Seawalls, Groynes and Breakwaters: Their impacts on the Kerala's beaches and small-scale fisheries

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Introduction

The sandy beaches of Kerala coast where a rich small scale fishery thrived, has had many engineering interventions made for various reasons. This study reviews the reasons that arise from engineering structures such as seawalls, groynes and breakwaters and investigates how these structures have impacted the sandy beaches and the small-scale fishery that thrived on them.

In an ideal situation a healthy and stable coastal ecosystem is very supportive of traditional shore based small scale fisheries. This health in turn is maintained by the desirable linkages with the riverine systems that supply sediments and nutrients to the coasts. Kerala's unique geography maintained this linkage between the coast and the mountains with network of forty one west flowing rivers and the chain of backwaters with dynamic estuaries. However, this unique feature of Kerala's coast has undergone rapid changes in the recent past. Since the Third Five Year Plan(1961-1966), Government of Kerala emphasized creation of infrastructure facilities such as fishing harbours, fish landing centers, fisheries roads, fisheries dispensaries, guide lights, community resource centres, fisheries research institutes and schools for the coastal fishing communities[1]. Today it is estimated that currently 63 percent of its coastline is tampered with engineering structures such as sea-walls and groynes.

Over the last four decades, these fishery harbors and landing centres with their breakwaters constructed along the coast tampered with the rhythms of nature resulting in increased erosion at one part of the coast and accretion on another. Rapid changes of the shoreline with loss of property and other coastal assets set in motion a series of action from the government side in the form of seawalls and groynes. These structures were built, according to government sources, to protect the coast from erosion. This government action had long standing negative impact on centuries of fine-tuned skills and methods of shore-based fishing activities. When beaches vanish, dependence on fishery harbours become inevitable and the demand for fishery harbours arise everywhere. Breakwater constructions become an inevitable necessity at the harbour entrance. These breakwaters jutting out into the sea, perpendicular to the coast, trigger off erosion and/or accretion depending on various geomorphic and oceanographic characters of the coast.

Apart from impinging on the traditional small scale fisher's rights to livelihood, these engineering structures are also built and maintained at a very high financial cost. It is not with people's participation or consultation that the State constructed breakwaters. The State relied heavily on agencies like Central Water & Power Research Station (CWPRS), Pune for technical advice relating to engineering structures on coast. CWPRS has a single solution for erosion caused by breakwaters: build seawalls and groynes. The State does not acknowledge the adverse effect of breakwater construction and continues to rely on CWPRS or IIT, Chennai for designing fishery harbours. This vicious cycle of cause and effect, unless addressed at a broader coastal ecosystem level, will lead to irreversible damage to the

1 Harikumar G and G Rajendran. 2007. An Overview of Kerala Fisheries – With Particular Emphasis on Aquaculture. IFP Souvenir. Pp 6-8.

coast and livelihoods of the already marginalized and vulnerable traditional and small scale fishing communities.

Focus of this study and study area

This study examines how coastal engineering structures such as seawalls, groynes and breakwaters have had a long term impact on the coast and traditional small-scale fisheries in Kerala.

Kerala is a coastal state with 9 of its 14 districts having a coastline the total length of which is 580 kms. The coastal zone of Kerala is also densely populated, particularly the southern districts of Thiruvananthapuram and Alappuzha where population densities exceed 2500 persons per sq.km on an average compared to 780 persons per sq.km for the state as a whole and 2022 persons per sq.km among coastal districts of the State[2]. The high-rising mountains of the Western Ghats, reaching upto 2695 m above mean sea level in the east, and the hills of the midland, greatly influence the ecological setting of coastal Kerala. Within a short spatial span, varying from 60 to 120 kms, rivers that originate in these high rising mountains, discharge their waters into the Arabian sea. Sand replenishment to the entire sandy beaches of Kerala comes from the 41 west flowing rivers that bring down sediments which consist of alluvium (silt and clay) along its downhill journey. But construction of dams and reservoirs curtailed this sediment flow and thereby sand replenishment to the beaches. Rivers downstream of the dam are subjected to intense sand mining. However, during the monsoon months, torrential downpour carves out land downstream of the dams and the load is discharged into the sea, often silting up estuarine mouths. This poses immense risk to fishing crafts steering through the estuarine mouths – called “azhi” in Malayalam.

The entire coastline of Kerala is very diverse both in geography and ecology. Continuity of the coastline is broken by river mouths and estuaries. The coastal plains are a mosaic of backwater bodies, agricultural fields and coastal flora. In a study by the National Centre for Earth Science Studies (NCESS), it is reported that 360 kms of the coastline is vulnerable to erosion and that only 86 kms of coast is structurally stable[3].

Historically communities living closer to the barrier beaches developed their fishing skills in shore-based fishery. For example, shore-seine fishery and near shore fishing using *kattamarams* (found in Trivandrum) and dugout canoes (common to entire Kerala) basically thrived because of the sandy beaches where they could drag in the crafts and engage in all fishing related activities.

Specific locations for in-depth investigation

We utilized the shoreline change assessment maps for the Kerala coast undertaken by the Ministry of Environment and Forests (MoEF, 2000-2010) depicting the status of beaches – whether eroded, accreted or stable and the Census of Crafts and Gear undertaken in 1998 by South Indian Federation of

2 Ramesh R *et al.,* Shoreline change Assessment for Kerala. National Centre for Sustainable Coastal Management, Ministry of Environment and Forests, Government of India. *http://www.ncscm.org*

3 M. Samsuddin and G. K. Suchindan. 1987. Beach Erosion and Accretion in Relation to Seasonal Longshore Current Variation in the Northern Kerala Coast, India. Journal of Coastal Research, Vol. 3, No. 1 (Winter, 1987), pp. 55-62.

Fishermen Society (SIFFS) to choose the specific locations for deeper investigation.

Field visits to these locations gave us an idea of the importance of sandy beaches for traditional/small scale fishing. The focus of specific locations helped us understand the multiple lines of causation that produced coastal degradation by interviewing members of the traditional/small scale fishing communities. It also then helped us understand and generalize the social stress arising along the coastal regions of Kerala.

1. South: Adimalathura and Poothura in Trivandrum district.
2. Central: Chavakkad beach on the north to Nattika beach on the south in Trissur district.
3. North: Kasaba beach to Bekal fishing village of Kasargod district.

1. Adimalathura and Poothura in Trivandrum district:

In this southern study location, Karamana and Neyyar rivers supply sediment to the coast. However, dams are constructed on both these rivers. This curtails smooth flow of water and sediments to the coastal waters. Two dams, namely Aruvikkara and Peppara, curtail flow in the Karamana river that drains out at Vizhinjam. The dam across Neyyar river built in 1958 for irrigation arrests the sediment flow that discharges at Poovar river mouth just where it meets Arabian sea.

