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Aquatic Procedia 4 (2015) 548 – 555

Aquatic Procedia

www.elsevier.com/locate/procedia

INTERNATIONAL CONFERENCE ON WATER RESOURCES, COASTAL AND OCEAN ENGINEERING (ICWRCOE 2015)

Erosion hotspots along southwest coast of India

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Abstract

The south west coast of India consists of beaches and cliffs which support a highly dense costal community. Coastal erosion is confined to southwest monsoon season when the waves are rough. Seawalls and groins are the major management strategies adopted for coastal protection along Kerala coast. Erosion hotspots are identified from extensive field work carried out during the southwest monsoon season in 2013 and 2014. These hotspots are mostly dependent on the morphology and coastal structures. Identified hotspots are down drift side of mudbanks, fishing gaps, down drift sides of coastal structures including harbor breakwaters, locations of slumping seawalls, mining sites, wave over topping sites and piecemeal maintenance locations of seawalls. Tidal inlets are also vulnerable spots of coastal erosion. Highly viscous fluid mud formation that surface during southwest monsoon in the nearshore of the southwest coast is known as mudbank. It acts as wave dampening structures and triggers beach accretion and erosion in the mudbank region and its vicinity. Migration of seasonal tidal inlets which get opened during southwest monsoon induces erosion in the adjoining areas. Gaps within seawalls for facilitating traditional fishing are known as 'fishing gaps' towards which a pressure gradient develops pushing wave/swash into the gap accelerating erosion. In many places frontal beaches seaward of seawalls have disappeared bringing wave breakers closer to seawalls. Scouring at the base of seawalls accelerates slumping. Wave overtopping and flooding of the coastal zone landward of seawalls are also the resultant of high waves breaking very close to seawalls during southwest monsoon. Downdrift sides of harbor breakwaters are erosion hotspots because of the lack of proper Morphological Impact Assessment and mitigation plans for the expected shoreline changes. Seawalls have to abruptly end at some locations alongshore which cause 'end erosion hotspots'. Maintenance of damaged seawalls is not well planned based on proper designs since most of the repair works are taken on piece meal basis and as emergency measures. The result is uneven shape of seawalls which itself weakens the protection measures making them highly vulnerable to erosion. The paper tries to understand the processes leading to erosion hotspots and propose measures to manage the hotspots

Peer-review under responsibility of organizing committee of ICWRCOE 2015

Keywords: Erosion; downdrift side; seawall, groin; breakwater

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Peer-review under responsibility of organizing committee of ICWRCOE 2015
doi:10.1016/j.aqpro.2015.02.071

1. Introduction

Coastal erosion is a major threat faced by all countries having a coastal zone. Different natural and anthropogenic factors have a role in causing coastal erosion (Heo, Kim and Kim; 2009). Coastal erosion along Kerala coast which is part of the southwest coast of India has been studied in the present investigation based on direct field investigations and morphological interpretations. Unlike earlier studies the present investigation looks into distinctly different coastal segments with distinguishable morphological signatures and different types of anthropogenic interventions. Various researchers have studied the nature of coastal erosion along southwest coast of India (Thomas et al, 1986; Kurian et al, 1987, Baba et al, 1987; Shamji et al, 2010). The efforts to control coastal erosion through structures were initiated along Kerala coast more than 100 years ago with the construction of groins and later seawalls and recently seawall-groin combination. Coastal protection measures have been holding the shoreline successfully in some sectors, through regular maintenance. In some other sectors the coastal protection measures have collapsed which increased the problem of erosion. End erosion and scouring have been reported, especially in areas adjoining seawalls (Thomas et al. 2013). Erosion hot spots along Southwest coast of India are identified by extensive field investigation carried out during the southwest monsoon season in 2013 and 2014. The focus in the present study is to bring out all the causative and contributing factors for coastal erosion along the southwest coast of India from direct observations based on field visits.

2. Regional Setting

The 590 km long coastline of Kerala, extending roughly north-south along the southwest coast of India from Pozhiyur in the south to Thalappadi in the north, has been selected for the present study (Fig. 1). The Kerala coast has about 18 fishing harbors and associated breakwaters. More harbours have been proposed and construction of 5 harbours is in progress. Groins are also constructed at different locations. Seawalls and combination of seawall-groins are also in place as part of the efforts for controlling coastal erosion.

