



# Pre-Feasibility Study support for Waterways Rehabilitation and Solid Waste Management in Chennai

## Part I: Waterways Rehabilitation

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June 2011  
Executive Summary

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## A. Background

1. The prime objective of this project support was to carry out Pre-Feasibility Studies (PFS) to prepare investment plans for infrastructure projects for the sectors of waterways and solid waste in Chennai for potential funding.

2. The Chennai Waterways Rehabilitation Project has been developed to project pre-feasibility level. The investment package is likely to be financed by a combination of international and national financing in accordance with the applicable infrastructure financing formula. The pre-feasibility work for this project is therefore envisaged to establish the prima facie case to take this project to feasibility level under standard arrangements with a financing institution. This pre-feasibility study report therefore adheres to a standard acceptable to national and international financing institutions, with particular reference to requirements for possible ADB or KfW financing, including flagging potential issues requiring in-depth review in accordance with the various ADB/KfW safeguards guidelines at the subsequent Feasibility Study stage.

## B. Study Area for Waterways

3. Chennai Metropolitan Area (CMA), comprising Chennai Municipal Corporation (CMC), 16 Municipalities, 20 Town Panchayats and 10 Village Panchayat Unions forms the study area. While the city with Chennai Municipal Corporation (CMC) boundaries covers an area of 174 km<sup>2</sup>, the metropolitan area is spread over 1,189 km<sup>2</sup>.

4. The study area, the CMA basin lies in the tropical monsoon zone. Chennai's climate is characterised by 2 major seasons –monsoon (southwest monsoon and north monsoon) and non monsoon. Though Chennai receives rainfall in both the seasons and it receives most of it during northeast monsoon that spans from October to December. But, the non-monsoon period is dry and receives almost insignificant rainfall.

5. The Study area, Chennai Metropolitan Area (CMA) is drained by 3 east flowing rivers–Kosasthalayar (also called as Koratalayar), Cooum and Adayar between its north and south borders. After meandering through the city, the rivers finally flow into the Bay of Bengal. A major canal, namely, Buckingham Canal traverses parallel to the coast and has considerable importance in shaping up the water environment of this city.

## C. Existing Situation

6. The condition of waterways in Chennai urban environs was reasonably healthy and pollution free till middle of the last century. But, the current condition of these waterways is highly deplorable on account of severe pollution and reduced carrying capacities. This can be attributed to cumulative effects of more than a century of settlement and land use, and the resultant urban pressures on the waterways.

7. The river **Cooum** is relatively free from point source pollution in its initial reaches before it enters the Chennai Metropolitan Area. In the CMA beyond Corporation area, municipalities and town panchayats that lie on either side of the river discharge wastewater either directly or by feeder drains into water bodies. The wastewater discharged into water bodies may spill over into the river, especially during rainy days in diluted condition. In the Chennai Municipal Corporation area which is densely populated both treated and untreated sewage is let out into rivers from various outfalls in its 17.98 km length. Currently, untreated sewage is observed to be let-out from around 109 sewage outflow points into the river.

8. Similarly, the river **Adyar** is also relatively free from contamination in the reaches outside the CMA boundary. Though this river is much smaller in its total length compared to other rivers and originates not so far away from Chennai, it carries very high load of pollutants on account of its convoluted path in the CMA area resulting from discharge of sewage from many a ULBs along its course. This condition is further aggravated severely in the CoC (Corporation of Chennai) area as it passes through densely populated areas wherein both treated and untreated sewage is discharged without any hindrance in to the river. In the city, about 70 sewage outflow points are observed in its entire stretch of 14.6 km. These outfalls include overflow from both sewers and the slums situated on the banks. Pollution levels in the rivers are shown in the figures above.

9. Though the length of river **Kosasthalayar** is 155 km it traverses for a relatively short distance in the CMA. This river joins Ennore estuary which is highly polluted by the industrial effluent in addition to domestic sewage from some of the urban local bodies along its course. This river at its tail end is prone to frequent floods. The floods in the river outflank the banks and inundate surrounding villages.

10. **Buckingham Canal** traverses from north to south parallel to coast and receives polluted waters both directly from the major rivers as well as from major and minor drains along its course. This highly polluted canal also passes through the populated areas in several reaches in the city.

11. The slopes of riverbeds of the waterways traversing Chennai are very flat as normally is the case with the rivers in its lower reaches before joining an estuary or sea. In addition, every year during north-east monsoon the rivers carry sediment laden waters which deposit considerable quantities in its course with in CMA, especially in the city limits. The sediments apart from sand and silt also contain various toxic substances including heavy metals. Sediment deposition in the rivers compounds the problem of free flow of sewage causing stagnation leading to formation of cess pools with in the river bed. Due to this, river waters in non-monsoon period, for over 10 months in a year, exhibit water quality parameters such as

12. BOD, COD, TSS, coli form bacteria and heavy metals in excess of permissible limits.

13. In addition, waterways are encroached at many places constricting the width of the rivers to carry high flood waters without overtopping their banks and embankments and entering into inhabited areas. Dumping of solid waste and construction debris either directly into the rivers or in their feeders is also a major reasons for not only for obstructing free flow of flood waters but also of leachate entering into the system. Bridges and causeways with insufficient vent to carry flood waters causes afflux at many a place in the river courses and inundate iadjacent areas during high flood conditions.