Adimalathura is located at south of Vizhinjam fishery harbor. Breakwaters for this fishery harbour were constructed in the ealry 1970s. The accretion that followed after the construction is clearly seen today at Adimalathura and therefore, this location assumes importance for the study. Poothura is about 35 kms north of Adimalathura and is on the northern side of a newly constructed fishing harbor known as Muthalappozhi. Here erosion started after construction of the breakwaters for the Muthulappozhi fishery harbour. We have chosen these two locations, although farther apart within Trivandrum district, one with a long history of accretion and the other with a short history of erosion.

2. Chavakkad beach on the north to Nattika beach on the south in Trissur district:

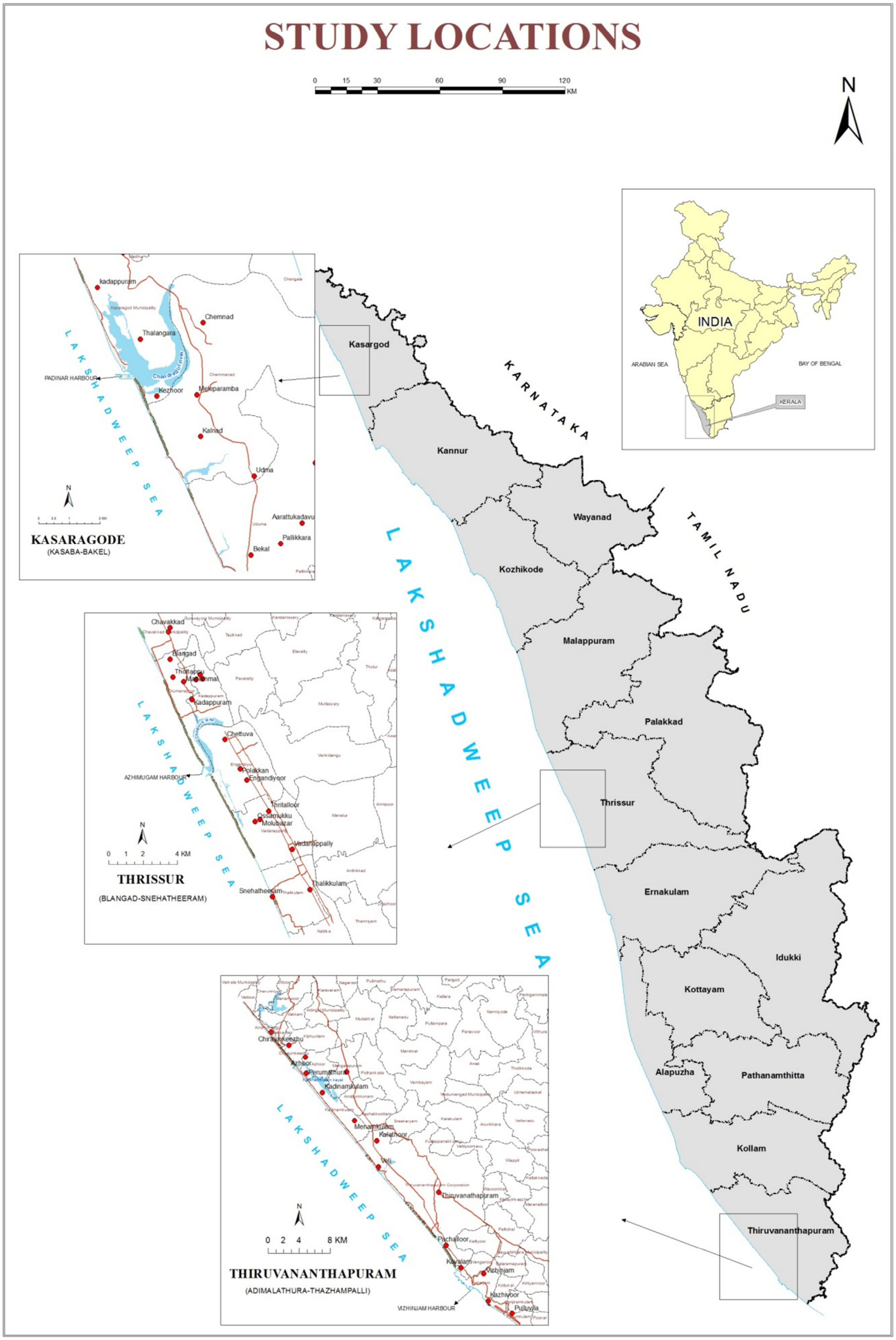
Chettuvapuzha is formed by two rivers – Keechery and Karuvannur puzha. River Keecheri originates at about 1830m in the Machad forest range in the Western Ghats. Parannur chira constructed across this river curtails sediment flow to the coast. Another irrigation dam constructed at Vazhani also arrests the flow of sediments. Karuvannur river flows through the southern part of Trissur district and empties into Chettuvapuzha. This river has two main tributaries which again branch out into several streams. There are two irrigation dams constructed across these branches – Peechi dam across Manali puzha; Chimmoni dam across Chimmoni puzha. A fishery harbour on the northern side of the Chettuwa estuary was in existence and is known as Munakkakadavu fishery habour with embankment protection structures built during the year 1983-86. The breakwater constructed at Chettuwa river mouth in 2010-12 was for the fishery harbour and is on the south of Chettuwa lake. This unique feature of two harbours within the same estuary – one with embankments and other with breakwater construction stands apart from the experience of the south. Unlike in south, there is erosion on both coastal north and south beaches of the breakwaters. However, severe erosion seems more on the southern side (Engandiyur) after the breakwaters were built.

3. Kasaba beach to Bekal fishing village of Kasargod district:

This is a long stretch of beach of 12 kms in length where Kasargod fishery harbour is constructed at Chandragiri river estuary. Although Chandragiri is a smaller river, it discharges high loads of sediment

and therefore, the estuary is also dynamic. Chandragiri originates from the southeastern part of Dakshin Kannada and the western part of Coorg districts of Karnataka where the river is known as Payswini. This river has a total basin area of 1342 sq.kms. About 42 percent of this basin is in Kasaragode district. There are no dams constructed across Chandragiri river on the Kerala side and therefore, sediment supply to the coast flows uninterrupted. The breakwaters are constructed at the river mouth, Keezhur. But the boat channel surprisingly got silted up with the heavy inflow of silt at the time of construction and hence the channel could never serve its purpose! Sand mining is one of the most notable activities in this study area and that too with patronage from the Harbour Engineering Department.

The current status of the sandy beaches of Kerala coast where a rich small scale fishery thrived is in various stages of degradation due to the above said factors which were observed in the specific locations in our case study.