3. Material and Methods

Field mapping through GPS survey has been carried out for locating erosion hotspots along the study region during the southwest monsoon seasons of 2013 & 2014. Morphological set up of each erosion hotspot is also assessed through direct observations. Impact of harbour breakwaters and groins on the coast were noted during field investigation. Local information on the nature and role of coastal erosion at specific locations has been obtained through interactions with local communities who shared traditional knowledge. The entire Kerala coast was visited and detailed sketch has been prepared to understand the role of natural and artificial structures for coastal erosion. The positions of occurrence of mud banks and various other morphological signatures like present and earlier shoreline positions, old seawalls, berm crests, etc. are also plotted using GPS. These are supplemented with local information and previous studies. Signatures showing changes in the shoreline and the changing scenarios of coastal erosion and accretion were evident and available in the field and these were recorded.

4. Results

Field observations have indicated that erosion occurred at the downdrift side of harbor breakwaters and groins. Seawall end, mining sites, fishing gaps and downdrift side of mudbanks are other locations of erosion. Places where protective measures are wrongly designed or improperly implemented are also locations of erosion. Major Erosion spots along the Kerala coast are shown in Figure 1 and Table 1. These are Panathura, Poonthura, Bhimapally, Valiathura, Thazhampally, Thanni, Iravipuram, Valiazheekal to Arattupuzha sector, Kattoor, Chenneveli, Kadappuram, Aayiram thai (north of Arthungal) along the southern sector. In central sector these are Njarakkal, Kara, Vatanapally, either side of Chettuwa breakwater, Puduponnani and Thanoor. Northern sector has major erosion spots at Gotheswaram, Kothi beach, Kolavippalam, Mattool, Chithari and Kasargode beach.

