Technology Fact Sheet for Adaptation

Beach nourishment [i]

Beach nourishment

29. **Sector**: Coastal

30. **Technology characteristics**

30.1 Introduction to Beach nourishment :

Beach nourishment is an adaptation technology primarily used in response to shoreline erosion, although flood reduction benefits may also occur. It is a soft engineering approach to coastal protection which involves the artificial addition of sediment of suitable quality to a beach area that has a sediment deficit. Nourishment can also be referred to as beach recharge, beach fill, replenishment, re-nourishment and beach feeding.

Addition of beach material rebuilds and maintains the beach at a width which helps provide storm protection. This approach is mainly used on sandy beaches but the term can also refer to nourishment with shingle or even cobbles. The aim, however, should be to ensure that nourishment material is compatible with the existing natural (or native) beach material (Reeve et al., 2004). Nourishment is often used in conjunction with artificial dune creation.

Beach nourishment helps to dissipate wave energy; when waves run up a beach and break, they lose energy and this interaction will be of different extents depending on the beach profile, shapes and gradients. The cross-sectional shape of a beach therefore affects its ability to attenuate wave energy. A ‘dissipative’ beach – one that dissipates considerable wave energy – is wide and shallow while a ‘reflective’ beach –one that reflects incoming wave energy seawards – is steep and narrow and achieves little wave energy attenuation. The logic behind beach nourishment is to turn an eroding, reflective beach into a wider, dissipative beach, which increases wave energy attenuation (French, 2001). beach nourishment addresses a sediment deficit: the underlying cause of erosion, while helping to dissipate incoming wave energy. This is achieved by introducing large quantities of beach material to the coastal sediment budget from an external sediment source, also referred to as a borrow site. The term ‘sediment budget’ is used to describe the careful balance which exists between incoming and outgoing sediment. When more material is added than removed, a build-up occurs and the shore builds seaward; conversely, when more material is removed than deposited, erosion occurs (Morton, 2004).

Nourishment addresses a sediment deficit – the cause of erosion – by introducing large quantities of beach material to the near-shore system. In turn, this can cause the shore to build seaward. It is important to note that beach nourishment does not halt erosion, but simply provides sediment from an

external source, upon which erosional forces will continue to act. In this sense, beach nourishment provides a sacrificial, rather than a fixed barrier against coastal erosion. Continuing erosional forces will likely return the beach to a state where re-nourishment is required. When the beach reduces to a critical volume, re-nourishment should be undertaken to avoid damage to coastal infrastructure.

According to the estimates done in 1990 by the IPCC Coastal Zone Management Sub Group Sri Lanka's coastal belt could be categorized in to following types (IPCC Report of the Coastal Zone Management Subgroup, Strategies for Adaption to Sea Level Rise, 1990) and areas under each type and the cost for providing necessary protections are also given in Table 1 and out of the total coast 30km^2 have been categorized as beaches and the cost for their nourishment has been estimated as US$ 203

Table 1: Types of Coasts available in Sri Lanka, respective areas &cost for providing necessary protections as estimated in IPCC Report of the Coastal Zone Management Subgroup, Strategies for Adaption to Sea Level Rise, 1990.

Coast type	Length km/Area km^2	Cost US$M
Coast length ("crow")	990 km	
Low Coast Length	4820 km	1,446.0
Total City water front length	124 km	1,860
Beach area	30 km^2	203
Harbour area	1.6 km	37
Total		3,545

30.2 Technology Characteristics/Highlights

Several methods of nourishment can be utilised, including placement by dredge, trucks or conveyor belts. Sand can be placed to create an extension of the beach width or as an underwater deposit which will be gradually moved onshore under the normal action of waves. Supply of nourishment material by offshore dredging is often favoured because it allows for large quantities and this method is practiced ion many countries. It is also possible in Sri Lanka where off shore sand deposits are available, but the high cost incurred for this process is a problem which needs to be solved. Beach nourishment could be enhanced by improvement of dune vegetation which reduces coastal erosion to a considerable extent.

12.1Institutional/ organisational requirements

This activity should be handled by the Coast conservation department with the assistance of Academic and research institutes, which has the capacity to estimate the annual coastal erosion in selected beaches with a touristic importance and in areas where sand dunes have faced

erosion due to anthropogenic activities such as extensive removal sand for construction purposes and due to destruction of sand dune vegetation in order to calculate the volume of sand to be dredged for nourishment of respective beaches. In addition to the above availability of offshore sand deposits and the quantities available for dredging without causing any negative impacts on the coastal belt or the sensitive marine and coastal ecosystems should be estimated. In other words annual sediment budget with respect to beaches having different physical characters should be estimated

13 Operations and maintenance

13.1 Endorsement by experts

Beach nourishment which is a soft defense technology, is known to complement hard protection measures such as seawalls and it is practiced worldwide and which may continue to be used as a last line of defense. The existence of a wide, sandy beach in front of hard defense structures greatly reduce the wave energy reaching them, thus providing additional protection.