STUDY LOCATIONS
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Malappuram
Palakkad
Thrissur
Ernakulam
Idukki
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Alapuzha
Pathanamthitta
Kollam
Thiruvananthapuram
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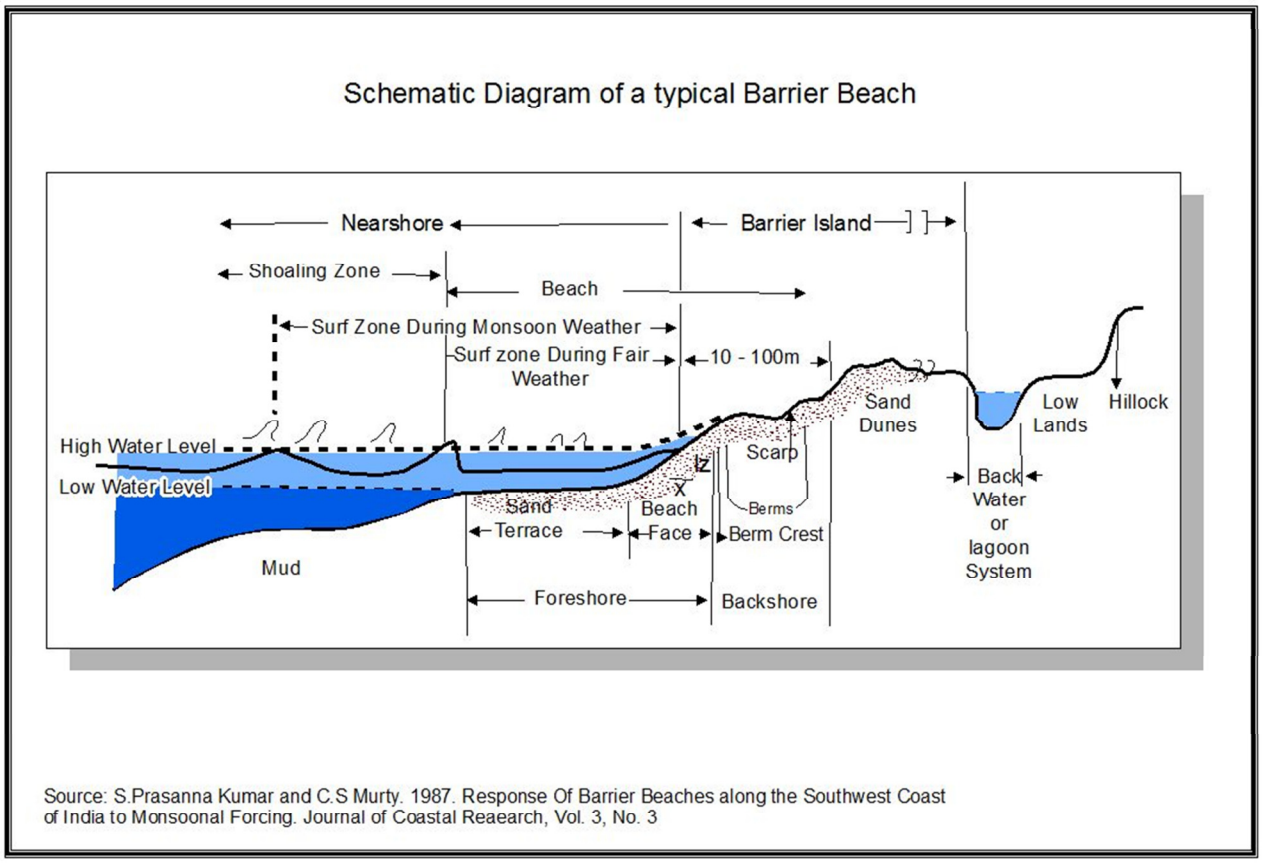
Thiruvananthapuram
Pachalloor
Kovalam
Vizhinjam
VIZHINJAM HARBOUR
Kazhivoor
Pulluvila

Dynamics of beach erosion – the natural and the unnatural

Geomorphic and sedimentation processes in the coastal regions were the result of sea level and climatic changes during the quaternary period[4].

The sources of sand replenishment along the sandy beaches of Kerala were from the 41 west flowing rivers, until they were dammed for purposes of irrigation and/or hydro-power. Through a complex combination of waves, currents and tides with seasonal and monsoon dynamics, this sand is distributed along certain areas – called barrier beaches -- which had the capacity to store them. Structure and geomorphology of the coasts was also such that there are innumerable backwaters strewn along the entire coastline



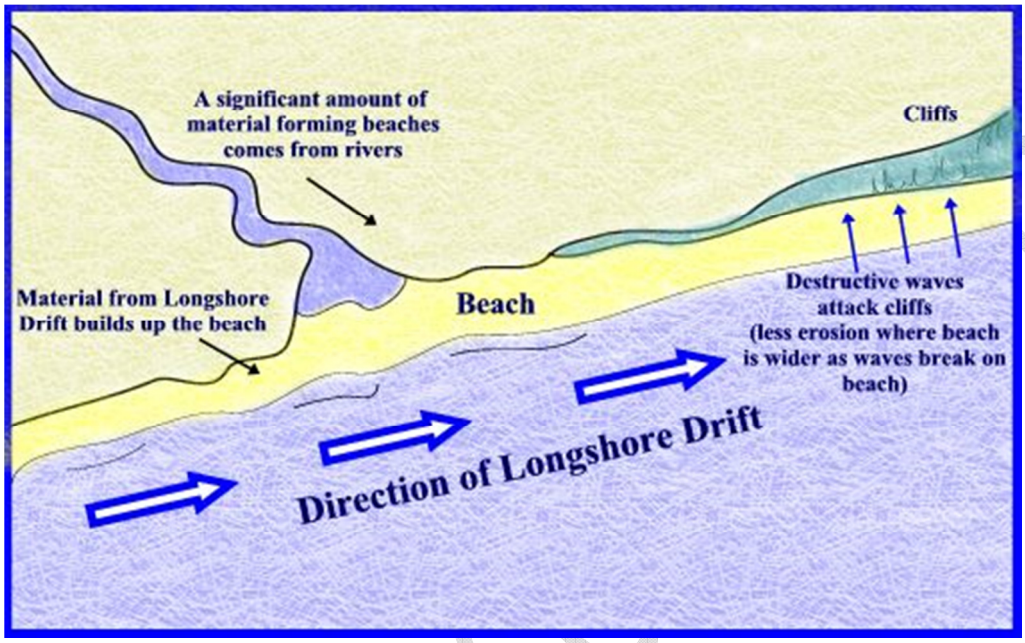
Source: S.Prasanna Kumar and C.S Murty. 1987. Response Of Barrier Beaches along the Southwest Coast of India to Monsoonal Forcing. Journal of Coastal Reaearch, Vol. 3, No. 3

With the seasonal change in the waves and long-shore sediment movement, the zones influencing the accretion/erosion of the beaches shift along the shore[5]. Coastal sandy beaches of Kerala respond to the

4 Roughly 2.5 million years to present.

5 Important to note the concept of littoral cell and sediment budget of INMAN and FRAUTSCHY (1966) where the cell is defined as a coastal segment that contains a complete sedimentation cycle including sources, transport paths and sinks. Forty one west flowing rivers of Kerala are the sedimentation source. Transport paths are littoral currents, waves and tides which shift seasonally.

monsoonal wave activity which results in erosion during the period of increased wave energy associated with monsoonal wave climate and accretion during the rest of the season. However, with the construction of dams on most of the west flowing rivers, the sediment supply became inadequate. The littoral currents with its under-saturated flows now carve out existing sandy beaches and the long-shore flows destabilize beaches exposing them to continuous erosion. This leads to recession of the shoreline.



