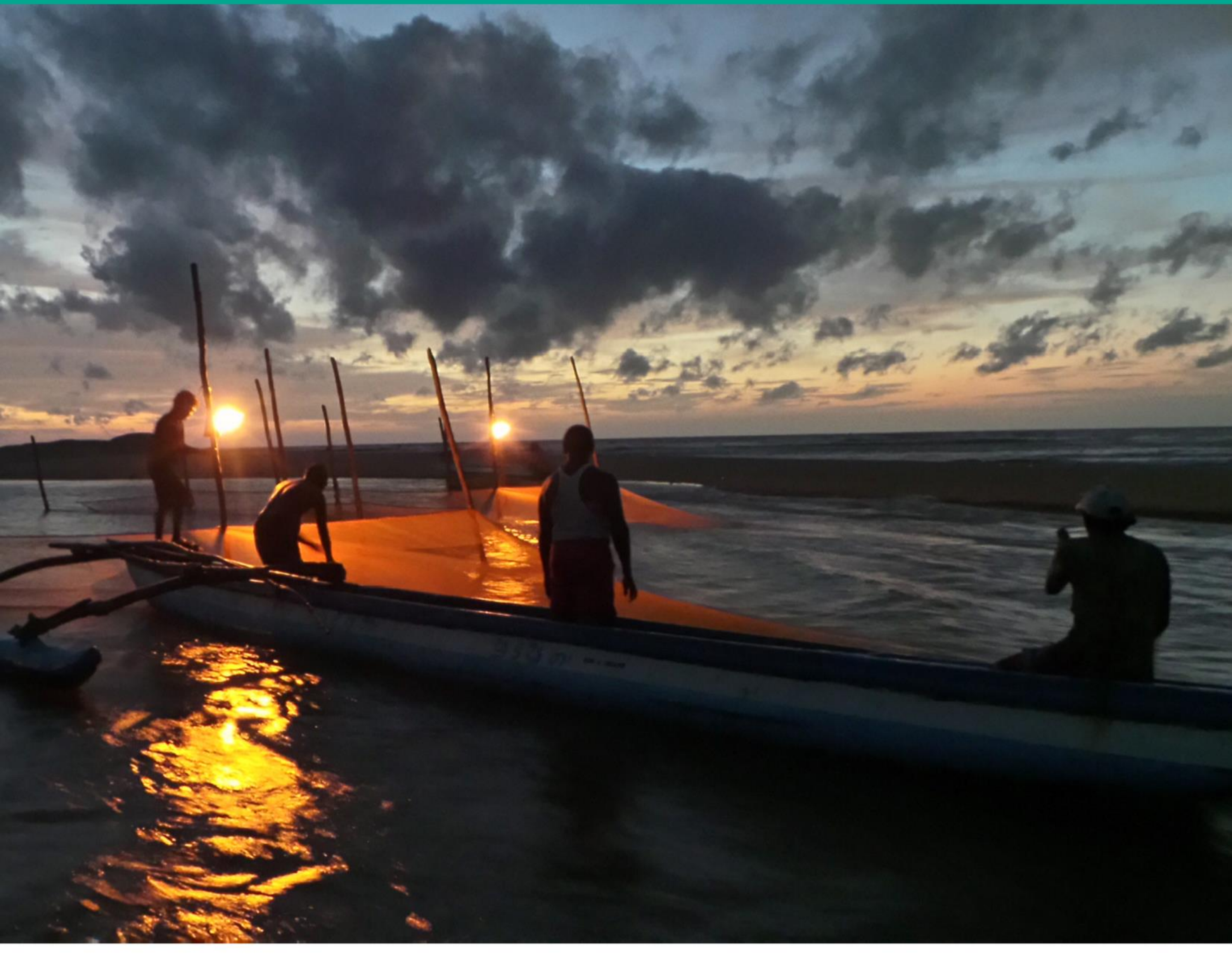
Finding sustainable solutions to address the issues of resource users of the Chilaw Lagoon



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Chilaw Lagoon and its vicinity

1. Chilaw Lagoon is located at Pambala (07◦30 N, 079◦49 E). The two lagoon mouths at northern-most point and southern-most points are narrowdue to sand bars which restrict free movement of water into and from the lagoon.There are no streams directly draining into the Lagoon from inland water courses. The lagoon shares the Thoduwawa estuary with the KarambalanOyaat its southern outlet. Whereas on the north, DeduruOya estuary is very close to the northern outlet of the lagoon and during heavy floods, DeduruOyaestuary can merge with the lagoon outlet.

