Sustainable coastal protection project

1. Introduction:

A 590 km long complex coastline including sandy/mud beaches, rock formations, lagoons, estuaries, barrier islands and depleted coastal vegetation and around 19000 fishermen families residing within 50m distance from shoreline make coastal erosion a major problem for Kerala. Studies show that along the Kerala coast, eroding and artificial coast (eroding coast managed by artificial structures) account for 65%. Accretion is found on 21% along the coast and only 14% fall under stable coast including rocky coast. Coastal erosion along the coast of Kerala is perennial. The extent of erosion during the southwest monsoon (June-September) causes extensive Loss / damage to property adjacent to shore. The recent hurricanes and depressions that happened in the season during which the accretion of beaches usually take place and the subsequent monsoons that followed have exacerbated the tidal surges.

Resettling vulnerable families along the coast (500 m off the coast as per the CRZ Act of the Coastal Regulatory Authority) is the best option; but is almost impossible. Therefore, there is an urgent need to build or rehabilitate the existing marine defences to enhance the safety of the people living along the coast.

The intent of the project is to implement sustainable solutions for coastal protection to mitigate the unsettled issues associated with the sea advancement to the areas of inhabitants. Kerala Coastline is roughly of the order of 590 km, which forms 10% of India's total coastline. The coastal line spread over nine districts of Kerala. The marine districts of Kerala are Thiruvananthapuram, Kollam, Alappuzha, Ernakulam, Trissur, Malappuram, Kozhikode, Kannur, Kasaragod. Each beach front is characterized by different wave characteristics and hence the extent of damage is dissimilar. In this context, the mitigation plan adopted would also vary.

Coastal erosion is specific to the site, and the adoption of a common coastal protection measure for the entire coast cannot solve the problem. Therefore, the implementation of the same cross-section of seawall in all parts of the Kerala coast will not solve the problem, on the other hand, the problem may be worsened. Although most of the vulnerable areas along the coast of Kerala are already protected by hard or soft structures, they are in a damaged / unstable condition and need to be rehabilitated after a detailed investigation into the stability of the cross-sections in case of seawall, wave tranquillity in case of groin field with the help of numerical/physical modeling.

Appropriate protection measures such as hard or soft measures to mitigate coastal erosion need to be considered on a case-by-case basis considering the erosion that occurs in each particular area, the density of the population, socio-economic aspects of coastal activities etc.

2. Concept:

Based on the shoreline changes (on vulnerability scale), the coastline can be stated as below:

- Very High Erosion
- High Erosion
- Moderate Erosion
- Stable

Based on the above scaling, technologies are planned and is presented in below sections.

3. Technologies planned to be adopted:

a. Double layered tetrapods with antiscour layer

In this methodology, tetrapods are used for protection of the shoreline. Tetrapods are concrete armour units which is the replacement of the rock armour . The tetrapods are designed in such a way that they dissipate the force of incoming waves by making the water flow around rather than against them. They also reduce displacement by allowing the random distribution of tetrapods to mutually interlock. Due to their weight and design, tetrapods can remain stable even under the most extreme weather conditions. Several tetrapods arranged together form an interlocking, porous barrier that dissipates the power of waves and currents. An antiscour rock protection at toe shall be provided to protect the structure from scouring by sea wave action.

b. Mangroves (in tetrapot)

The TetraPOT is designed to accommodate the fluctuating water levels of beaches. As the tide comes in and seawater rises around the tripod-like pot, a certain amount of water spills into the hollow part of the design. The organic cushion under the seeds become drenched, encouraging the plant to grow and develop roots downwards.

With roots reaching down for more moisture and nutrients, the plant's root structure eventually emerges from TetraPOT's three support chambers and the plant continues to grow into the ground below.

When a few TetraPOTs are grouped closely together, the tree roots eventually grow in a tangle and form a natural mangrove over time.

The heft of the TetraPOT allows it (when a number of them are arranged alongside one another) to form an above-ground barricade in the same way that existing cement blocks do and an additional defence is formed by the underground root structures. Not only do they hold the pot anchored in place, but the tree roots penetrate the earth below and continue to intertwine, physically supporting the soil against erosion.

In addition to the TetraPOT's protective design, it can create a new ecosystem of its own by providing a habitat for insects and other beach-dwelling creatures.

c. Diaphragm walls with antiscour layer

This is a permanent solution where the beach front is permanently protected from wave action. Diaphragm walls are rigid reinforced concrete walls made up several discrete panels joined together to form a single continuous wall. The rectangular shape of a diaphragm wall is well suited to resist bending and shear forces associated with lateral soil loads which makes them efficient for deeper excavations.

Diaphragm walls can also be provided with tetrapods by laying the same in the sea side

d. Rolling Barrier System

Rolling Barrier has a rotating barrel made of EVA (ethylene-vinyl acetate) with excellent shock absorption power, three-dimensional buffering frames and dense props supporting the frames. Rotating barriers come up with attached reflective sheeting for good visibility. The rotating barrel converts shock from the tidal waves to rotational energy. The upper and lower frames adjust the tidal waves to prevent the system from functional loss. The three-dimensional structure of the D-shaped frame and buffering bracket distribute and absorb the second shock. The roller absorbs collision shock (shock energy to rotational energy). The metal pipe inserted is to strengthen the post.

e. Geo-containers & Geo-tubes

Geocontainers are in fact large bags, filled in the hopper of a split barge and dumped by that barge on a selected position. Geocontainers has been applied at several places in recent years. mainly as fill units, shore protection and as breakwaters. Geocontainers will mainly be applied in situations where sand is abundantly available, and rock is costly; where gently construction slopes must be avoided and where erosion by currents and waves may be a problem. The main design considerations include sufficient strength of the geotextile and appropriate filling. Because Geocontainers are applied under water, the effect of UV and vandalism are usually negligible.