This process of erosion resulting in almost a permanent state of shrunken sandy beaches is different from seasonal erosion which otherwise, replenishes the sand. Shore protection measures could never withstand this phenomenon of nature of such magnitude and the dilapidated state of stone seawalls and groynes stand testimony to this.

According to Prasanna Kumar and Murthy (1987), "A wave of 1.5 m height and 10 sec period at the seaward periphery of the mud bank (%20 m water depth) loses 50% of its energy over a distance of about 1.5 km (%10 wavelengths) and nearly 100% over a distance of about 4 km (%24 wave-lengths)"[6]

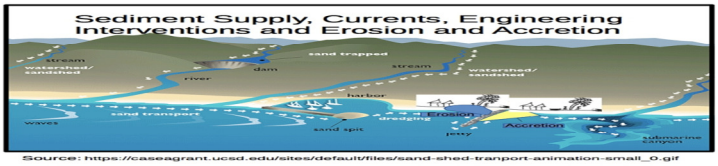
Beyond the low water level, most of Kerala's coast has a muddy stratum. The presence of these patches of mud during the monsoons, due to turbidity, makes the waters muddy over the wide and shallow near-shore areas. Coastal infrastructure built perpendicular to the coast offers maximum resistance from high waves of the southwest monsoon. They provide shelter to the beaches on the leeside. This is evident from the accretion seen on these beaches during this season. Extreme events such as tsunami generate waves that would inundate extensive area inland. Indian Tsunami of December 2004, generated wave heights upto 1.25 meters over Kerala coast[7]. Post tsunami field investigations revealed that in some parts of the state, particularly at Cheriyazheekkal of Kollam district, run-up level reached upto 5 meters (Rasheed et al., 2006).

In shallow waters, waves generate long-shore currents and these currents in turn move sediments giving shape to various coastal formations such as beaches. However, these long-shore currents also

6 S.Prasanna Kumar and C. S. Murty. 1987. Response of Barrier Beaches along the Southwest Coast of India to Monsoonal Forcing. Journal of Coastal Research, Vol. 3, No. 3 (Summer, 1987), pp. 343-358.

7 http://www.ngdc.noaa.gov/spotlight/tsunami/image/apiatanesimaximumwaterelevation.jpg

play an important role in coastal erosion and accretion. "The strength of the long-shore current is directly related to waves breaking at an angle to the shoreline, and this, combined with the agitating action of breaking waves provides energy for moving sediments along the beach"[8]. During the pre-monsoon period, January to March, littoral currents carry the sediments northward and with the influence of long-shore current, waves accrete sediments and beaches acquire sand and become wider. But with the advance of the southwest monsoon, winds become stronger and so do the waves and strong southerly currents are generated, leading to erosion when the beaches lose their sand and gets narrower. During the post-monsoon season, southerly currents give way to northern bound currents and by September, the long-shore currents deposit sand and the loss during the monsoon is partially made up.



Source: https://caseagrant.ucsd.edu/sites/default/files/sand-shed-tranport-animation-small_0.gif

The waves breaking on the beach retreat, taking away the finer particles of sand and coarser sand is left behind. This action of the wave in moving the sediments and creating sandy beaches is well explained by Puthur (2013, P.84), "The run-back (waves) being gravity driven and because of its brief run does not gain much momentum before merging with the sea. It is therefore capable of moving only fine sediments, clay and silt, occasionally some fine sand. Therefore, with every run-back, clay and silt are removed to sea from the beach. That goes on unceasingly. As a result, the coarser sand remains on the beach".

From this explanation we can also infer that quality of the sediments brought down by the rivers to the estuaries and sand accreted along the beaches if unhindered -- by any engineering interventions such as damming of rivers upstream or construction of breakwaters on estuarine mouths -- would help to attain an ecological balance. It is this equilibrium that helped sustain the traditional, small scale fishery for centuries.

What is the technical rationale for engineering interventions on the coast?

Recognizing the need for protection due to erosion which "calls for protection of houses, cultivated lands, valuable properties, monuments etc", and despite knowing that "the best natural defense against erosion is an adequate beach on which waves expend their energy", State machinery resorts to hard engineering interventions such as seawalls, revetments, anti-sea erosion bunds, system of groynes and breakwaters.[9]

8 M. Samsuddin and G. K. Suchindan. 1987. Beach Erosion and Accretion in Relation to Seasonal Longshore Current Variation in the Northern Kerala Coast, India. Journal of Coastal Research, Vol. 3, No. 1 (Winter, 1987), pp. 55-62.

9 Kudale M D and A D S Sarma (2010). Technical Memorandum on Guidelines for Design and Construction

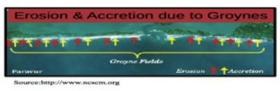
The Harbor Engineering Division (HED) functions as a Service Department for the Fisheries and Ports Department of the Government of Kerala. The HED is responsible for investigation, planning, design and construction of fish landing centres and fishery harbours which includes construction of breakwaters. The HED has built significant engineering structures such as ports, fishery harbours and breakwaters, landing centres, seawalls, groynes and piers all along Kerala's coast. There is one major port at Cochin, 17 non major ports, 11 fishery harbours, 90 landing centres, 310 kilometers of seawalls, and 25 locations where breakwaters and 106 groynes are placed[10]. Apart from the existing 11 fishery harbours, another 7 are anticipated by the year end.

Their benefits and costs

Construction of seawalls may protect dwelling units temporarily (for example, Nattika, Snehatheeram is being protected with strong seawalls). Such artificial measures may help to prevent damage at a very high financial cost. There is a recurring expense incurred through refurbishment either every year or on alternate years. This measure actually accelerates the process of erosion – if the beach is left as it is, the rate of erosion could be much slower compared to where the seawalls are constructed.

Once the stones are laid, erosion below it is accelerated and the stones sinks deeper down. Inquiries with the concerned department involved in creating seawalls reveal that they have little idea of the quantity of stones being used in any of the eroding stretches. There are no records of how much stone has been used, and since the stones placed over years sink, there is no way that it can ever be assessed. Thus we could not even make an assessment of the environmental cost of moving "mountains to the coast".

There is a growing realization that seawalls may not be the best option and therefore, groynes are being constructed along with seawalls. In Kerala, they started putting up groynes where seawalls are not at all suitable and where erosion is very high and unable to withstand the vagaries of storm surges and currents. For example, Panathura is an area in Trivandrum where groynes are put up. But here too the northern side has started eroding. Then they started putting up seawalls in these eroded areas. Now there is a growing demand for this combination of seawalls and groynes together as the solution to prevent sea erosion. The status paper on Kerala by NCSCM shows that wherever groynes are put up, erosion also follows in the northern side and yet the State continues to install groynes.



of Seawalls. Central Water and Power Research Station. Ministry of Water Resources, GoI, New Delhi.