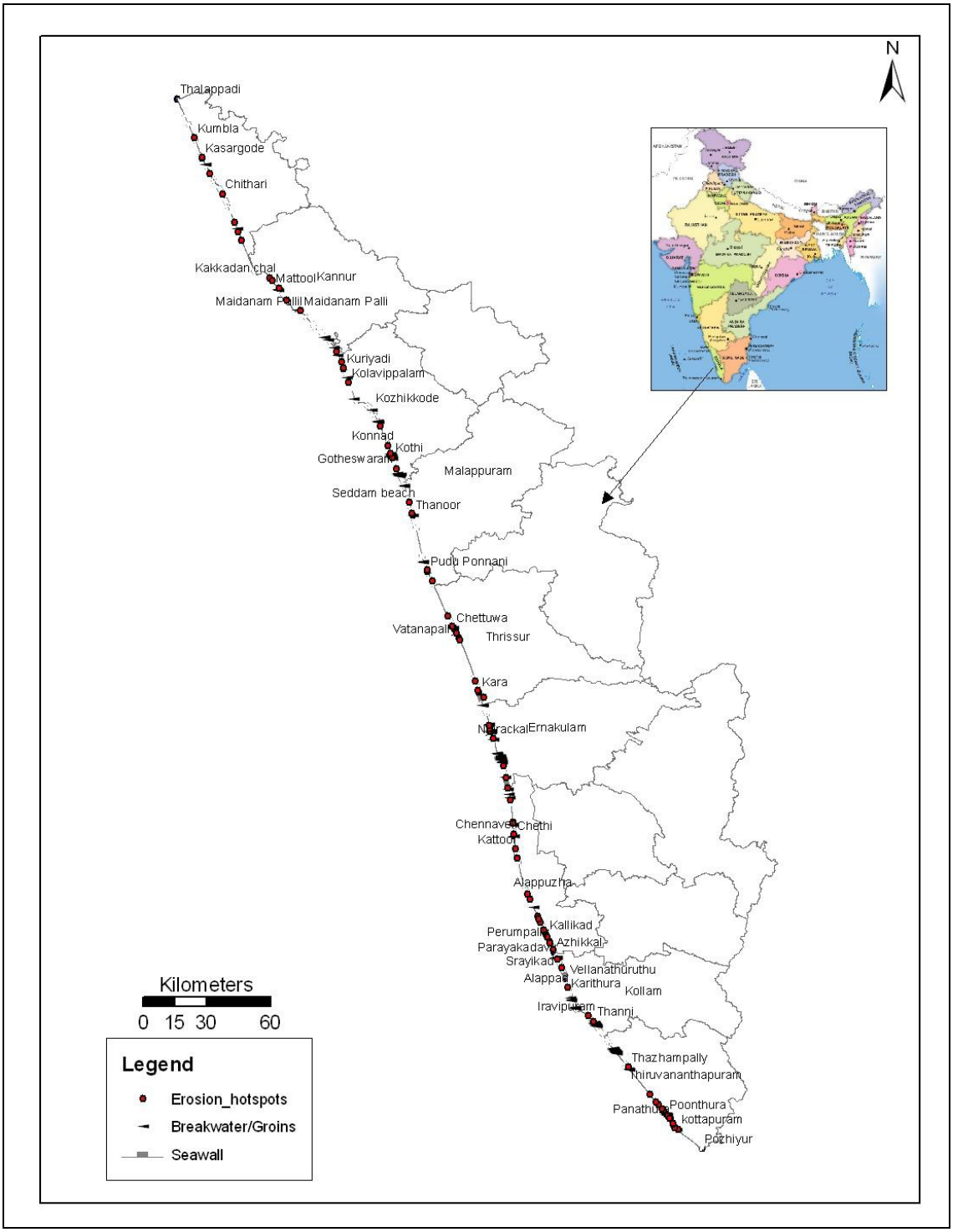

Fig. 1 Erosion hotspot along Kerala coast with respect to artificial structures

Table 1. Erosion with respect to artificial and coastal morphology

Location (District)	Affected Area	Remarks
Panathura	Erosion	Seawall slumped & Wave overtopping. Heavy inlet erosion
Poonthura	Erosion and wave overtopping	Erosion extends towards north
Bhimapally	Seawall is partially or completely damaged and Erosion through out the area	Erosion extends towards north
Valiathura	Erosion observed around 1 km in either side of Valiathura pier	seawall is in effective to control severe wave activity
Thazhampally	Erosion observed around 1 km stretch and wave overtopping	North side of the Muthalapozhi harbour
Thanni	Seawall slumped and it is north side of the Paravoor groin field	Severe erosion observed along Thanni to Iravipuram sector. It is around 4 km in length
Iravipuram	Seawall slumped and maximum erosion observed at fishing gaps	
Vellanathururthu to Azhikkal sector	Wave overtopping and seawall got slumped most of the location along this sector	Major erosion sites are Vellanbathuruthu (Mining site), Karitura, Alappad, Srayikadu and parayakadavu
Valiazheekal to Arattupuzha sector	Slumping of seawall most of the location and hence wave overtopping has observed	Major erosion sites are Perumpally, Kallikad and Arattupuzha
Kattoor	Seawall slumped and 2 Km stretch is affected by erosion	Sand filled bags are present throughout the affected area for temporary protection
Chenneveli Kadappuram	Seawall damaged partially or completely. Erosion affected 1.5 Km stretch	North side of Chethi harbour
Aayiram Thai	Seawall partially damaged and wave overtopping observed. Erosion affected 1km stretch	North side of the Arthungal groins
Njarakkal	Wave overtopping	Comparing with other coastal district erosion is less in Ernakulam. Good seawalls are present
Edavanakkad	Wave overtopping	
Kara	Severe erosion observed arond 2 km stretch. Seawalls is not in good condition	Downdrift side of mudbanks
Vatanaplly	Seawalls partially damaged and wave overtopping is observed	Erosion observed towards north upto Chettuwa. Seawall end erosion also observed south of the seawalls
Chettuwa	Erosion observed either side of the Chettuwa inlet	Ongoing Chettuwa harbour construction enhanced erosion either side of the breakwater
Pudu Ponnai	Severe erosion observed where sea wall having gaps along this sector	New seawall construction started
Thanoor	Severe erosion observed north side of the Thanoor harbour and it is extended 2 Km towards north	Ongoing Thanoor breakwater enhanced the erosion
Seddam beach	Severe erosion	Fishing gap
Gotheswaram	Severe erosion and it affected 0.5 Km stretch	Seawall absent this sector
Kothi	Severe erosion	Fishing gaps
Valiyangadi	Erosion affected 1km stretch	Seawall end erosion
Konnad	Erosion affected 0.5 Km stretch	Seawall end erosion
Kolavippalam	Wave overtopping	Seawall is partially or completely damaged
Kuriyadi	Wave overtopping	Seawall slumped
Mattool	Severe erosion inside harbour	River bangs of Valapattanam
Kakkadan chal	Erosion affected around 1.5 km stretch	North side of Azhikkal harbour and excess mining is carried out by locals may be the reason for erosion
Chithari	Erosion affected around 2 km stretch	North side of the Spit
Kasargode	Severe erosion affected around 300 m stretch	Seawall end erosion