14. These waterways can be rated very poor as a result of high loads of sediment and nutrients, high turbidity, highly prohibitive odours and very low levels of dissolved oxygen. Apart from this, ability to discharge flood waters during high floods without inundation and carry low flows to meet environmental needs without stagnation is also uncertain for the reasons cited above.

15. The river mouths have a strong influence on the river flows at least in the estuary portions where transactions between tidal flows and river waters take place. In Chennai, owing to several reasons including both natural coastal processes and those influenced by man-made interventions, the size and permanence of the river mouths opening are adversely affected due to formation of sand bars. Mouths of the rivers Cooum and Adyar are sufficiently open for only a few months in a year. For rest of the period, they are either closed or have very narrow openings obstructing free flow of river waters into the Bay of Bengal. This results in stagnation of polluted waters in the rivers for several kilometres distance from

the mouths, in the densely populated areas. Therefore, in Chennai, the condition of river mouths significantly modify urban environment affecting a large number of people adversely.

### **Institutional Setting**

16. There are several ministries and organisations involved at the national and state level in decision making, administration, funding and delivery of the services in the water sector involving waterways issues. Some of them are directly involved in planning, execution, operation & maintenance and monitoring of waterways while others influence either positively or adversely in efficient function of waterways.

17. In Chennai, CMDA (Chennai Metropolitan Development Authority) is the agency responsible for preparing master plans, annual plans and city development plans apart from surveys and various other functions as the government entrusts it with. Infrastructure planning, implementation and operation in Chennai rest with various agencies CMC (Chennai Municipal Corporation, PWD (Public Works Department), CMWSSB (Chennai Metropolitan Water Supply and Sewerage Board), TNPCB (Tamil Nadu Pollution Control Board) for sectors Storm Water Drainage and SWM, Waterways, Water Supply & Sewerage and Pollution Control respectively.

### **D. Efforts to Improve Waterways & Water Environment**

18. To clean up the waterways and improve the sections of the rivers many projects had been contemplated and some of them were implemented in the last 4 or 5 decades.

#### **Efforts -Major Waterways**

##### Cooum River

19. Groyne arrangements at Cooum river mouth: As suggested by National Institute of Ocean Technology (NIOT) the north and south groynes are extended by 140 m and 170 m respectively with their top at + 4.5 m above MSL. This has facilitated sustained opening of river mouth between 20 and 50m all round the year.

##### Adyar River

20. In one of the reaches, a project to remove silt from the bed and formation of banks under Chennai city waterways projects is in progress. Recently, two check dams, one at Nandambakkam and the other at Manapakkam have been completed. Excavation of a surplus course from Chembarambakkam tank to Thiruneermalai Junction at Adyar to convey surplus waters during floods from Chembarambakkam Tank is also in progress. This project includes bridges and other cross drainage works.

##### Kosasthalayar River

21. There are no ongoing projects as the works contemplated under the Chennai City River Conservation Project have been completed.

##### Buckingham Canal

22. Currently, no works are being undertaken for the Buckingham canal. But in the north Buckingham canal watershed, excavation of surplus courses of Ambattur, Korattur, Madhavaram and Red hills tanks are in final stages. Legal issues in land acquisition for the surplus course in some of the reaches have caused delays in the execution. In the south Buckingham canal watershed Pallavaram Tank, Velacheri, Perungudi tanks have been taken up for rehabilitation & improvement works.

### Efforts–Micro and Macro Drainage

23. Recently, the Corporation of Chennai jointly with the Public Works Department contemplated a set of projects for improving micro and macro drainage systems at a cost of Rs. 1,448 Crores under JnNURM programme. These projects have been grouped into 4 packages as Northern, Central, Eastern, and Southern basins of Chennai Corporation Area. The projects are formulated essentially to address the issues of Chennai Corporation Area for the problems identified in the City Development Plan and Second Master Plan. The projects consist of rehabilitation works for major and micro natural and man made drains, desilting drains, construction of new stormwater drains and cross drainage works. The process of implementation has been commenced recently for the first phase of works. The projects are currently under implementation with the commencement of 1st phase of projects.

### Efforts–Sewage and Sanitation

24. The Chennai City River Conservation Project (CCRCP) was formulated with an integrated approach to address the pollution and hydraulic problems of the rivers. This project envisaged projects –Interception works, Augmentation of pumping capacity, Sewage treatment facilities, Stormwater drainage works, desilting of rivers, removal of sand bars, rehabilitation and resettlement of slum dwellers. Project was implemented jointly by CMWSSB, PWD, CoC, and TNSCB. The CMDA has monitored and managed the project. Though the project was completed, the desired results could not be realised and hence the CMWSSB has again implementing many additional works to strengthen the existing sewerage system by capacity augmentation and plugging the sewage outfalls into waterways in a phased manner. In case of ULBs the implementation of organized sewerage system with treatment facilities is at various stages. Municipalities like Alandur, Ambattur are at advanced stage while many others lagging.