2. The main water body of the lagoon is nearly 5 km^2 which is connected to sea at the northern outlet running through 7.8 km of a narrow canal. Similarly, the southern canal is 5.5 km long. The longest stretch of the lagoon is 7.8 km in length and the widest points perpendicular to the longest points account to 4.2 km. While average depth of the lagoon is nearly 1 m.

3. Drainage in the hydro-catchment area of the lagoon is quite complicated as it has some tanks connected to DeduruOya. Direct catchment of the lagoon is about 45.3 km^2. Further, a part of this catchment also can drain into DeduruOya through the paddy fields and low lying areas as there are some tank bunds which prevent drainage towards the lagoon. Railroad and the Colombo - Puttalum highway embankments also prevents the surface runoff draining into the lagoon except at several culverts and small bridges. Peak freshwater inflow through catchment runoff during a storm event with a 2-year return period is about 44 m^3/s.

4. The maximum runoff is usually recorded during October/November, corresponding to the high rainfall received during this time in the catchment area. High water level of the lagoon as well as freshwater in the estuary therefore coincides with peak rainfall in the catchment areas. The lagoon acts as flood water storage. However, during heavy rainfall, when the estuary overflows and causes serious flood problems in the residential areas, the residents are known to dig an escape channel from LunuOya to the sea (Joseph, 2011).

5. Tidal fluctuations in Chilawestuary range up to a maximum of 12 cm. As a consequence, the estuary and the connecting channel towards the sea show a gradual change from more fresh towards more saline water conditions. Generally, the lagoonwater is too saline (at least part of the year) for agriculture activities (e.g., paddy cultivation) but suitable for aquaculture. Recorded ranges of some physical-chemical characteristics of Chilaw estuary vary from month to month and depend highly on the rainfall and tidal fluctuations. For example, tidal ingress of sea water into the estuary, especially during the dry season makes the water highly brackish.

6. The estuary is polluted by extensive dumping of domestic waste and sewage from a large number of settlements. In addition, many

shrimp farms discharge polluted water containing high nutrient remains and chemicals viaconnecting canals. The Chilaw market, situated close to the estuary is a significant polluting source within the estuary.Organic wastes including decomposing fish waste are discharged directly into the estuary from the Chilaw market. Siltation, accumulation of pollutants due to extensive shrimp culture and dumping of waste (both wastewater and solid waste) have threatened the fish production in the lagoon.

7. Mangroves have been cleared for the construction of ponds for shrimp culture. Mangrove destruction has been severe on the eastern and southern sides of the estuary and on either side of the Dutch Canal. Some narrow stretches of mangrove stands still exist on the southern and western parts of the estuary. The few mangrove patches in the east are heavily exploited for firewood, fencing material, etc. One of the direct consequences of intense shrimp culture after clearing the mangroves is sedimentation of the lagoon. Destruction of mangroves and salt marshes for the construction of shrimp cultivation ponds, and the associated support infrastructure, including settlements and access roadshave caused severe negative impactsaffecting the lagoon's stability.This has a definite negative consequenceon the shrimp farms because it leads to changes in soil pH in and around the ponds, and enhances sedimentation; which further decreases water circulation and may increase the frequency of flooding during the wet season.

