Feasibility Studies on Sustainable Fisheries Infrastructure Development

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Abstract— *A need exists for the development of appropriate fisheries infrastructure to meet the demands of the expanding fisheries sector in the country. With such developments, however, a possibility exists for the coastal constructions associated with fisheries infrastructure to cause adverse impacts in the form of coastal erosion and/or accretion in the vicinity of facilities as well as siltation in the sheltered areas within the facilities, raising concerns related to the sustainability and the effectiveness of the developments. In view of these circumstances, a number of studies were conducted recently to assess the feasibility of developing sustainable fisheries infrastructure in various parts of the country. In the absence of recorded nearshore data at many of the locations considered, the investigations were mainly based on field studies, analysis of available data and local knowledge gathered through community consultations. The details of selected investigations are presented and the recommendations are elaborated.*

Keywords— Fisheries Infrastructure, Nearshore Wave Climate, Sediment Transport

I. INTRODUCTION

Sri Lanka, being an island, fisheries activities are carried out along its entire coastline and a large coastal population is engaged in fisheries activities. Marine fishing is carried out by a variety of crafts ranging from smaller non-motorized traditional craft to larger multi day boats with inboard engines. Plans have been formulated by the government to increase the fish production and the expansion of the marine fishing fleet and the development of appropriate fisheries infrastructure for the operation of such craft would play a vital role in achieving the future targets for fish production. Also, fisheries activities have resumed/expanded in the northern and eastern regions of the country and, with many of the facilities in these regions currently in a dilapidated state, a strong need exists for the rehabilitation and development of appropriate fisheries infrastructure facilities. In view of these circumstances, a number of studies were conducted recently in Sri Lanka (JICA 2011, Samarawickrama 2010, UNOPS 2009, UNOPS 2010) to assess the feasibility of developing sustainable fisheries infrastructure in various parts of the country and the details of such investigations conducted in Vakarai on the eastern coast, Point Pedro area on the northern coast of Jaffna peninsula and Galbokka on the south-western coast are presented.

II. METHODOLOGY

The investigations were conducted at the sites for which improved facilities were requested by the local fishing communities and/or relevant authorities. In these investigations, attention was mainly focussed on related coastal engineering aspects in order to minimise the adverse impacts on the facility as well as the neighbouring coastline to ensure the sustainability and effectiveness of any proposed development. In the absence of recorded coastal engineering information at many of the locations considered, the investigations were mainly based on field studies, analysis of available data and local knowledge gathered through local community consultations. Attempts were made to assess, qualitatively, the exposure of the site to the nearshore wave climate and the resulting coastal processes associated with sediment (sand) transport in the area. The types of coastal constructions required were identified and the severity of potential impacts due to such developments was considered to assess the suitability of the site for potential development.

III. FISHERIES INFRASTRUCTURE AND COASTAL PROCESSES

The fisheries infrastructure facilities provide essential shelter for mooring and/or beach landing and loading/unloading activities of fishing crafts and shore facilities for related support activities. The level of coastal infrastructure requirement to provide the necessary protection is closely related

to the nearshore wave climate of the area, and depending on the severity of the resulting coastal processes, it may vary from the enhancement of the natural shelter provided by features such as headlands and reefs to full breakwater protection. The coastal areas of the country are predominantly sandy beaches and the construction of fisheries infrastructure in the form of breakwaters and/or jetties could cause alterations in sand transport patterns in the area. Such alterations could lead to adverse impacts in the form of coastal erosion and/or accretion in the area as well as siltation in the sheltered area, raising concerns related to the sustainability and the effectiveness of the development.

IV. NEARSHORE WAVE CLIMATE

The wave climate in the coastal waters of Sri Lanka is characterized by two wave systems, the swell and the monsoonal waves. The swell approaches from a southerly direction throughout the year. Two seasonal monsoonal periods are dominant, south-west and north-east. The coastal areas extending from the western region to the south-eastern region are directly exposed to the swell as well as the south-west monsoonal waves while the rest of the coastal areas are less exposed to the swell and sheltered from the south-west monsoonal waves. The coastal areas extending from the northern region, along the eastern coast, to the south-eastern region are mainly exposed to the refracted swell and north-east monsoonal waves.