### E. Need for Waterways Rehabilitation

25. Various issues have been identified that are currently plaguing Chennai waterways. Efforts made to address these issues by taking up a range of projects in the sectors of water & wastewater management and storm water & waterways management are also discussed briefly. However, for a variety of reasons, the pace of efforts made in this direction did not meet the pace of urbanization, leaving the problems to persist still. This is mainly due to growth of population. Chennai, like any other major metropolitan city in India is very dynamic in its growth –population, urban sprawl, economy, etc.

26. In case of wastewater management, efforts are being made in arresting flow of sewage into drains, rehabilitation of old sewers, introducing sewer systems to new areas like ULBs, and augmentation and addition of new treatment capacity. But, the process of implementation is gradual and hence to arrest completely any inflow of sewage into waterways, as explained earlier, is expected to take many years. Similarly, new initiatives have been taken up for stormwater and waterways improvement in the corporation area excluding major rivers. Despite taking up various measures the problem of arresting wastewater entering waterways and mitigation of floods and inundation owing to insufficient carrying capacities would persist for a long time in the future. Considering the above mentioned on-going initiatives and identified gaps a number of projects have been identified.

27. **Justification** for waterways rehabilitation is as follows:

- 27.1. to free Chennai from diseases caused due to pollution of waterways and stagnation of water and sewage in the waterways and its surrounding areas;
- 27.2. to flush pollutant load from waterways;
- 27.3. to mitigate problems of inundation due to inadequate function of waterways;
- 27.4. to improve aesthetics of the water environs –vision, smell and other tangible impressions;
- 27.5. to improve ecology of the surrounding areas –to provide habitat for flora and fauna, to provide people proximity to nature;
- 27.6. to improve social functions –people enjoy meeting near water bodies, religious rituals;
- 27.7. to attract tourists; and
- 27.8. to make economy vibrant (indirectly);

28. The costs resulting from not increasing the efforts to protect and improve waterways beyond those currently being undertaken, including immediate costs (e.g. likely impact on various industries and higher public health risks) and future costs (on account of worsening situation) are likely to be substantial and unacceptable.

## **F. Waterways Rehabilitation - Strategies and Design Options**

### **Rationale for Identification of Waterways Rehabilitation Measures**

29. A number of problems have been identified that are causing to deteriorate quality of water in the waterways and efficient function of waterways that they are intended to. The rationale on broad basis for identification of projects to address the problems and their impacts is as follows:

- 29.1. give maximum environmental benefits;
- 29.2. reduce city's ecological foot print;
- 29.3. contribute to mitigation and adaptive measures to climate change; and
- 29.4. maximally benefit the poorer sections;

30. The rationale for project identification when described in specific terms:

- 30.1. minimise pollution in the waterways;
- 30.2. address flood and inundation problems;
- 30.3. address the current urban development constraints;
- 30.4. address the constraints imposed by the future urban growth;
- 30.5. mitigate/ eradicate mosquito menace;
- 30.6. improve overall aquatic and biotic environment; and
- 30.7. address the problems in holistic manner on integrated water management principles;

### **Strategy for Rehabilitation of Waterways**

31. The adopted Strategy for Waterways Rehabilitation is to prepare an integrated set of actions that all the stakeholders should be committed to implement in parallel to achieve better results in timely manner. The strategy intends to achieve pollution free and environmentally benign waterways that would lead to overall improvement of environment in the Chennai Metropolitan area:

#### Primarily

- 31.1. by improving flushing capacity of waterways to discharge pollutants into the sea; and
- 31.2. by improving the carrying capacity of the waterways to convey flows during high floods and low flow period.

And sustained

- 31.3. by reducing point source pollution caused by sewage in the growth corridors along waterways;
- 31.4. by improving overall environment and reducing non-point source pollution from storm water; and
- 31.5. by reducing non-point source pollution caused by solid waste.

32. In order to rehabilitate waterways in a timely manner and achieve better results on sustainable basis, the strategy devised above comprising engineering solutions also integrates into the study the following:

- 32.1. social aspects;
- 32.2. economical aspects;
- 32.3. financial aspects; and
- 32.4. institutional aspects.

**Clustering of Projects**

33. Based on integrated water management principles and as the ToR calls for adopting water and wastewater catchment concepts to identify and rank projects for the alleviating problems in the study area, CMA, comprising CMC and ULBs has been divided into 4 catchments:

- 33.1. Cooum river catchment;
- 33.2. Adyar river catchment;
- 33.3. Kosasthalayar river catchment; and
- 33.4. Buckingham canal catchment.

34. And accordingly, projects for these rivers are clustered and presented as investment packages:

**(A) Cooum River Rehabilitation Project**

35. To alleviate the problems caused by the current deteriorated condition of waterways and to meet the impending pressures from the future growth, various solutions have been envisaged. The environmentally benign solutions are arrived at after studying the processes –coastal, hydrological, hydraulics and environmental. Besides, urban development constraints imposed by other sectors and socio-economic issues arising out of developmental projects have also been integrated into the study.

36. To identify the projects the total length of the river meandering in the study area for over 41 km has been divided into 4 reaches. The division is made based on several factors like possibility for flushing by tidal action, severity of sludge and waste deposition, gradient, extent of urbanization along the river and other specific characteristics that are similar in each reach.