5. Discussions

Erosion hotspots are mostly dependent on coastal morphology and shore protection structures. Identified erosion hotspots such as; induced erosion due to coastal structures, mining sites, wave over topping sites, fishing gaps, seasonal monsoonal erosion, erosion due to cliffs, down drift side of mudbanks and tidal inlets are examined.

5.1 Induced Erosion

In many places frontal beaches seaward of seawalls have disappeared bringing wave breakers closer to seawalls. Scouring at the base of seawalls accelerates slumping. Wave overtopping and flooding of the coastal zone landward of seawalls are also the resultant of high waves breaking very close to seawalls during southwest monsoon. Seawalls have to abruptly end at some locations alongshore which cause 'end erosion hotspots'.

Seawall along Poonthura to Valiathura (3 Km stretch) often gets damaged and slumps (Fig. 2) leading to emergency repair and strengthening. Wave overtopping and severe wave attack occurs along this sector. Houses and coastal road were damaged during severe wave attacks (Fig. 3). This is again noticed at Kattoor in Alapuzha coastal district and affected around 2 Km stretch (Fig. 4). Seawalls are damaged or slumped along Perumpally to Arattupuzha sector (6 Km stretch) and hence wave overtopping is observed throughout the sector. Being an open spot in a seawall stretch, fishing gaps at Iravipuram and elsewhere experiences a pressure gradient towards the gap which causes pushing of wave/swash into the gap accelerating erosion. Thanni located downdrift side of groins at Mayyanad which accelerated erosion and slumping of seawalls and hence severe erosion is observed (Fig. 5).

Figure 2. Damaged Seawall at Bhimapally

Figure 3. Damaged houses at Valiathura

Figure 4. Slumped Seawall at Kattoor

Figure 5. Slumped Seawall at Thanni

Erosion at Thazhampally (north of breakwater) is due to the downdrift effect of Muthalapozhi breakwater. Valiazheekal (north of Kayamkulam breakwater), Chenneveli Kadappuram (north of Chethi harbour), Aayiram thai (north of Arthungal groins), Thanoor (north of Thanoor harbour) are similar areas in the downdrift side of groins or harbour breakwater which are erosion hotspot (Figs. 6 & 7). Severe erosion observed at Chenneveli Kadappuram beach and it affected about 1 Km area. Coastal road and some houses were also damaged along this sector. The north of ongoing harbour breakwaters at Thanoor also severely affected by storm waves and it severity extends around 2 Km further north.


Figure 6. Erosion at Thanoor (north of breakwater)


Figure 7. Erosion at Chenneveli (north of Chethi harbour)

Erosion at Vatanapally to Chettuwa sector (5 Km stretch) is driven by the piecemeal maintenance of seawalls without a proper design. Ongoing harbour breakwater construction at Chettuwa inlet is also contributing to this. Fishing gap in seawall at Puduponnani sector is one among such areas of severe erosion (Fig. 8) and it is affected around 0.5 km sector. Erosion at Gotheswaram, Kothi beach, and Kolavipalam are other examples of 'fishing gap erosion'. Erosion at Kakkadan chal is due to the downdrift effect and mining of sediment from north of this sector. Major erosion observed at Kasargode beach is due to end erosion due to seawalls (Fig. 9).


Figure 8. Erosion at Puduponnani


Figure 9. Seawall end erosion at Kasargode

Most of the erosion spots are the result of induced erosion by coastal protective structures or harbour breakwaters. This indicates lack of proper Morphological Impact Assessment studies preceding construction of coastal structures. Maintenance of damaged seawalls is not properly planned based on appropriate designs since most of the repair works are executed on piece meal basis as an emergency measure. The result is uneven shape of seawalls which itself weakens the protection measure making them highly vulnerable to erosion. The normal procedure is to design coastal structures with insufficient data base due to reluctance to collect site specific morphological and hydrodynamic data. This is done to save time and reduce cost at the expense of the coast and beach.