V. COASTAL SAND TRANSPORT AND SHORELINE BEHAVIOUR

Nearshore currents, both longshore and on/offshore, generated by the interaction of the approaching waves with the sea bed and the resulting coastal processes of refraction, breaking etc, are the main causes of sand transport in coastal areas. In Sri Lanka, studies conducted have revealed a general trend of net sand movement northwards along the south-western and western coasts, eastwards along the southern coast and northwards along the south-eastern and southerly parts of the eastern coasts during the south-west monsoon. During the north-east monsoon, a general trend of sand movement southwards along the eastern, south-eastern and western coastlines and westwards along the southern coastline has been revealed (Fittschen et al 1992). However, the alongshore sand transport rates depend on a number of factors including wave characteristics (height, period, angle of approach etc), bathymetric features (influencing refraction, breaking etc) and beach characteristics (geometry, size and availability of sand etc) and a significant local variations are apparent in view of the diverse features in the coastal environment of the country. Seasonal erosion and the steepening of the beaches during the monsoonal periods and recovery during non-monsoonal periods is also a common characteristic in many of the beaches in the country.

VI. COASTAL CONSTRUCTIONS AND SHORELINE RESPONSE

Coastal erosion and accretion can be considered in terms of sand imbalance due to changes in inflow and outflow rates and such imbalances caused by the disturbances to the longshore transport have been identified as a major cause for erosion. Coastal constructions, in the form of groynes, jetties or breakwaters could cause disturbances of longshore sand transport and such constructions in areas of high levels transport could lead to severe impacts associated with erosion, accretion and siltation. The mitigation of the resulting adverse impacts would usually involve the structural interventions in the form of series of groynes or offshore breakwaters or other interventions such as sand nourishment, all of which would require substantial expenditure. It is evident from these considerations that the assessment of the level of sand transport processes in a locality would play a vital role in identifying the sites for fisheries infrastructure development with coastal constructions which would cause relatively low levels of adverse impacts leading to long term sustainability and effectiveness of such facilities.

VII. INVESTIGATIONS IN VAKARAI AREA ON THE EASTERN COAST

The site at which investigations were conducted is located in Vakarai Central, at the outlet of a lagoon near the centre of a coastal cell formed by two natural headlands as shown in Figure 1.

Figure 1. Location of Vakarai Central
(Source of Image: Google Earth)

The coastal area is characterised by wide sandy beaches and sand deposits in shallow areas of the lagoon near the outlet and a wide sand bar across the outlet. The sand bar blocks the outflow from the lagoon but breaches during the north-east monsoon to release flood waters and once breached, it remains open for a few months. The site is located away from the areas sheltered by the headlands and is seasonally exposed to both swell and north-east monsoonal waves as indicated in Figure 1. Significant seasonal variations of coastline positions and steepening of beaches indicate high level of longshore and on/offshore sediment transport in the vicinity. In spite of small tidal range in coastal waters of the country, a potential exists for ebb and flood tidal currents through the channel across the breached sand bar formation with accompanying sand transport patterns. Significant variations in the form of the outlet and the lagoon sand deposits in the vicinity were also evident. The abundance of sand and the dynamic and complex nature of coastal processes and the high level of sand transport activity in the vicinity became clearly evident by the investigations.

Coastal constructions in the form of jetties or breakwaters for the development of fishery infrastructure development in such dynamic coastal environments would most likely lead to high levels of adverse impacts in the form of severe erosion/accretion and siltation due to the disturbance caused to natural transportation processes which could also affect the nearby beaches as well. Any structural interventions, usually in the form of groynes, to maintain an uninterrupted lagoon outlet throughout the year in order to provide mooring facilities for fishing crafts in the lagoon also would likely to cause similar adverse impacts. The changes in mixing patterns of sea water in the lagoon due to such interventions could severely affect the fishing activities and ecological aspects associated with the lagoon. In view of these considerations, the site in Vakarai Central was not recommended for fishery infrastructure developments. In view of the complexities involved with the site identified in Vakarai Central and the need to develop Fishery Harbor/Anchorage facilities in the Vakarai area, the possibility of selecting an alternative site was also explored and investigations were conducted at a number of locations in the area. Based on a comparative evaluation of the level of potential for development at these locations, the site in Palachenai was identified as the most suitable site for development.