Cooum Reach	Name of Reach	Length of Reach
CR-1	Coastal Reach	0.0 – 6.4 km
CR-2	Central City Reach	6.4 – 9.3 km
CR-3	Outer City Reach	9.3 – 20.0 km
CR-4	CMA Reach	20.0 – 41.0 km

37. Options explored to flush dry weather flows (treated and untreated sewage entering the river ways):

- 37.1. by creating fresh water storage to flush the pollutant loads in the river;
- 37.2. by providing gradient to the river bed and drain the polluted waters by gravity;
- 37.3. by deepening the river bed in the coastal reaches to flush the polluted river waters making use of possible tidal transactions;
- 37.4. by maintaining minimum flows in the river and flush the dry weather flows; and
- 37.5. by exploring the possibility of utilising the reservoir waters meant for other purposes for flushing;
- 37.6. Surface aeration at existing pollution 'hot spots' in the rivers.

38. Options explored to address the flood and inundation issues:

- 38.1. by deepening the river bed;
- 38.2. by widening/ restoring the river bed;
- 38.3. by diverting flood flows partly into new or existing channels;
- 38.4. by streamlining the river in the bends;
- 38.5. by removing the obstructions in the river bed;
- 38.6. by strengthening the bunds;
- 38.7. by raising the bunds;
- 38.8. by providing flood protection walls;
- 38.9. by removing encroachments on the banks; and
- 38.10. by incorporating possible impacts from the climate change;

39. Options explored to carry low flows on account of low intense rainfalls and dry weather flows (sewage and wastewater):

- 39.1. by providing cunette section in the river bed; and
- 39.2. by providing transverse slope.

40. Options explored for viability of the projects:

- 40.1. with river front; and
- 40.2. without river front.

41. In the river front option, sturdier bank protection measures will be proposed to take additional civil and other structural loads in the case any infrastructure is planned along the waterway on either side.

42. In the option "without river front", the banks are protected with bunds but will be rehabilitated by strengthening and raising the bund height.

43. The following measures are proposed either as stand alone or in combination:

#### **Proposals for Coastal Reach – CR1 (0.0 – 6.4 km)**

- River Mouth
- Earth work excavation for 500m length in the mouth by dredging up to - 2.4m level and conveying the dredged material from mouth to far inside the sea;
- Dredging of the sand deposited on the south side of the groyne to a depth of -1.5 meters for 200 meters;
- Dismantle of the old double vented regulator located at north flank of the mouth up to below -2.5 meters;
- Bank protection for the stretch 0.0 to 0.5 km -0.75 meters thick rubble gabion packing on slopes on both sides;
- Maintenance dredging to maintain the tidal prism;

- River reach
- Earth work excavation by machinery for 2m depth from 0.5 km to 6.4 km plus north arm of 2.0 km (dredging only);
- Buttress type RCC Retaining walls of 40cm thick 6m height (-2m below MSL and 4 m above MSL) with buttresses at 3.0 m centre to centre and 4m wide bottom slab;
- Precast RCC sheet piles of 20 cm thick and 3 m deep (from -2.0 to -5.0 m) preferably up to dense sand or medium stiff clay with inter locking grooves, shoes, etc;
- Increase height of the bunds to +3.5 m;
- Cutting apron or any protection in the river bed up to -2.0m without affecting stability of bridges, besides providing additional vent wherever feasible and necessary.
- Lay WBM road on south side or north side bund; and
- Dewatering wherever necessary.

**Proposals for Central City Reach –CR2 (6.4 – 9.4 km)**

- Earth work excavation by machinery to provide gradient to the river bed and bed levels -2m below MSL at 6.4 km to 0m at 9.4 km;
- Bank protection:
- At 6.4 Km: Buttress type RCC Retaining walls of 40cm thick 6m height (2m below MSL and 4 m above MSL) with buttresses at 3.0 m centre to centre and 4m wide bottom slab on either sides;
- At 6.4 Km: Precast RCC sheet piles of 20 cm thick and 3 m deep (from -2.0 to -5.0 m) preferably up to dense sand or medium stiff clay with inter locking grooves, shoes, etc;
- At 9.4 Km: Buttress type RCC Retaining walls of 40cm thick 4m height (0.5m below MSL and 3.5 m above MSL) with buttresses at 3.0 m centre to centre and 3m wide bottom slab on either sides;
- At 9.4 km: Precast RCC sheet piles of 20 cm thick and 2 m deep (from -0.5 to -2.5 m) preferably up to dense sand or medium stiff clay; and
- Increase height of the bunds to +3.5 m.
- Increase the height of bunds by 1 meter.
- Lay WBM road on either south side bund or north side bund; and
- Dewatering wherever necessary;

**Proposals for Outer City Reach –CR3 (9.4 – 20.0 km)**

- Earth work excavation by machinery to provide gradient to the river bed and bed levels -0.0 at 9.4km to 10m above MSL at 20.0km;
- Provide cunette section of 3 meter wide and 2 meter deep in the river bed;
- Provide transverse slope to the river bed;
- Bank protection using pre-cast concrete blocks of size 50x50x10cm over 15 cm thick gravel backing; and
- Provide 60cm x 60cm toe wall over doubly reinforced RCC M20 precast sheet piles of 20 cm thick and 3 m deep with adequate inter locking grooves and shoes.

