr BP. Detailed study is required to confirm this event.

The shoreline changes and the variation in the total area of the northern segment of the Kerala from 36 kyr to the present is analysed. At about 36 kyr, while the sea level situated at about 25 m below PMSL, the total area of the northern Kerala was around 11621 km², which is nearly 24% more than that of the present day area. During the LGM (18 kyr) when the sea level stood at its maximum of ~100m, the northern Kerala extended seaward.
occupying 125% more area and was around 21085 km². Since 14 kyr, with rapid rise in sea level, the coast retreated and the land dwindled continuously, which continued till 6 kyr. Since 14 kyr, with rapid rise in sea level, the coast retreated and the land dwindled continuously and ultimately got almost stabilised to its present position for the last 1000 years.