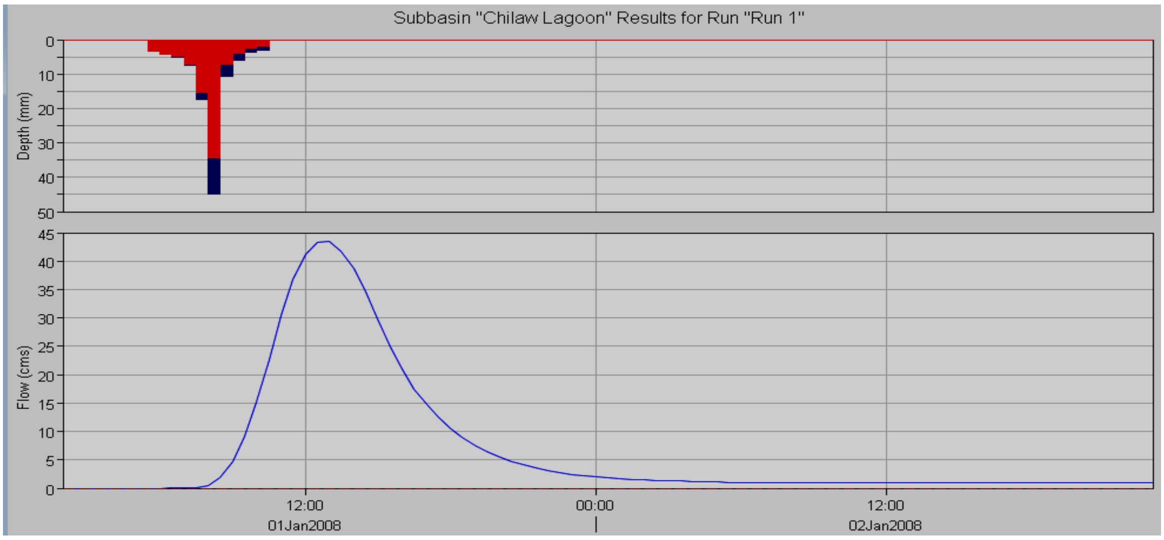
8. Effluents from the shrimp farmsthat reach the Dutch Canal are high in total suspended solids (200-600 mg/l) and have high BOD levels (60-180 mg/l). These effluents cause heavy siltation in the canal, thus increasing water turbidity. High sulphides and ammonia levels in these waters are also attributed to shrimp farm effluents (Corea et al., 1995).

9. Upstream deforestation in KarambalanOya (and DeduruOya) basin has led to serious flooding problems downstream further exacerbated by the construction of shrimp ponds. In addition, flood waters wash down excess pesticides, therapeutics and nutrients from shrimp ponds and sediments from rivers which raise the estuary bed.

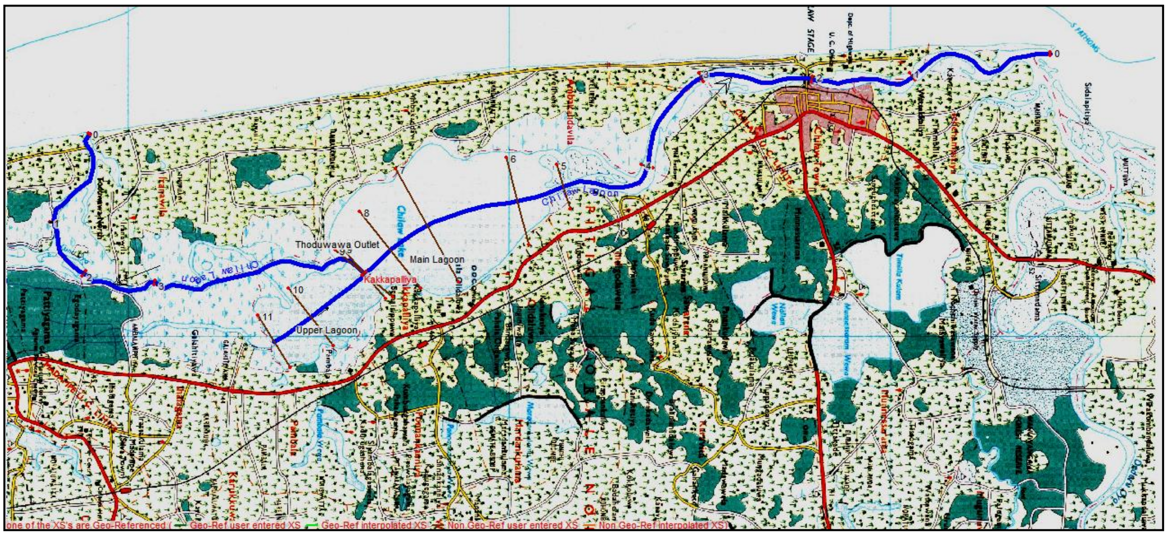
Hydrological Simulations to find solutions to the existing issues

10. In order to assess the catchment runoff of the lagoon, the HEC-HMS model was used with SCS curve number loss method and SCS unit hydrograph transform method. A five-hour design storm event was prepared using the balanced storm method. Rainfall intensities with two-year return period for the design storm wastaken from the Chilaw Intensity-Duration- Frequency curves given in Ranatunge, D.G.L. (2001).