**Proposals for CMA Reach –CR4 (20 – 40.9 km)**

- Earth work excavation by machineries to provide gradient to the river bed and maintain bed levels
- 10m above MSL at 20km to 29m above MSL at 40.9km;
- Provide cunette section of 2 to 1 meter wide and 1 meter deep in the river bed;
  - Provide transverse slope to the river bed;
  - Form bunds on either side at 1.5:1 side slopes with model sections at every 500 meters; and
  - Provide inspection track on one of the bunds.

**Ancillary Works that are**

**common to all the reaches**

- Removal of existing structures in the river bed with provision for conveyance within 5 km.
- Excavate sides of river for maintaining uniform width;
- Provision of barricades near bridges to prevent people from dumping solid waste.
- Collection and Conveyance of sewage /minor inflow entering the river directly to the downstream of river by pumping through pipeline during construction;
- Approach roads for entering into the river bed;
- Preparation of sludge disposal site with special protection during conveyance of sludge;
- Barges and sludge drying pans for works in open river bed conditions;
- Miscellaneous works like site office, turfing, etc.

**Proposals for Cooum Catchment Improvement**

- Rehabilitation of old check dams and anicuts;
- Construction of Soranjeri check dam;
- Rehabilitation of Korattur anicut; and
- Strengthening and augmenting capacity of storage tanks.

**Cost Estimate**

**The total cost estimate of the Cooum River investment package:  
INR 400 Crores (USD \$ 81.66 millions)**

44. Although the issues are addressed at reach level, it is necessary to implement the selected priority projects in all the reaches of the river till 41 km from the river mouth. The four zones of the river can be strategically rehabilitated and developed as follows.

**(B) Adyar River Rehabilitation Project**

45. The river Adyar has been divided into three reaches for identification of projects. The division is made, as explained earlier for Cooum, based on a host of factors like possibility for flushing by tidal action, severity of sludge and waste deposition, gradient, urbanization along the river and other specific characteristics that are common to each reach.

46. The following measures are proposed either as stand alone or in combination:

**Proposals for Coastal Reach – AR1 (0.0 – 4.2 km)**

River Mouth (0.0-0.5 km)

- Initial Dredging for 2.5 million cubic meters in the mouth to clear sand bars to create 400 x 2 m tidal prism and conveying sediments from the mouth to far into the sea;
- Earth work excavation/ dredging by machineries for 2m depth below mean sea level from 0.0 km to 0.5 km;
- Bank protection for the stretch 0.0 to 0.5 km -0.75 meters thick rubble gabion packing on slopes on both sides;
- Maintenance dredging to maintain the tidal prism;

**River Reach (0.5 - 4.2 km)**

Option-1 without river front

- Earth work excavation by machinery to a depth of 2m below MSL from 0.5 km to 4.2 km;

- Bank protection Construction of Rubble gabion packing on slopes on both sides;
- Bank protection using pre-cast concrete blocks over 1.5:1 slope bunds -Precast concrete slabs of 50x50x10cm;
- Toe walls of 60x60cm thick over 3m deep sheet piles on 60cm wide base concrete;
- Increase height of the bunds to +3.5 m;

Option-2 with river front

- Earth work excavation by machinery to a depth of 2m below MSL from 0.5 km to 4.2 km;
- Buttress type RCC Retaining walls of 40cm thick 6m height (2.5m below MSL and 3.5 m above MSL) with buttresses at 3.0 m centre to centre and 4m wide bottom slab;
- Precast RCC sheet piles of 3 m deep (from -2.0 to -5.0 m) preferably up to dense sand or medium stiff clay with inter locking grooves, shoes, etc;
- Increase height of the bunds to +3.5 m;

**Proposals for Central City Reach – AR2 (4.2 – 12.2 km)**

Option-1 without river front (4.2 – 12.2 km)

- Earth work excavation by machineries to provide gradient to the river bed and bed levels -2m below MSL at 4.2km to 0.5m above MSL at 7km;
- Provide cunette section of 3 meter wide and 1 meter deep in the middle of the river;
- Provide transverse slope to the river bed;
- Bank protection using pre-cast concrete blocks of size 50x50x10cm over 15 cm thick gravel backing;
- Provide 60cm x 60cm toe wall over sheet piles of 3 m deep and 20cm thick with 20 cm thick doubly reinforced RCC M20 with adequate inter locking grooves and shoes; and
- Increase height of the bunds to +3.5 m.