A. Investigations in Palachenai

Palachenai is located in bay formed between two headlands, next to the northern headland formed by a rocky formation extending into the sea as shown in Figure 2.

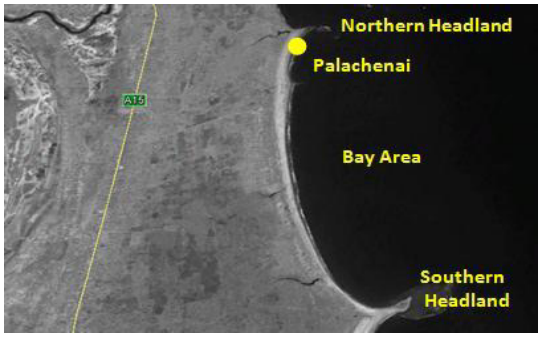

Figure 2. Location of Palachenai
(Source of Image: Google Earth)

The site is partially sheltered by the rocky headland from north-east monsoonal waves. Northward sand transport is also curtailed by the headland, as evident by the small scale seasonal coastal erosion on its northern side. The bay extends over a length of approximately 3.5 km and no large water bodies drain into the bay area. A small rocky formation exists approximately 750 m from the northern headland restricting sand movement and forming a smaller coastal cell in the vicinity of site. Even if a reasonable level of sediment activities is envisaged in the larger bay area, sand movement in the vicinity of the site would be restricted due to possible trapping of sand at this rocky formation. Based on these considerations, the site in Palachenai was identified as a suitable site for fishery infrastructure development. The construction of a fishery infrastructure facility is unlikely to aggravate coastal erosion on the northern side of the headland. However, a small

scale coast protection scheme was also recommended together with any fishery infrastructure development. The conceptual layout of a fisheries infrastructure facility shown in Figure 3 was proposed for further investigations.

Figure 3. Conceptual Layout of Proposed Developments in Palachenai

(Source of Image: Google Earth)

VIII. INVESTIGATIONS IN POINT PEDRO AREA ON THE NORTHERN COAST OF JAFFNA PENINSULA

Prior to the conflict that prevailed in the region, Jaffna Peninsula had been one of the most productive fishing regions in the country. The fishery infrastructure facilities in the region are currently in a dilapidated state due to the damages during the conflict and years of neglect and in need of restoration and development. Since the end of the conflict, the fishing sector has shown a recovery with increased fish production. The fishing fleet in the area, soon after the end of conflict, consisted of only smaller boats and, in spite of the potential for offshore fishing by larger boats, such boats were not in operation-due to restrictions imposed by security conditions and the absence of adequate facilities in the region. However such boats have recently commenced operations and a need exists for the development of appropriate fisheries infrastructure facilities. Point Pedro region had been one of the most productive fishing areas in the peninsula and investigations were conducted to assess to the potential for fishery infrastructure development in the area. The investigations were conducted in the Divisional Secretary (DS) Division of Point Pedro (Vadamarachchy North).

A. Coastal Characteristics and Fisheries Activities

The coastline of the area of investigations extends from Thondamanaru along the northern coastline of the peninsula towards the northeastern edge of Munai and along the eastern coastline beyond Kathkovalam over a length of 20 km as shown in Figure 4.