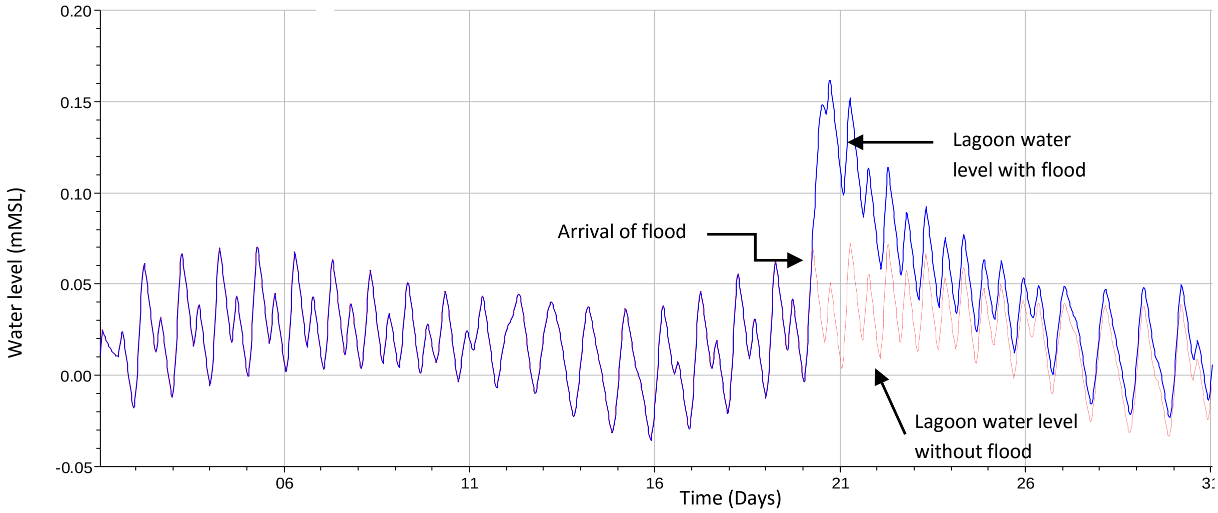
11. In order to represent the vast extents of flood retention areas in the catchment, a SCS curve number 40 was used. Figuregiven below shows the design storm event and the resulting catchment runoff hydrograph.



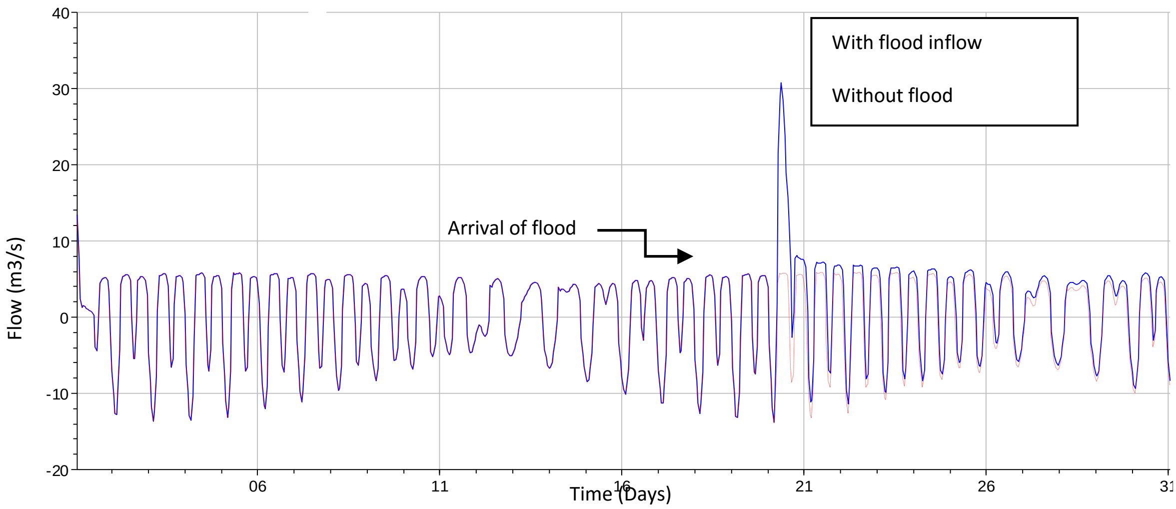
12. Impact to the lagoon due to flood inflow was analyzed using HEC-RAS software. Chilaw lagoon with its two outlet channels were modeled using a set of lagoon and channel cross sections extracted from topographic and bathymetric data available in the literature. Set up of the model network is shown in the map below.