Option-2 with river front (4.2 – 7.0 km)

- Earth work excavation by machineries to provide gradient to the river bed and maintain bed levels -2m below MSL at 4.2km to 0.5m above MSL at 7km;
- Provide cunette section of 3 meter wide and 1 meter deep in the river bed;
- Provide transverse slope to the river bed;
- Bank protection:
- At 4.2 Km: Buttress type RCC Retaining walls of 40cm thick 6m height (2m below MSL and 4 m above MSL) with buttresses at 3.0 m centre to centre and 4m wide bottom slab on either sides;
- At 4.2 Km: Precast RCC sheet piles of 20 cm thick and 3 m deep (from -2.0 to -5.0 m) preferably up to dense sand or medium stiff clay with inter locking grooves, shoes, etc;
- At 7.0 Km: Buttress type RCC Retaining walls of 40cm thick 4m height (0.5m below MSL and 3.5 m above MSL) with buttresses at 3.0 m centre to centre and 3m wide bottom slab on either sides;
- At 7.0 km: Precast RCC sheet piles of 20 cm thick and 2 m deep (from -0.5 to -2.5 m) preferably up to dense sand or medium stiff clay; and
- Increase height of the bunds to +3.5 m.

Option-2 with river front (7.0 – 12.2 km)

- Earth work excavation by machinery to provide gradient to the river bed and bed levels -0.5m below MSL at 7km to 2m above MSL at 12.2km;
- Provide cunette section of 3 meter wide and 1 meter deep in the river bed;

- Provide transverse slope to the river bed;
- Bank protection using pre-cast concrete blocks of size 50x50x10cm over 15 cm thick gravel backing; and
- Provide 60cm x 60cm toe wall over doubly reinforced RCC M20 precast sheet piles of 20 cm thick and 3 m deep with adequate inter locking grooves and shoes.

### **Proposals for Outer City Reach – AR3 (12.2 - 24 km)**

#### Option-1 without river front

- Provide cunette section of 2 to 1 meter wide and 0.5 to 1 meter deep in the river bed;
- Provide transverse slope to the river bed;
- Form bunds on either side at 1.5:1 side slopes with model sections at every 500 meters; and
- Provide inspection track on one of the bunds.

#### Option-2 with river front

- Provide cunette section of 2 to 1 meter wide and 0.5 to 1 meter deep in the river bed;
- Provide transverse slope to the river bed;
- Form bunds on either side at 1.5:1 side slopes with model sections at every 500 meters; and
- Provide inspection track on one of the bunds.

### **Ancillary Works common for all the reaches**

- Cutting apron or any protection in the river bed up to -2.0m without affecting stability of bridges; besides providing additional vent wherever feasible and necessary; and
- Removal of existing structures in the river bed with provision for conveyance within 5 km.
- Excavate sides of river for maintaining uniform width;
- Provision of barricades near bridges to prevent people from dumping solid waste.
- Collection and Conveyance of sewage /minor inflow entering the river directly to the downstream of river by pumping through pipeline during construction;
- Preparation of sludge disposal site with special protection during conveyance of sludge;
- Barges and sludge drying pans for works in open river bed conditions;
- Lay WBM road on south side or north side bund;
- Dewatering wherever necessary; and
- Miscellaneous works like site office, turfing, etc.

### **Proposals for Adyar Catchment Improvement**

- Rehabilitation of old check dams;
- Strengthening and augmenting storage for feeding tanks of Adyar at Pillaipakkam, Porur Manimangalam, Sriperumadhur and Nemam Tanks. and
- Construction of check dam at Thiruneermalai;

47. The total cost estimate of the Adyar River investment package is:

**Option I (without river front): INR 2,150,000,000 (INR 215 Crores/ USD 43.89 millions)**  
**Option II (with river front): INR 2,900,000,000 (INR 290 Crores/ USD 59.20 millions)**

48. Although the issues are addressed at reach level by proposing solutions that result in recommendation of projects or works for successful function of the river and to meet the

desired objectives, it is necessary to implement the selected priority projects in all the reaches of the river till the end, 24.7 km from the river mouth at the sea.

### **(C) Kosasthalayar Rehabilitation Project**

49. The short reach that the River Kosasthalayar is traversing with in the CMA has been proposed by several measures to address the problem of flooding and inundation.

50. The following measures are proposed:

#### **Proposals for Kosasthalayar rehabilitation**

##### Flood Banks

Raise flood bank to a height of +9.44 m against the existing top level of around +7 m for a length of 12.80 Km. The tank bund level is fixed 1.5 meters above the maximum flood level observed in the area, 7.94 m.

##### Bank Protection

Bund slopes are proposed 2:1 gradient to maintain the surface of the slope well above the phreatic line for maximum flood conditions.

##### Flood Protection Walls

Protection walls for the vulnerable reach near Edayanchavadi, Napalayam and Sadayan kuppam villages for a length of 1900 m are proposed to streamline the flood and route it to the tail end without inundating agriculture lands and villages on either sides from Napalayam Bridge up to sea mouth.

##### Regulators

Very high flood banks also prevent entry of run off from the out skirts of Minjur area draining into the estuary. Therefore, Regulators are proposed for drains joining the river.

The outlet structure near Edayanchavadi is proposed for letting out the run off from this portion of the estuary, after the flood level in the estuary recedes.

**The total cost estimate of the Kosasthalayar River Development investment package is INR 16 Crores (USD 3.26 millions).**

### **(D) Buckingham Canal Rehabilitation**

51. Recently, as mentioned earlier, the Ministry of Urban Development, Government of India has approved proposals for the Buckingham Canal as part of the Micro and Macro Drainage Improvement Programme for Chennai city. The Corporation of Chennai has initiated the process of implementing the 1st Phase of the projects.