13.2 Adequacy for current climate

Beach nourishment alone is not adequate to be practiced alone but it should be implemented as a complementary technology together with other hard defecnse structures such as sea walls, dykes, etc. and soft defense technologies such as restoration of dune vegetation. However it will be an acceptable solution for erosion and inundation due to sea level rise, in beaches which are having an economic importance (beaches facing tourist hotels).

13.3 Size of the beneficiary group

- Persons involved in tourism and hotel industry
- Persons depending on dune vegetation for socioeconomic activities
- Persons using beaches for recreational activities.
- Tourists coming to Sri Lanka (more than 300,000 to 400,000 per year)
- Increase of boat landing sites

In addition to human beings other organisms living in the coastal sands and using them for their biological needs also will benefit out of this technology. Turtles and other organisms using sandy beaches for nesting and organisms living in burrows within sandy beaches also could be considered as beneficiaries. Therefore turtle hatchery owners and the employees of such hatcheries also could be considered as indirect beneficiaries of this project.

14 Costs

According to the estimates done in 1990 by the IPCC Coastal Zone Management Sub Group Sri Lanka's coastal belt could be categorized in to following types (IPCC Report of the Coastal Zone Management Subgroup, Strategies for Adaption to Sea Level Rise, 1990) following (a, b &c)are the estimates for types of beach nourishment applied globally

(a) **Beach nourishment of sandy beach without protection works**

Dimenensions: 1 m thick sand layer over morphologic active zone; up to MSL -8 m contour line, approx 1000 m wide

Construction: Nourishment by "tshd" (trailing suction hopper dredge) from offshore sources or by "csd" (cutter suction dredge) from nearshore/inshore sources

Unit rates:

Project length: 2-6 km, sand from near (<10km) sources - 3.5M$/km

Project length: > 6km, sand from nearby sources- 3.0M$/km

Project length: 2-6 km, coarse sand from remote (>10km) sources- 6.0M$/km

Project length: >6 km, coarse sand or sand from remote sources- 5.5M$/km

Average unit cost- 4.0M$/km

(b) **Beach nourishment of sandy beach with existing protection works (groynes, under water beams, etc.)**

Dimensions: 1 m thick sand layer, over 75% of morphologic active zone, 750m wide

1 m raising of existing construction with 50 ton stone/m construction: nourishment by "tshd" from offshore sources or by "csd" from nearshore/inshore sources stones placed by land dumping or crane placement unit rates: nourishment- 3.00 M$/km [see (a)]stone work:

Over land from local sources : 0.40 M$/km

Over water from local sources : 0.80 M$/km

Over water from remote sources: 1.25 M$/km

Average unit cost : 4.00 M$/km

(c) **Tourist beaches**

Construction of additional works to preserve specific recreational functions of existing facilities, by various (not specified) measures. Unit cost: estimated additional value of 50% of beach nourishment costs- totally 6.0M$/km

Note1 :It is assumed that tourist beaches cover some 25% of the total beach length to be replenished. Calculations are, therefore, made with a unit rate of 4.5 M$/km beach length, without any further discern of function.

Note 2 :Technical feasibility has been assumed for beach nourishment, including areas where sand sources are expected to be scarce.

4.1 Cost to implement adaptation options

According to the IPCC Report of the Coastal Zone Management Subgroup, Strategies for Adaption to Sea Level Rise (1990), the average cost for beach nourishment has been estimated as 3.0 to 6.00 MUS$ if the beach is lifted by 1m (see a, b & c), and the beach width and length have been considered as 750m and 1km respectively and the extent of Sri Lankan beaches have been estimated as 30 km and the cost for beach nourishment has been estimated as 203 MUS$ for year 1990. Therefore the cost for nourishment of Sri Lankan Beaches have been calculated as follows.

Cost to nourish 30 km of beach at 1m lifting as estimated by IPCCC (1990)

= 203MUS$

Mean beach width ofv Sri Lanka according to CCD =300m

Cost for beach nourishment per 1m^2 of beach area =203÷(30x1000x300) MUS$

=22.5 x 10^{-6}

MUS$=22.5US$

By considering the depreciation of US$ from 1990 to 2011cost for nourishment of 1m^2 of the beach will be taken as 25US$/m^2

Activity	Unit cost/m2 (US $)	Total cost (US $)
Beach Nourishment for an area withion 3km beach length & 300m mean beach width	25/m^2	22,500,000/3km (or 900,000m^2)
Unforeseen expenses		500,000
Total cost Beach Nourishment for an area within 3km beach length &300m beach width (900000 m^2)	**25.56/m^2**	**23,000,000**

14.1 Additional costs to implement adaptation option, compared to "business as usual"

- Hotels and industries should maintain environmentally friendly methods for disposal of waste water which will not pollute the nourished beaches.
- Coastal waters & sand deposits utilized for nourishment should be tested for possible hazardous material as the sandy beaches will be used for human recreational activities and sunbathing.
- In addition to the beach nourishment beaches used by turtles for nesting should be protected as major alterations may prevent them from visiting their nesting sites.
- In connection with the above, sites used for *ex situ* conservation of turtles also should be taken in to consideration. Beach nourishment should not alter the texture and other physicochemical properties of sand where turtle hatcheries are located.