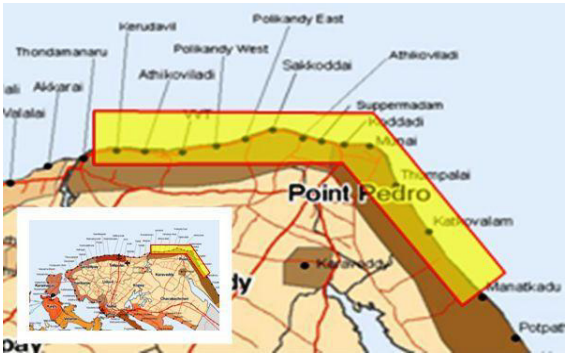

Figure 4. Area of Investigations in Point Pedro

The coastline on the eastern side of peninsula is directly exposed to north-east monsoonal waves and difficulties in mooring/beach landing of fishing boats are experienced by the fishing communities and, as a result, relatively a lesser number of Landing Sites are located along this coastline. A wide, straight, sandy coastline exists in the area and investigations revealed significant seasonal variations of the beach profile indicating level of sand transport. Under such dynamic conditions, the construction of coastal structures is likely to cause coastal erosion/accretion problems and such constructions without extensive investigations were not recommended.

The coastline along the northern side of peninsula in Point Pedro is characterized by rocky/sandy beaches and a reef formation is located close (< 300 m approximately from the coastline) and parallel to the coastline as shown in Figure 5. Although the coastline, by its orientation, is potentially exposed to north-east monsoonal waves, protection against coastal erosion is provided by the reef formation along most of the coastline. The presence of reef formation has also resulted in a number of naturally sheltered basins in the area, suitable for mooring of fishing craft. Many of the Landing Sites in Point Pedro area are located in such basins. These include the Landing Sites in Thondamanaru, Valveddithurai, Athikoviladi, Polikandy West, Polikandy East, Sakkodai, Imparsiddy, Suppermadam, Koddady and Munai. Mainly the smaller fishing boats are operated from these Landing Sites but, depending on the depths in sheltered areas behind the seaward edge of the reef formation, some of the larger boats, which have become operational

recently, are also based in some of the sites, in spite of the absence of proper facilities for the operation of such craft.

Figure 5. Northern Coastline: Point Pedro Area
(Source of Image: Google Earth)

B. Current Status of Fisheries Infrastructure and Recommendations

The tsunami in 2004 has caused significant damages to the reef formation and spreading of broken parts of the reef in sheltered basins has caused difficulties in using the Landing Sites due to reduced depths and partial blockage of access channels. The cyclone in 2008 has also caused further damages. The improvement of fisheries infrastructure at Landing Sites for the operation of mainly the smaller fishing craft, in the area could generally be achieved by strengthening the natural protection provided by the reef formation. Raising the crest level of reef formation and strengthening of its seaward slope with the use of larger armor may be needed to provide effective protection. The clearing of scattered rocks from the access channels and sheltered basins would also be needed. Deepening of access channels and the basins may also be required at some of the sites and in such situations due attention need to be paid for and adverse environmental issues associated with any dredging of reef formations. A possibility also exists for the use of excavated and cleared material for the use in the strengthening of protection measures.

In addition, a need also exists for the development of appropriate infrastructure facilities, in the form of a fishery harbor or anchorage, to cater for operations of larger fishing craft. The only fishery harbor facility in Jaffna peninsula is located in Myliddy on the northern coast of the peninsula to the west of Point Pedro. Fishery activities are not currently carried out at Myliddy and even if it is operational, the potential exists for other fishery harbor developments in the region, mainly due to the relatively smaller size of the harbor basin in Myliddy which may not be capable of meeting the needs of the expanding fleet of larger fishing craft in the area. In view of these considerations, recommendations were made for the development of a fishery harbor/anchorage facility in Point Pedro area at an appropriate location identified based on socio-economic, environmental and coastal engineering considerations. Appropriate protection measures, usually in the form of breakwaters would be required in such a development to provide a sheltered basin of adequate extent and depth against north-eastern monsoonal waves. A typical conceptual layout in the form of that shown in Figure 6 can be recommended for such a development. No severe adverse impacts associated with coastal erosion are envisaged due to such a development in view of the protection provided by the coastal reef formation in the area.