13. The Model test was carried out to verify how the flood inflow canbe absorbed by the lagoon and to see whether a storm event with two-year return period can effectively flush out the lagoon and its outlets. Freshwater inflow due to the storm event with a two-year return period is about one million cubic meters.



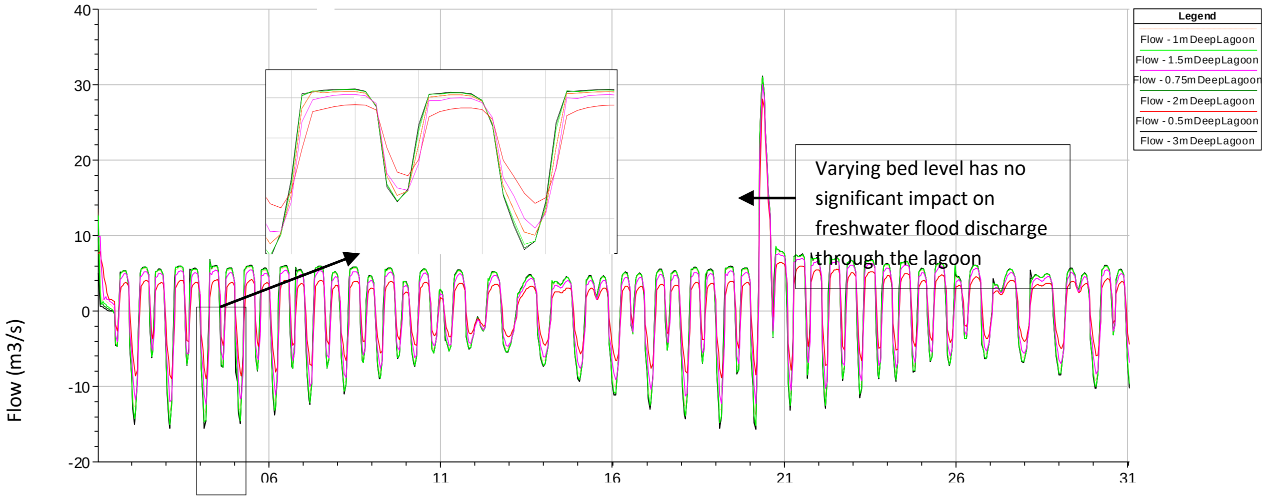
14. As shown in the Figure below, the arrival of catchment runoff raises the water levels by about 0.1m above the tide dominated lagoon water level. Also, it takes about 3 days to drain out the flood water due to a 5 hour storm event. Flood discharge is about 5 times the tidal out flow rate. During the spring ebb tide, sea water outflow rate is about 6 m^3/s and lasts for about 6 hours whereas during flood tide, peak inflow rate is about 12 m^3/s and lastsfor about 6 hours during which inflow rates exceed 5 m^3/s. It shows that a storm event with 2-year return period can effectively flush out the lagoon.



15. In order to investigate the consequences of reducing lagoon water level on the water exchange of lagoon, model tests were carried out for several average lagoon depths. Figure below shows how the water flow rates at the center of the lagoon vary when the average lagoon bed levels are at -3 m, -2 m, -1.5 m, -1 m, -0.75 m and -0.5 m on the mean sea level.

16. The bed level reduction is not significantly sensitive to water exchange until it reaches about -1 m MSL. At bed levels of -3 mMSL and -2 mMSL, the tidal exchange flow rates are almost the same. However, the flow rate reduction starts when the bed level reduces to about -1 mMSL and it worsens with further reduction of lagoon water depths. Average lagoon bed levels at present are around -1 mMSL and the lagoon fishermen are experiencing changes. As shown in the inset of the Figure below, beyond -1 mMSL, any further reduction in water depths will intensify the reduction of water exchange of

the lagoon and that will lead to deterioration of the water quality beyond irrecoverable levels.