Since the projects firmly planned under the JNNURM programme for this canal are quite comprehensive and meet the desired objectives of the current PFS for Waterways Rehabilitation, it is advised that no major proposals are required separately under the study and hence not recommended any new projects.

These proposals when implemented in tandem with the current PFS proposals recommended for the other waterways in the CMA would perfectly be integrated and improve the overall environment of the city and sub-urban areas and enhance the quality of life in Chennai.

## **G. Sanitation and Drainage**

52. The Chennai Metropolitan Water Supply and Sewerage Board is observed to have comprehensive plans and diligently implementing a number of projects in a phased manner that addresses the treatment requirements, plugging of leakages and replacement of old undersized and defunct sewers. However, it is advised to expedite the project execution so that the time lag between urban growth and wastewater infrastructure in place, could be minimised. So is the case with the ULBs in the CMA as the sewerage projects are at various stages of implementation.

53. Similarly, the CoC is implementing a major urban storm drainage project approved recently by the Ministry of Urban Development, Government of India under JNNURM programme. This programme is essentially to free the city from waterlogging conditions during monsoons caused by micro and macro drainage system inadequacies. Though urban drainage infrastructure is grossly insufficient barring a few ULBs, they are developing storm drainage systems and the projects are at various stages of implementation. It is advised to expedite implementation of urban drainage projects. No separate projects are suggested for this sector.

## **H. Financing Plan**

54. The following observations were made:

- 54.1. The PWD gets assistance from the budgetary support of the GoTN for developing projects and maintaining waterways;
- 54.2. Internal accruals of the major beneficiaries of the waterways projects, the CoC and the ULBs is not sufficient to meet the project cost;
- 54.3. Possible assumed external financing by:
  - 54.3.1. Tamil Nadu State: e.g. 15%
  - 54.3.2. National Government: e.g. 35%
  - 54.3.3. International Financing Institutions (IFIs): e.g. 30%
  - 54.3.4. Commercial Banks: e.g. 10%
  - 54.3.5. Private sector/PPP projects: e.g. 10%
- 54.4. Probably need to levy user charges to make the loans financially viable
- 54.5. Continuation of borrowing funds for infrastructure projects without considering the committed fund flow to repay the loan may not attain financial viability.

## **I. Economic Analysis of Proposed Investment Packages**

55. Economic analysis has been conducted for all the river projects/packages based on the following approach and elements:

- 55.1. Economic Cost includes capital cost and operational cost of the proposed investment schemes
- 55.2. Value of Economic Benefits
- 55.3. Cost-Benefit Assessment: based on the following economic assessment parameters:
  - 55.3.1. Economic Internal Rate of Return (EIRR)
  - 55.3.2. Net Present Value (NPV) at a discount rate of 10%
  - 55.3.3. Benefit/Cost Ratio (BCR) at a discount rate of 10%

56. Sensitivity analyses have been made of the cost-benefit assessment for the following scenarios:

- 56.1. Economic costs go up by 10%
- 56.2. Economic benefits down by 10%
- 56.3. Economic Costs up & Economic Benefits go down by 10%

57. The main results of the economic analyses for all the projects are:
- 57.1. Satisfactory EIRR (>10% discount rate, ranging from 20 to greater than 50) in all sensitivity scenarios, implying that the River Rehabilitation Projects are economically beneficial to the society including the poorer sections;
  - 57.2. BCR is more than one (>1, ranging from 1.45 to 2.12) in all sensitivity scenarios, hence these proposed packages are economically viable and sustainable.

## **J. Implementation Arrangement**

58. Implementation of the Waterways project will be followed in line with the standard ADB organizational structure for multi-sectoral projects i.e. by forming a Project Management Unit (PMU) and Project Implementation Unit (PIU). In addition, engagement of Project Management Consultant (PMC) and Design and Supervision Consultants (DSC) is required to support the project. CMDA will form the PMU for managing the project. A PIU will be formed for each River Rehabilitation Project. Representatives from the respective divisions of the WRD will be part of the PIU. DSCs will provide technical support to the PIUs whereas PMC will provide both technical and managerial support to the PMU for implementation of the project.

59. For the current institutional setting, Chennai Metropolitan Development Authority (CMDA) should be the Project Implementing Agency (PIA). In addition an “Apex Body” represented by all the major sectoral heads, both administrative and technical, would act as “Steering Committee” (SC) for the Waterways Rehabilitation Projects with a mandate mainly to review the financial and technical progress of the project and also decide on the major policy issues.

## **K. Project Prioritising and Implementation Plan**

### **Priority Setting**

60. The following broad based criteria have been framed to prioritise project clusters:
- 60.1. Environmental benefits (reduced ecological footprint, mitigation of climate change)
  - 60.2. Quality of life (environmental safety, mosquito control)
  - 60.3. Benefits to the poor
61. The priority setting for the identified rehabilitation projects has been done on basis of the following quantifiable subcriteria in successive order:
- 61.1. Selection of the river catchment cluster with the most environmental problems and the most affected population.
  - 61.2. Selection of clusters with the highest pollution reduction potential.
  - 61.3. Selection of clusters with the highest flooding reduction potential.
  - 61.4. Selection of alternative project packages with the highest benefit-cost ratio.