10 Ramesh R et al., Shoreline change Assessment for Kerala. National Centre for Sustainable Coastal Management, Ministry of Environment and Forests, Government of India. http://www.ncscm.org

Kerala Government has identified 478 kms of coastline that needs protection, of which 355 kms of new seawall has been constructed and 123 kms of work will be carried out soon. The target envisaged for the utilization of Twelfth Finance Commission Award of Rs. 1750 million was to construct new sea walls for a length of 34 Kms, 21 groynes and reformation of 53 Km. With this amount, as per Economic Review 2011, a length of 16 Km of new sea wall and reformation of 42 Km of damaged sea wall have been completed. However, utilizing the State Fund, Tsunami Rehabilitation Package and XIII Finance Commission Award, an amount of Rs.1787 million has been spent for the construction of a new seawall for a length of 22.50 km and reformation of damaged seawall for a length of 70 km during the XI Plan period[11].

When beaches are accreting, the government/harbor engineering department sells it to private contractors who take out truckloads of sand mainly from the breakwater constructed sites. This has happened in Perumathura in Trivandrum as well as Keezhoor in Kasaragod. However, the possibility of transferring the accreted sand to replenish the nearby eroding coast has never occurred to the authorities, though it is advocated by experts as a scientific measure. Though this can be a partial solution to the erosion-accretion problem created by the breakwater, it only adds further costs. This may be the reason why the government seeks to make a small bonanza from the accreted sand !

How seawalls, groynes and breakwaters impact fisheries

Organic matter enrichment in upper-slope sediments is due to a combination of hydrodynamic processes such as winnowing, cross-margin transport and sorting (Cowie et al., 2014). This enrichment along the coasts is enhanced by the rivers and runoff from the land which forms the base in the coastal-marine food-web. The runoff water from the land is rich in nutrients – most important among them, nitrates and phosphates are essential fertilizers for the growth of phytoplankton which is the food for the zooplankton and which is eaten by small fish and they in turn eaten by larger fishes giving rise to the food chain

Forty one west flowing rivers bring down nutrients and sediments that made both the coast and coastal waters ideal conditions for development of fisheries. Beach landing fishing crafts were the hallmark of the traditional marine fishing crafts of the Kerala coast. One of the main reasons for this was the presence of long sandy stretches of beaches. It used to account for 80 percent of the coastline of the State[12].

As a consequence the State had a continuous chain of traditional fishing villages where beach landing was the norm – with the exception of very few stretches where nature itself created barriers like rocky cliffs/headlands/protrusions. Historically communities living closer to the barrier beaches developed their fishing skills in shore-based fishery. For example, shore-seine fishery and near shore fishing using *kattamarams* (found in Trivandrum) and dugout canoes (common to entire Kerala) basically thrived because of the sandy beaches where they could haul in the crafts and use the beaches to engage in other fishing related activities such as fish drying, curing, repairing nets and so forth.

According to the SIFFS Census of Artisanal Marine Fishing Fleet in 1998, Engandiyur had 90 small non-motorised crafts using 110 gillnets of small and very small sizes. Interestingly there were no motorized fishing crafts there in 1998 at the time of the Census. The previous SIFFS Census in 1991 also showed the same feature with 40 non-motorised crafts and no motorised ones

11 State Planning Board (2012). Chapter 10, Economic Review, 2011. Govt of Kerala. http://spb.kerala.gov.in/
12 Lakshmi A *et.al.,* 2012. The Challenged Coast of India – A Report. PondyCAN, BNHS and TISS.

Currently, according to local people, all these non-motorised crafts have disappeared. The new Chettuva fishing harbour, built in Engandiyur is vibrant with a large fleet of IBM (In-board Motor) crafts (Kappal Vallams).

Only a more detailed investigation will reveal what happened to the local fishers who were owning and operating the non-motorised crafts earlier. Did they become owners/shareholders/crew in these large crafts?

The coastal situation of the three study areas as a result of seawalls, groynes and breakwaters

The engineering interventions such as seawalls, groynes and breakwaters on the coast are a major cause for the beaches to erode and then vanish. However, erosion caused by these structures is dealt with by the Irrigation Department, as prevention of beach erosion is one of their core responsibilities. Completed and partially commissioned fishery harbours and fish landing centers require periodic maintenance dredging within harbours and in approach channels.

The vanishing nature of the beaches and new artificial rocky formations such as sea walls and groynes taking shape also have had many ramifications on the lives and livelihood of small-scale fishers. These artificial structures first led to decline in number of beach landing points. Fishers then migrate to safer beaches or harbours. This in turn affects women's proximity to beach landings and hence their access to fish to take to the markets. It also changes the patterns of post-harvest activities.

Construction of breakwaters for harbours seems to have accentuated erosion all along the coast, particularly more intensely near the breakwaters. Intensity of erosion is severe in the northern side of the breakwaters in southern Kerala and erosion is seen on both sides in northern Kerala.

Construction of seawalls has increased the risks to lives as well as fishing crafts given the possible

collisions into seawalls. It has also resulted in abandoning certain types of fishing units such as shore-seines which require stretches of sandy beaches for operation. This situation has in turn increased the demand for safe, artificial fishing harbors. The sandy beaches also used to be the nursery for young to learn the basic skills of venturing into the sea including swimming and understanding the wave patterns. The vanishing beaches have thus deprived the new generations to learn about the 'nature and the culture of the sea' -- a prerequisite for continuance of vibrant small-scale fishing in Kerala.

The current coastal situation in the specific locations for in-depth understanding is elaborated in the following section:

*1. **Adimalathura and Poothura in Trivandrum district:***

Construction of groynes, envisioned as the single most effective solution against erosion was first introduced to Kerala at Varkala by the British as a protective measure against the water seepage into the inland water navigation tunnel located close by. Later groynes were constructed in various locations and the negative consequences are being felt by the coastal inhabitants.

With the construction of the Vizhinjam breakwaters, Panathara area started eroding and 10 groynes were constructed here. Initially, the south side of the groynes accumulated sand but eventually that accretion also stopped and is now submerged in the sea. The pattern of erosion and accretion observed in the southern districts, particularly in Trivandrum (Vizhinjam and Muthalapozhi) after breakwaters are constructed, is erosion on the north and accretion to the south.

In Adimalathura (South of Vizhinjam breakwaters) and Perumathura (South of Muthalappozhi breakwaters) higher accretion is observed in the southern side adjacent to the breakwaters, much more than any other study locations even in the northern districts of Kerala.

In Adimalathura, accretion extended to form a wide beach of more than 350 meters from the existing road. People's strategy was to claim the land by planting coconuts and fencing it off as individual property. Currently, that entire accreted land is occupied. The community institution (church) made a rule that people should not put up houses or privatize on the western side of the new road on the beach, while public utilities are promoted. The youth are happy that they have football and cricket grounds in these newly formed beaches. People take out sand also from the newly formed beaches to ‘create’ land and to construct houses elsewhere.