17. Maximum flow rates during ebb and flood tides at spring and neap tide conditions are listed in the Table below.During a spring flood tide, seawater inflow rate at the central parts of lagoon (highest seawater inflow rate during a two-week tidal cycle) when the average depth reduces to 0.5 m is almost half that occurs when the depth is 1 m.

Average lagoon depth	Spring tide period		Neap tide period	
	Flood tide (m^3/s)	Ebb Tide (m^3/s)	Flood tide (m^3/s)	Ebb Tide (m^3/s)
3 m	15.0	6.0	5.4	4.7
2 m	15.0	6.0	5.4	4.7
1.5 m	14.5	6.0	5.1	4.7
1 m	13.1	5.8	5.1	4.6
0.75 m	11.6	5.4	4.6	4.3
0.5 m	8.7	4.1	3.4	3.3

Structural interventions that are needed to improve the present condition of the lagoon

18. In order to arrest the continuing reduction of tidal water exchange in the lagoon, either the lagoon water depth has be increased or some improvements should be done at the two outlets to keep them open. This will improve the water exchange patterns to and from the lagoon, thereby eliminating undesirable conditions that are a consequence of water stagnation (or poor water exchanges).

19. Dredging to deepen the lagoon may cause the whole lagoon ecosystem to change, especially if the lower mud layers with toxic (or objectionable)matter are disturbed or exposed. Few test samples analyzed during the present study

indicated thatthese mud layers contained toxic substances present in it.Therefore, a comprehensive soil quality investigation for toxic substances should be conducted covering the whole lagoon for a depth at least 3m below the present lagoon bed level. For the locations with favorable under layers, dredging (or desilting) can be done for about 2m below the bed level. This will certainly improve the tidal exchange volumes and therebyimproving the lagoon water quality.

20. There isa large amount of sand in this shoreline which is in a dynamic state of equilibrium. Millions of cubic meters of sand move seasonally across these outlets. Several attempts to keep the Thoduwawa outlet open by constructing a groyne and dredging the sand at the outlet did not result in a long lasting solution. At present, it is a completely closed outlet most of the time. At Thuduwawa outlet the net sand movement is from South to North direction. Therefore, the groyne constructed on the Right bank (South side) of the outlet, traps the sand and bypasses it once filled up to its off-shoreward end. If there is an arrangement to bypass the sand to the left bank (North side),this groyne can effectively delay the outlet closure. Daily volume of sand that needs to be bypassed can be determined only after comprehensive sediment transport study is conducted based on sediment transport measurements. Sand pumping and transport by trucks are possible methods to be adopted. However, this process is costly and may not be financially justified.

21. Northern outlet is in opened position throughout the year though it is very shallow in dry periods. Due to the undefined outlet position and the vast amount of sand at site, no simple structural arrangement can be proposed to improve the conditions at this outlet. However, if the lagoon is deepened, the tidal water exchange volumes will be increased resulting in increased flow velocities at the outlet. This will certainly help to flush out some sand and deepen the outlet.

Improving the lagoon water quality

22. The lagoon can be effectively flushed out by a storm event with a 2-year return period. However, lagoon water circulation due to tidal water exchange is not going to be effective when the average water depth reduces to less than 1 m.

23. Therefore, precautions should be taken to stop the sediments flowing into the lagoon. Preventing pond washouts coming into the lagoon, installing sediment traps at locations where high sediment inflow rates are unavoidable should also be considered.Effective control of sediment accumulation in the lagoon will help to avoid deterioration of lagoon ecosystem due to poor water quality.

Structural interventions proposed

24. There are no financially viable long lasting structural measures that can be adopted at the outlets to help sustain the lagoon ecosystem. Only structural intervention possible will be the construction of sediment traps at locations where sediment inflow rates are high. However, a thorough study on sedimentation

(including sources of sediments, modes of transport, locations and quantities of inflow) should be done before deciding to plan sediment traps. Re-establishment of the groyne at Thoduwawa outlet can also be done to keep it open but the associated sand bypassing will be a costly operation.

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