Figure 6. Conceptual Layout of Proposed Development
(Source of Image: Google Earth)

IX. INVESTIGATIONS IN GALBOKKA ON THE SOUTH-WESTERN COAST

An investigation was conducted to assess the feasibility of developing a fishery landing site in Galbokka in Rathgama in the Galle District. The site had been identified based on the availability of land to develop shore facilities. The location of the site is shown in Figure 7. A wide sandy beach exists in the area next to a rock outcrop, from which the beach extends uninterrupted for a few kilometres in the north-western direction. The investigation revealed significant seasonal variation in the beach, in the order of up to 40 m in the vicinity of the project site indicating high level of sediment activity. A beach profile with a steep gradient is formed at the site during the south-west monsoon, which, together with adverse wave conditions, makes it difficult for landing/mooring of fishing

craft. Due to the orientation of the beach at the site, it is directly exposed to the south-west monsoonal waves and no sheltering effect is provided by the rocky outcrop. In view of the exposed nature of the site, it is evident that appropriate costal structures are required in any proposed development to provide a safe mooring and landing environment at the site. The layout of such structures will depend on local bathymetric and wave conditions but, based on the site conditions observed and considerations of exposure and protection requirements, a conceptual layout in the form of that shown in Figure 7 can be identified for further investigations.

Figure 7. Location of the Site in Galbokka and Conceptual Layout(s) for Further Investigations
(Source of Image: Google Earth)

Fishery infrastructure facilities are usually developed in locations with a certain degree of natural protection and lower levels of sediment movement. The developments enhance the natural protection while causing minimum disturbances to sediment transport patterns to limit the adverse impacts in surrounding areas. The costs associated in developing the facilities and providing impact mitigation measures can be kept relatively low by selecting appropriate locations for development. However, no such natural protection exists at the site in Galbokka which is located in a sandy beach with high levels of sediment movement. The protection for mooring and landing and loading/unloading operations needs to be provided entirely by coastal structures which could disturb the sediment transport patterns leading to potential coastline changes and erosion problems. In such a case, coast protection systems, usually in the form of groynes, may need to be included in the overall development plan. In view of these considerations, it is evident that the costs associated with any proposed development at the site proposed in Galbokka are likely to be significantly higher than the costs involved with a development of similar nature at a site with some form of natural protection.

A. Investigations in the Alternative Site

In view of the potential adverse impacts associated with the developments at the proposed site, as an alternative, the technical feasibility of another site was investigated which is located next to the proposed site on the opposite side of the rocky outcrop, as shown in Figure 7. The sandy beach at the site extending from the outcrop is interrupted by another smaller outcrop nearby (Figure 7) forming a smaller coastal cell in which relatively lesser extent of sediment movement is apparent. The larger outcrop provides partial protection from south-west monsoonal waves which can be enhanced by a coastal structure extending from the outcrop as shown in Figure 7. From a coastal engineering point of view, it is apparent that this site is more suited for development of fisheries infrastructure but, similar to the proposed site, detailed investigations are required to assess the development potential in detail.

X. CONCLUDING REMARKS

The details of investigations conducted recently to assess the feasibility of developing sustainable fisheries infrastructure in various parts of Sri Lanka- Vakarai area on the eastern coast, Point Pedro area on the northern coast and Galbokka on the south-western coast- are presented. Although socio-economic aspects, availability of land for shore facilities and other related aspects were also considered in assessing the feasibility, attention was mainly focussed on related coastal engineering aspects to minimise the adverse impacts on the coastline in order to ensure the sustainability of the proposed development. As the investigations in Vakarai area revealed that the site identified initially is not favourable for development and, based on further investigations, a location in Palachenai was identified as more suitable for further investigations for development. Investigations in Point Pedro area revealed that many of the existing landing sites can be developed further by enhancing the natural protection offered by the natural reef formation in the area. The need of a Fishery harbor/anchorage facility for the area was also became evident and the form of constructions required for such a facility was identified for further investigations. The investigations conducted in Galbokka revealed the

potential for significant adverse impacts due to coastal constructions at the site initially identified for development, in view of which, an alternative site next to it was identified for further investigations for development.

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