Recently, an intense downpour of rain flooded the entire area by not draining out to sea as the beach area is elevated with accreting sand. Many pools of water have formed in the accreted land. However, the advantage is that they got an expanding beach and keeping fishing crafts is not a problem unlike in the eroded beaches of places like Poonthura. Accretion seems to continue at the same pace even today. This sandy stretch of beach extends southward for another 16 kms, narrowing towards the south.

Field visit to Adimalathura accretion zone and interview with an elder fisher yielded interesting history of the accretion. Saloman, aged 66 provided a wealth of information about the place, history, life and livelihoods. He acquired a variety of fishing skills from the age of seven. Two years of formal education is all that he had before learning fishing from his father and other older fishers in his birth place, Adimalathura.

Saloman recollects the rough sea during the monsoon advancing all the way beyond the present road and to the base of the cliff where the Adimalathura church and his dwellings stand today. This, he said,

is roughly fifty five years back. Saloman's recollections of having seen the sea waves reaching his dwelling unit and the church would mean during the period 1960 to 1970, the present day accreted land was not there.

Thazhampally present the opposite scenario. It is one of the badly hit fishing villages in terms of coastal erosion. Many households were relocated and people resettled across the Chirayinkeezhu backwaters. This village is in the northern side of the Muthalappozhi.

Source: Google Earth Pro, August 2015.

2. ***Chavakkad beach on the north to Nattika beach on the south in Trissur district:***

Engandiyur is a fishing village lying immediately south to the Chettuva (lake) bar mouth. On the northern side lake/river embankment protection structures were built in the 1983-86 period. This was done as part of developing a fish landing centre/harbour namely Munakkekkadavu on the Chettuva Lake on northern side.

In 2011, the Chettuva fisheries harbour (locally called Banglayen harbour) was built on the Engadiyur side, south of Chettuva lake. On both sides of the bar mouth, two breakwaters were built in 2010-12 period. This construction could be part of the new fishery harbour on theEngandiyur side. There is heavy erosion on both sides of the breakwaters. Local people complained that the design/construction of breakwaters is not proper. According to them this construction has led to more problems. They pointed out that water channels inland are clogged with sand while river banks are eroding. Severe erosion is observed on the southern side after the breakwaters were built. Electric posts right on the beach stand testimony to the intensity of erosion. Interviews at the location revealed that a house with 65 cents of land was engulfed by the sea.

Seawalls are constructed all along Chavakkad to Nattika but in many locations they are dilapidated or submerged in sea. Blangad beach in Chavakkad Municipality area, is a stable beach. Thalikkulam (Snehatheeram) has a stretch of evenly eroded sandy beaches. North of Nattika, after a small stretch of stable beach, many sea walls were observed. Interviews with the local folk revealed that erosion occurs all through the year.

Source: Google Earth Pro, August 2015.

Tanur, where a new fishing harbor is being constructed is in an open beach unlike other harbours and landing centres, for, there are no river mouths or estuaries here. It is also a place booming with large IBM fishing crafts. The question that comes up while visiting this location is whether the fishery with the new harbor sustain in the long run at the cost of eroding beaches in adjacent areas?

3. ***Kasaba beach to Bekal fishing village of Kasargod district:***

Though silting up of the river/estuary mouths is common to all three locations, its intensity is very high at Keezhur in Kasargod district. Chandragiri river discharges its waters and sediment here at Keezhur as it is unhindered by any dams or reservoirs. Field visits and local interviews revealed that this estuary is highly dynamic and the sedimentation within breakwaters constructed clogged the entire boat channel.

Source: Google Earth Pro, August 2015.

The impact on small-scale fisheries in the three study areas as a result of seawalls, groynes and backwaters

*1. **Adimalathura and Poothura in Trivandrum district:***

Adimalathura is located south of Vizhinjam fishery harbor. The breakwater for this fishery harbour was constructed in the early 1970s. The accretion that followed after the construction is clearly seen today at Adimalathura and therefore, this location assumes the importance for this study.

Poothura is about 35 kms north of Adimalathura and is on the northern side of a newly constructed fishing harbor known as Muthalappozhi. Here erosion started after construction of the breakwaters for the Muthulappozhi fishery harbour. We have chosen these two locations, although farther apart within Trivandrum district, one with a long history of accretion and other with a short history of erosion.

In Adimalathura, as the beach got accreted over the period the main changes that took place in the area as well as fishing and fishing community are the following:

As new land began to emerge landless fishers started to put up houses there, others who already had houses started planting coconut trees and claimed rights over that land/coconuts.

This also helped fishers with more space for keeping the fishing crafts and gear.

Shore-seine fishing flourished. According to SIFFS data the number of shore-seines in Adimalathura increased from 18 in 1991 to 33 in 1998. During our visit, fishers said there are now more than 40 shore-seines. Older and middle aged fishers thus continue to engage in fishing and as they do not have to venture into rough seas. Apparently shore-seines here operate almost throughout the year. The case is same with nearby Pulluvilla also, where the number of shore-seines increased from 18 to 30 as per SIFFS data of 1991 and 1998.

Apparently the number of motorized plywood crafts in the area also increased over the period. While SIFFS data shows that in Adimalathura there were 34 plank transom motorized crafts in 1991, in 1998 there were 42 plywood crafts. But in 2015 we could count more than 100 plywood crafts on a Sunday at the beach.

Apparently there is in-migration to Adimalathura as open free land is available to put up houses, though there is water-logging during rainy seasons.

At Poothura-Thazhampally villages on the northern side of the district coast the situation is different. These two villages are experiencing erosion after construction of breakwaters for a fishery harbor started recently. Fishers of these villages are traditionally depending more on shore-seines and only very few have the skills to do hook and line fishing in the deeper coastal waters.

With increased erosion shore-seine fishery was very much affected with the loss of open beaches.

Some fishers have gone into "Kollivala" (in-board engine ring-seine fishery), as second-hand medium sized boats were available at cheap prices from the Karunagappally-Kayamkulam areas where they had become uneconomical due to the uncontrolled competition.

According to SIFFS census, in 1998 there were 24 and 10 shore-seines at Poothura and Thazhampally respectively. But their numbers have gone down now after their beaches eroded. Total number of shore-seines in two villages together now according to the fishers is around 15 only.

The spurt in kollivalas has however resulted in conflicts and altercations in the sea between the new kollivala fishers and boat-seine/hook and line fishers of Anjengo fishers on the north. The disputes have grown into a law-and-order issue. The district collector called many meetings to sort out the issue and though some agreements were reached to use the new kollivala only beyond certain distance from the shore, tension still prevails. Recently ring-seine fishers from Karunagappally area came through the sea to fish in Anjengo waters and the 'intruders' were caught and brought to shore by the local fishers. This also had some communal repercussions as the intruders were of another religious faith. Apparently the situation is getting out of control and some management regime is very much necessary.