Geo tubes are geotextile wrap bags that have proven to be economical alternative for the construction of offshore reefs, groynes, and seawall etc. They have also been used for slope/bank protection in the riverine problems. The tubes are made up with woven/non-woven polypropylene/polyesters fabrics. The tube exhibit high strength, while having good workability and physical toughness and is relatively cheap. They are permeable fabric, which can hold back material while water flows through. Geotextile tubes are large tubes filled with sand slurry mix. The mix usually consists of dredged materials from the nearby area. Geotextile tubes are the flexible units for the coastal protection work. It has no adverse environmental impact on the aquatic habitats at the site.

Off shore breakwaters can also be constructed either by using soft measures like geotubes or caissons

4. Approach & Implementation methodology

Based on the vulnerability scale, the approach is to go with option 1 to 4 or a combination of these. In the implementation of the proposals identified, most of the companies involved in marine projects have the capability in dealing with execution of these options. Currently KIIFB financed project is using some of the above-mentioned methodologies as part of the coastal protection works. The SPV's involved currently in such activities are KSCADC and KIIDC. The technology that is being implemented are tetrapods (Kollam , Alappuzha , Kannur) and geo tubes (as a pilot project in Poonthura, Trivandrum)

Regional centers for tetrapod casting are developed with the support of experienced agencies with technical supervision by an SPV and KIIFB. this centers will supply adequate number of tetrapods with lowest possible cost for executing option no 1&2 . With regard to the option 2 &3 , design, supply, installation , maintenance type of contracts are entered by the SPV with the technical support of KIIFB.

5. Cost provision

The approximate cost based on different combinations is as shown below. The total cost is approximately 5162Crs. As about 1000 Crs projects are being planned through various schemes including KIIFB projects the additional budget outlay may be for an amount of 4162 Crs. This can be completed in 5 years time.

Location	Length of coast line (Km)	Vulnerability		Methodology proposed	Anticipated Equipment	Approx Cost / km	Item Cost	Total Cost / District	Grand Cost
		Status	Approx length (km)						
Thiruvananthapuram	78	a) Very high erosion	15.6	Diaphragm Wall	Excavators	12,50,00,000	1950000000	**6825000000**	**51625000000**
		b) High erosion	27.3	Diaphragm Wall	Excavators	12,50,00,000	3412500000		
		c) Moderate erosion	7.8	Rolling barrier system , tetrapod , geotubes and or its combinations	Crane / sand pumps	10,00,00,000	780000000		
		d) Stable	27.3	Mangroves (in tetrapot)	Crane / Excavator	25000000	682500000		
Kollam	37	a) Very high erosion	7.4	Diaphragm Wall			925000000	**3237500000**	
		b) High erosion	12.95	Diaphragm Wall/tetrapod			1618750000		
		c) Moderate erosion	3.7	Rolling barrier system , tetrapod , geotubes and or its combinations			370000000		
		d) Stable	12.95	Mangroves (in tetrapot)			323750000		
Alappuzha	82	a) Very high erosion	16.4	Diaphraghm Wall			2050000000	**7175000000**	
		b) High erosion	28.7	Diaphraghm Wall/tetrapod			3587500000		
		c) Moderate erosion	8.2	Rolling barrier system , tetrapod , geotubes and or its combinations			820000000		
		d) Stable	28.7	Mangroves (in tetrapot)			717500000		
Ernakulam	46	a) Very high erosion	9.2	Diaphragm Wall			1150000000	**4025000000**	
		b) High erosion	16.1	Diaphragm Wall/tetrapod			2012500000		
		c) Moderate erosion	4.6	Rolling barrier system , tetrapod , geotubes and or its combinations			460000000		
		d) Stable	16.1	Mangroves (in tetrapot)			402500000		
Trissur	54	a) Very high erosion	10.8	Diaphragm Wall			1350000000	**4725000000**	
		b) High erosion	18.9	Diaphragm Wall/tetrapod			2362500000		

		c) Moderate erosion	5.4	Rolling barrier system , tetrapod , geotubes and or its combinations			540000000		
		d) Stable	18.9	Mangroves (in tetrapot)			472500000		
Malappuram	70	a) Very high erosion	14	Diaphragm Wall			1750000000	**6125000000**	
		b) High erosion	24.5	Diaphragm Wall/tetrapod			3062500000		
		c) Moderate erosion	7	Rolling barrier system , tetrapod , geotubes and or its combinations			700000000		
		d) Stable	24.5	Mangroves (in tetrapot)			612500000		
Kozhikode	71	a) Very high erosion	14.2	Diaphragm Wall			1775000000	**6212500000**	
		b) High erosion	24.85	Diaphragm Wall/tetrapod			3106250000		
		c) Moderate erosion	7.1	Rolling barrier system , tetrapod , geotubes and or its combinations			710000000		
		d) Stable	24.85	Mangroves (in tetrapot)			621250000		
Kannur	82	a) Very high erosion	16.4	Diaphragm Wall			2050000000	**7175000000**	
		b) High erosion	28.7	Diaphragm Wall/tetrapod			3587500000		
		c) Moderate erosion	8.2	Rolling barrier system , tetrapod , geotubes and or its combinations			820000000		
		d) Stable	28.7	Mangroves (in tetrapot)			717500000		
Kasaragod	70	a) Very high erosion	14	Diaphragm Wall			1750000000	**6125000000**	
		b) High erosion	24.5	Diaphragm Wall			3062500000		
		c) Moderate erosion	7	Rolling barrier system , tetrapod , geotubes and or its combinations			700000000		
		d) Stable	24.5	Mangroves (in tetrapot)			612500000		