5.2 Erosion due to Mudbanks

Mudbanks are patches of calm, turbid water with high load of suspended sediments appearing close to the shore along the southwest coast during south west monsoon season (Kurup, 1977; CMFRI, 1984). Accretion observed along mudbank locations and its updrift side. Erosion is observed on the downdrift side. The role of mudbanks for shoreline change along Kerala coast is given in table 2.

Table 2. Role of mudbanks occurrence for erosion/accretion along southwest coast of India

Reported earlier locations	Present Locations	Observations
Arattupuzha/Kayamkulam & Thrikunnapuzha.	Not occurring since 1988	Beaches accreted started eroding once mudbank stopped occurring
Purakkad	Shifted further north to Punnapra & confined to Punnapra for last 5-6 yrs	Erosion at Punnapra disappeared; started accreting pushing seawalls constructed during eroding time further away from shoreline.
Andhakaranazhi, Chellanam, Njarakkal & Edavanakkad	During the last 40 yrs mudbank not forming in these sectors	Highly eroding sectors & protected by seawalls
Chettuwa, Vatanappally, Thalikulam, Nattika.	Mudbank location shifted from Chettuwa to Vatanappally to Thallikulam to Natiika and presently to Kaipamangalam - Kara sector	Chettuwa & Vatanappally became highly eroding; Seawalls constructed during eroding times at Nattika-Kaipamangalam pushed further away from shoreline making it non-functional; Erosion south of Kara
Chavakkad (Blangad)	Continues at Blangad to further north	Accretion & wide beach towards north; erosion south
Ponnani	Not occurring	Changed scenario due to harbour breakwater
Kozhikode/Puthiyapa & Koyilandi	Reappeared at Kozhikode/Puthiyapa & Koyilandi in 2009 after a gap of 10 yrs but with a difference – concentration of mud in suspension has been considerably reduced	Beach started eroding during non occurrence of mudbank; Seawalls constructed to protect coast from erosion when mudbank formation was absent.
Ajanoor	Continues to occur at Ajanoor & Padanna	Wide beaches present

5.3 Seasonal erosion with negligible net erosion

Monsoon storm waves are the major causative force inducing seasonal erosion. Seasonal erosion is observed throughout the sandy coasts along the southwest coast during southwest monsoon (Figs. 10 & 11). Beach again starts to rebuild when long period swell waves approaches from southern ocean. Only temporary measures are required to address this.


Figure 10. Seasonal erosion at Pozhiyur


Figure 11. Seasonal erosion at Alapuzha beach

6. Conclusions

Erosion hotspots along southwest coast of India are identified from extensive field work carried out during the southwest monsoon season in 2013 and 2014. Direct field investigations and morphological interpretations have addressed distinctly different coastal segments with distinguishable morphological signatures and different types of anthropogenic interventions. The erosion hotspots are mostly dependent on the morphology and coastal structures. Identified hotspots are down drift side of mudbanks, fishing gaps, down drift sides of coastal structures including harbor breakwaters, locations of slumping seawalls, mining and adjoining sites, wave over topping sites and sites of haphazard maintenance of seawalls. Tidal inlets and adjoining areas are also locations of coastal erosion. Among the erosion hot spots a majority is the result of induced erosion by coastal protective structures or harbour breakwaters. This indicates lack of proper Morphological Impact Assessment studies preceding construction of coastal structures. The normal procedure is to design coastal structures with insufficient data base due to reluctance to collect site specific morphological and hydrodynamic data. This is done to save time and reduce cost at the expense of coast and beach. The haphazard way in which maintenance of damaged seawalls is undertaken as emergency measure causes vulnerable spots along the seawall lines.

Acknowledgements

We would like to thank Dr. N.P Kurian, Director, National Centre for Earth Science Studies (NCESS) for providing the facilities. We are conveying our sincere thanks to Sreeraj, Rafeeque, Asif and other colleagues who have participated for data collection.

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