Erosion in Thazhampally also forced many fishers to leave the village and government in collaboration with the Church had to relocate about 100 families, at considerable coast and dislocation for the people, to the eastern side of the backwaters.

***2. Chavakkad beach on the north to Nattika beach on the south in Trichur district*:**

A fishery harbor on the northern side of the estuary was built at Munakkakadavu with embankment protection structures during the year 1983-86. But a new harbor at Chettuwa on the southern side was built in 2010-12 with breakwater protection on the estuary.

The new harbor resulted in sudden growth of large in-board ring-seine boats in a short period of time.

But the casualty with construction of breakwaters was the otherwise vibrant non-motorized fishing units on the southern part of the estuary. According to SIFFS census, Enganidyur had 90 non-motorized fishing units in 1998. Their number actually increased from 40 in 1991. Now in 2015, after construction of the breakwaters and new harbor all these units have disappeared. Earlier Engandiyur was the only fishing village in the district without any motorised crafts.

Unlike in south Kerala, there is erosion on both north and south beaches of the breakwaters, although severe erosion seems more on the southern side (Engandiyur) after the breakwaters were built. Apparently traditional fishers lost their landing places after this development.

***3. Kasaba beach to Bekal fishing village of Kasargod district*:**

This is a long stretch of beach 12 kms long where Kasargod fishery harbour is constructed at Chandragiri river estuary. Although Chandragiri is a smaller river, it discharges high loads of sediment and therefore, the estuary is also dynamic. The breakwaters constructed at Keezhur got silted up along with the construction and could never serve its purpose. It is also interesting to note that there are no dams built across this river and therefore does not affect the sediment load. Sand mining is one of the

most notable activities in this study area and that too with patronage from the Harbour Engineering Department.

The newly constructed breakwaters in Keezhur for the fishery harbour have in no way helped either the mechanized fishing or traditional fishing units in any way. Fishers continue to use the old estuary to venture in and out of the sea as the new boat channel between the breakwaters in blocked with silt.

New stretches of seawalls are built in many coasts of the district. Interestingly in Kasaba, the seawalls are now being built well within the land side of the beach. Here, people were earlier not residing on the seaside of the road, but now one or two rows of houses have come up. Some people encroached the beach and the seawall was built to protect these houses. Considering the costs involved it would have been ideal if these people were relocated to safe areas on the eastern landward side rather than going for construction of seawalls.

Though erosion is an issue in the coast here, with a long coastline of 80 km and a mere 16 fishing villages, the intensity is not obvious if we compare it with densely populated and greater number of fishing villages as we see in southern coastal districts like Trivandrum.

What the experts say

In the preface to the technical memorandum on guidelines for design and construction of seawalls, Kudale and Sarma (2010) writes, "The best natural protection against erosion is an adequate beach on which waves expend their energy"[13].

Of the various methods of shore protection such as seawalls, revetments, anti-erosion bunds, system of groynes or jetties and system of offshore breakwaters, the preferred method, according to Central Water and Power Research Station (CWPRS), is beach nourishment. But due to ease of construction seawalls, revetments and anti-sea erosion bunds are adopted. The shore protection manual list out the following human induced reasons for beach erosion[14]:

- Dams, dykes and other coastal structures causing rise and concentration of tides.
- Groynes, breakwaters, jetties etc., causing down-drift erosion.
- Man-made entrances causing interruption of littoral drift. This includes jetties for protection of tidal entrances.
- Fills protruding in the ocean to an extent that they change local shoreline geometry radically. Such fills are often bulk-headed.
- Damming up of rivers without providing material sluices which allow continuation of drift of materials. Irrigation projects decreasing flow of water and sediments to the shore.
- Removal of material from beaches for construction and other purposes.
- Digging or dredging of new inlets, channels and entrances. Offshore dumping of materials.

Officials from Field Engineering Division (also known as Coastal Erosion Studies Division) of the Irrigation Department of Government of Kerala opine that the erosion has intensified after the groynes

13 Kudale M D and A D S Sarma (2010). Technical Memorandum on Guidelines for Design and Construction of Seawalls. Central Water and Power Research Station. Ministry of Water Resources, GoI, New Delhi.

14 Bruun P and Nayak B U (1980). Manual on Protection and Control of Coastal Erosion in India. National Institute of Oceanography, Goa, India.

were constructed, particularly in the northern sides of the breakwaters of Puthiyakadappuram.

A higher official from the same department pointed out that protection walls often intensify erosion and as an example, he pointed out the protection walls constructed at Snehatheeram which is broader than normal seawalls. According to the same official, their division does not have the facilities to develop models and study the effects of seawall/breakwater constructions and therefore, requests Central Public Works Research Centre (CWPRS) to carry out the investigation and based on their report, further actions are taken.

Such a study has been undertaken by CWPRS in the Chavakkad coastal belt recently. The study concluded that littoral drift is comparatively lesser in this stretch (In normal circumstances, dominance of littoral drift is north to south, although anomalies are observed – pockets of south to north drift is seen) and that as against what is normally observed when groynes are constructed, accretion in the southern side and erosion in the northern side, Chavakkad area, due to absence of littoral drift, there is not sufficient quantity of sediment transported and deposited in the south of breakwaters, but erosion seems to continue unabated. CWPRS study report, therefore, concludes that the construction of breakwaters has no effect on coastal erosion.

This conclusion is opposed and rejected by various officials from the Field Engineering Division of the Irrigation Department. The study suggests construction of 20 meter long groynes every 100 meters and seawalls all along the coast (similar small groynes are constructed at the northern side of Kayamkulam kayal estuary).

During our field visits we observed accretion taking place on both south and northern sides of Azheekal breakwater. In most of the other areas where breakwater are constructed, there will be intense erosion either north or south, but four or five kilometers away from the site of construction. According to Field Engineering Division experts, this is a balancing act of nature. The division has been carrying out systematic data collection of coastline changes since 1973. They have laid out “Control Point” stones (CP Stones) at 200 meter intervals, all along the coast and every month, actual field observations are made by measuring the highest wave mark recorded during that particular month, from these CP stones. They have the GPS coordinates of these stones.

Severe erosion is taking place on the southern side (Engandiyur) after the breakwaters were built. Electric post right on the beach stands testimony to the intensity of erosion. Locational interviews revealed that a house with 65 cents of land is engulfed by sea. This is in contrast to pattern of erosion in southern districts, particularly, Trivandrum (Vizhinjam and Muthalapozhi) where erosion takes place on the north and accretion on the south, after breakwaters are constructed.

Officials of the Geological Survey of India state that swash and backwash effects of the waves need to be studied before seawalls are put in place. It is a fact that erosion of sand from the beach due to backwash effect on a sea-walled coast is twice to that on an untampered beach (Shareef, 2007).