15 Development impacts , indirect benefits

15.1 Economic benefits

- **Employment**
  - This project will provide employment opportunities for those who involved in the sand mining, dredging and operation of respective machinery during beach nourishment
  - More employment opportunities will be available in the tourism industry and in hotels
  - Coastal communities will make living through activities related to tourist industry
- **Investment :**
  - Improvement of foreign exchange earnings through tourism
  - Coastal SMEs will have economic benefits due to attraction of the attention of foreign and local visitors coming to beach resorts

15.2 Social benefits :

- **Income**
  - Improvement of economy of coastal communities due to
    a. Establishment of SMEs related to tourism
    b. Improvement of eco-tourism
    c. Widening of the beaches increases protection to the properties of coastal communities from erosion, strong winds and waves, which reduces the cost for property owners implementing protective measures.
  - Socioeconomic status of coastal communities will improve as a result of improved income
  - Increased income to persons involved in tourism (especially in eco-tourism), coastal resource management and hotel sectors.
- **Education**
  - Improvement of awareness on the beach sand dynamics and offshore sand dynamics
- **Health**

There can be both positive and negative impacts

Positive impacts on health

1. Improved physical conditions and aesthetic appearance of beaches will help to maintain good health among people living near the coastal beaches and those who visit the beaches for recreational activities
2. Security of coastal dwellings will naturally improve the health conditions of coastal communities

Negative impacts on health

- If off shore sand deposits or any other sands used for beach nourishment contain contaminants they could cause health hazards.

15.3 Environmental benefits

- Widening the beach helps to dissipation wave energy which helps to protect the landward environment ;
    - Provision of shelter and additional breeding sites for turtles, sea birds and other endangered and ecologically important organisms and the sand burrowing organisms, which would in turn improve the biodiversity in sandy and dune habitats only if the sand used for nourishment is not containing hazardous material

16 Local context

16.1 Opportunities & Barriers

- **Opportunities**
    - Coastal scientists and sedimentologists will get an opportunity to use their experience and knowledge when extracting offshore sand deposits for beach nourishment.
    - those who were involved in destructive activities within the coastal belt could find an alternative employment related to tourism or beach nourishment
    - Provide more opportunities to local & foreign tourists for recreational activities which in turn helps to maintain good health conditions
- **Barriers**
    - Offshore sand deposits should be able to support the annual sand budget requires for nourishment, otherwise erosion will exceed the nourishment rate
    - High cost incurred on nourishment of beaches
    - Illegal sand mining in coastal belts
    - Insufficient or lack of motivation and knowledge of certain sections of the coastal communities for conservation and/ sustainable management and maintenance of beaches to increase its attraction to tourists.
    - Illegal sand mining
    - Release of pollutants and hazardous material from land based industries in to the coastal beaches without proper treatment

16.2 Status

- Although knowledge on technology for beach nourishment is locally available its high cost will not allow such activities to be implemented to all beaches.

- Offshore sand deposits which could be used for this purpose has been identified by marine geological surveys and they are utilized for more prioritized construction and beach nourishment activities patronized by the state.

16.3Time frame

	Year 1 divided to 4 quarters				Year 2 divided to 4 quarters				Year 3 divided to 4 quarters			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Survey for selection of sites for most suitable beaches for nourishment considering its economic importance with respect to expected inundation due to SLR and availability of offshore sand	X	X	X									
Implementation of nourishment to most suitable sites			X	X	X							
Evaluate the cost effectiveness depending on the sediment budget				X	X	X	X					
If economically feasible implementation to more suitable sites							X	X	X	X	X	X

16.4Acceptability to local stake holders:

- Depends on the economic gains, protection received from wave actions, opportunities for recreational activities acceptability local stakeholders
- There is a strong possibility of acceptance by the local stake holders if the nourished beaches are in the vicinity of touristically attractive sites.

17 References

- Linham, Mathews M. & Robert J. Nicholls((2010). Technologies for Climate Change Adaptation –Coasta Erosion & Flooding- (Xaanil Zhu ed.). UNEP Riso Centre, University of Southhampton. ISBN978-87550-3855-4

- Olesen, S., D. Sadachandran, J.I. Samarakoon, A.T. White, H.J.M. Wickremaratne & M.S. Wijeratne (1992). Coastal 2000: Recommendations for A Resource Management

strategy Volumes I & II, Coast Conservation Department , Coastal Management Project , Sri Lanka &b Coastal Resource Centre, University of Rhode Island. ISBN 955-9108-05-0

- Report of the Coastal Zone Management Subgroup, STRATEGIES FOR ADAPTION TO SEA LEVEL RISE. Intergovernmental Panel On Climate Change, Response Strategies Working Group, November, 1990. http://www.epa.gov/climatechange/effects/downloads/adaption.pdf

- Preuss, Jane (), FAO corporate Document Respository. CVoastal Protection in the aftermath of Indian Ocean tsunami. Chaper 5: Coastal Area Planning & Management

[i] **This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Adaptation – Sir Lanka. You can access the complete report from the TNA project website http://tech-action.org/**