Discussion and conclusions

Fishermen in all three locations are aware that during the months of June to September, beaches erode and slowly thereafter, waves and currents bring the sands back to their shores. But they say that in recent times, this centuries old process was interrupted causing increased destruction of fisher's physical assets – land and houses -- due to sustained erosion. Opinions are divided among them as to whether it is a response to engineering interventions or increasing rough weather. There are, without

any doubt, many ramifications due to engineering interventions on our coast. The problems stems right from the upper reaches of the rivers with dams and reservoirs, river diversion schemes, spillways and bunds constructed for irrigation. Then there are the roads and other infrastructures. Finally at the coast itself constructions of breakwaters at river mouths and beaches followed by seawalls all along the coast and groynes in few locations.

There is a kind of spiraling vicious cycle where breakwaters constructed triggers off erosion on one side and accretion on other -- and sometimes erosion on both sides. This leads to popular demand for seawalls to protect the communities dwelling units and property even if it is a temporary relief. But the fact that a harbour accommodates safe berthing of fishing boats attracts fishers to demand for more harbours in their respective areas. Loss of beach also impacts certain type of fisheries and they in turn migrate into adopting destructive forms of fishing methods. The conflicts reported in various localities could be attributed as a result of this spiraling vicious circle.

Various studies, in fact, have shown that large-scale erosion of beaches takes place during SW monsoon but almost all the open beaches regain the lost sand during fair weather season. However, this balance of sand “loss and gain” is not found along engineered shorelines (Jayappa et al., 2003). This is true in all three study locations.

Sanil Kumar *et al.,* (2006) has shown that whenever free passage of long shore sediment transport is tampered with engineering interventions, there is noticeable deposition/siltation occurring in harbour channels and river mouths. Our in-depth studies on three locations had fishery harbours and landing centres which were located in river/estuary mouths and breakwaters are constructed in all three locations – Muthalappozhi in South, Chettuva Fishery Harbour in the mid region and Fish Landing Centre at Keezhur in the north. Construction of breakwaters seems to tamper with the sediment movement in all three locations.

Lack of data on the amount of rocks being used for breakwaters, seawalls and groynes leaves a big gap to grasp the impact it has on the mountain environment of Kerala. The quarries that supply rocks for these engineering structures may have serious impact on the ecology of the areas where they are extracted from. Therefore, there is a need to assess the amount of rocks quarried from nearby hills and Western Ghats and transported for seawalls construction. With increased demand for new seawalls and strengthening (reformation) of existing seawalls, the rampant quarrying and destruction of mountain ecology will be inevitable. Similarly, groynes construction together with seawalls is now mooted by CWPRS as a permanent solution to erosion in Kerala. Apparently Kerala Govt has also endorsed this, and at many places work on this is initiated including Thazhampally and Beemapally.

Finally, it is important to look at what the government can do? Since the erosion and degradation has become an irreversible phenomena, government should seriously think of rehabilitation measures. While leaving beaches open for nature to continue with its natural ways of sand budgeting, State could acquire land adjacent and behind current dwelling units of vulnerable households and motivate them to move back. This would become all the more important when we look at the new CRZ notification. According to the new CRZ notification, harbors should not be permitted in eroding coasts. Now, with Kerala government going ahead with more and more commercial and fishery harbors/landing centers with breakwaters this needs further investigation to establish that these activities are violations of CRZ norms.

One of the officials from the Field Engineering Division suggested channelling the money budgeted for sea walls to moving the people further interior and giving them space for housing and cultivation; then

removing seawall stones, use them for building houses for coastal inhabitants. This would give Nature the opportunity and time to rebuild the natural coastline. He also feels that planting casuarina protects the coast better than coconut palms as the interval between trees could be much closer in the case of casuarina.

Seawalls offer hardly any protection against extreme events such as tsunami when waves could be as high as 10 meters as experienced during the December 2004 tsunami. Beaches, therefore, should be realized as the buffer zone between land and the properties on it and the vast sea. Till date, there is no scientific evidence to suggest that the entire Kerala's coast will be engulfed by sea and yet seawall construction continues unhindered. An impartial audit/enquiry on this state of affairs should be conducted.

Bibliography

Bruun P and Nayak B U (1980). Manual on Protection and Control of Coastal Erosion in India. National Institute of Oceanography, Goa, India.

Census of India. 2011. Census Publications. Govt of India. New Delhi

Cowie G *et al.*, 2014. Comparative organic geochemistry of Indian margin (Arabian Sea) sediments: estuary to continental slope. Biogeosciences, 11, 6683–6696.

Harikumar G and G Rajendran. 2007. An Overview of Kerala Fisheries – With Particular Emphasis on Aquaculture. IFP Souvenir. Pp 6-8.

Jayappa K. S, G. T. Vijaya Kumar and K. R. Subrahmanya (2003). Influence of Coastal Structures on the Beaches of Southern Karnataka, India. Journal of Coastal Research, Vol. 19, No. 2, pp. 389-408.

Ketchum B (Ed). 1972. The Water's Edge: Critical problems of the Coastal Zone, Cambridge MA: MITPress, 393 p.

Kudale M D and A D S Sarma (2010). Technical Memorandum on Guidelines for Design and Construction of Seawalls. Central Water and Power Research Station. Ministry of Water Resources, GoI, New Delhi.

Lakshmi A et.al., 2012. The Challenged Coast of India – A Report. PondyCAN, BNHS and TISS.

Prasanna Kumar S and C. S. Murty. 1987. Response of Barrier Beaches along the Southwest Coast of India to Monsoonal Forcing. Journal of Coastal Research, Vol. 3, No. 3 (Summer, 1987), pp. 343-358.

Puthur J J. 2013. The Untold Story of a Coast. Star of Sea Publications, Bangalore, India.

Ramesh R et al., Shoreline change Assessment for Kerala. National Centre for Sustainable Coastal Management, Ministry of Environment and Forests, Government of India. http://www.ncscm.org

Rasheed Abdul K A, V Kesava Das, C Revichandran, P R Vijayan and Tony J Thottam. 2006. Tsunami Impacts on Morphology of Beaches Along South Kerala Coast, West Coast of India. Science of Tsunami Hazards, Vol.24, No.1. Pp.24-34.

Sanil Kumar V, K. C. Pathak, P. Pednekar, N. S. N. Raju and R. Gowthaman. 2006. Coastal processes along the Indian coastline. CURRENT SCIENCE, VOL. 91, NO. 4. Pp. 530-536.

Samsuddin M and G. K. Suchindan. 1987. Beach Erosion and Accretion in Relation to Seasonal Longshore Current Variation in the Northern Kerala Coast, India. Journal of Coastal Research, Vol. 3, No. 1 (Winter, 1987), pp. 55-62.

Shareef N M. 2007. Disappearing Beaches of Kerala. Current Science. VOL. 92, NO. 2. Pp.157-158.

State Planning Board (2012). Chapter 10, Economic Review, 2011. Govt of Kerala. http://spb.kerala.gov.in/