### **Evaluation of ranking**

62. From the environmental criteria 1 to 3 it is evident that the priority order of the investment packages is following:
- Priority 1 Cooum River Development package
  - Priority 2 Adyar River Development package
  - Priority 3 Kosasthalayar River Development package

63. However from financial-economic point of view the priority order of criterion 4 is different:

- Priority 1 Kosasthalayar River Development package
- Priority 2 Adyar River Development package - Option I
- Priority 3 Cooum River Development package
- Priority 4 Adyar River Development package - Option II

### Implementation Plan

64. The following Time Frame is proposed for Implementation of the Projects:

<b>Priority 1</b>	<b>Cooum River Development package</b>	<b>: 0 – 5 years</b>
<b>Priority 2</b>	<b>Adyar River Development package</b>	<b>: 6 – 10 years</b>
<b>Priority 3</b>	<b>Kosasthalayar River Development package</b>	<b>: 11 – 12.5 years</b>

### L. Social Aspects

65. For assessment of the social aspects a limited public opinion survey has been conducted as part of Pre-feasibility. In addition, outcome of the stakeholder workshops conducted has also been incorporated in the study. The major social issue arising out of the river rehabilitation projects from the surveys and workshops are the resettlement and rehabilitation of the poor living in the slums located in the encroached areas of the river banks. More than 15,000 families are living in the slums located on the banks of the rivers Cooum and Adyar with in the city. While in the CMA outside city, around 3,800 families are living on the river banks. In Tamil Nadu, TNSCB (Tamil Nadu Slum Clearance Board), a statutory body, has a mandate to rehabilitate slum population in the State. Currently, it is implementing several schemes and constructing shelters to relocate 36,000 slum dwellers uprooted by various developmental projects, including those affected by the MRTS (Metro Rail Transport Scheme) and living on the river banks. The major issue from the R& R programmes is the loss of livelihood as the slum dwellers are relocated to places far away from their earlier dwellings. Most of the people in the slums, depend for their livelihoods on the informal sector. Therefore, there is a need to rehabilitate and support livelihood programmes for the affected population from the waterways rehabilitation projects which is around 18,800 families.

66. The potential social impacts of the waterways projects have been assessed as follows.

#### Positive impacts:

- 66.1. Improved living environment
- 66.2. No risk of death due to floods
- 66.3. Less health hazards
- 66.4. New jobs possibilities in new areas and from the development of river banks.

#### Possible negative impacts:

- 66.5. Involuntary resettlement to make place for the rehabilitation projects
- 66.6. Loss of livelihood due to relocation from core city areas
- 66.7. Impacts on educational/social settings

#### Mitigating Measures and Social Safeguards:

- 66.8. Resettlement and compensation schemes (RAP)
- 66.9. Livelihood support, and other social development support for the affected families
- 66.10. Skill development programmes for as part of livelihood support;
- 66.11. Subsidized transport facilities from the relocated settlements to central city
- 66.12. Comprehensive Social Impact Assessment (SIA) need to be carried out in subsequent Feasibility Study stage

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## Stakeholder Consultation

67. River Rehabilitation Projects have been formulated with strong stakeholder participation at various levels. The project team has participated in the consultation programmes conducted by the CDP review team as resource persons for the functional areas concerned with the water and related environmental sectors. Concerns of the public, mostly local in nature, are incorporated into the studies. Engineers and other specialists from various departments are consulted several times during the course of study to understand the issues more clearly and integrate their views while arriving at solutions to the problems. Finally, the fully developed projects for the waterways rehabilitation are presented in the workshop conducted on 16th September, 2009 to various stakeholders –public, NGOs, Government Agencies. No major issues have been raised barring proper implementation of livelihood programmes.

### M. Environmental Aspects

68. A brief environmental assessment has been carried out for the proposed river rehabilitation projects. The following major environmental benefits are envisaged:

- 68.1. Less pollution in waterways;
- 68.2. Improvement in groundwater quality;
- 68.3. Less inundation in the developed areas -residential, commercial and industrial areas ;
- 68.4. Reduction in damages or loss of property or valuables;
- 68.5. Mitigation of Mosquito Menace;
- 68.6. Improvement in public health;
- 68.7. Improvement to fish life;
- 68.8. New recreational avenues; and
- 68.9. Overall improvement of environment;

69. The following major issues have been identified:

- 69.1. Ground water pollution caused by sea water ingress into the aquifers as sea water is allowed to enter into the river to flush pollutant load by tidal action;
- 69.2. Existing bio-diversity in the estuaries may be disturbed;

### N. Further Studies

70. The following studies are recommended:

- 70.1. Coastal, Hydrologic and Hydraulic Simulation for Detailed Assessment of the Proposed Projects;
- 70.2. Modelling Sea Water Intrusion in to the Aquifers;
- 70.3. Preparation of Detailed Structural Designs based on primary data;
- 70.4. Study on Operation and Maintenance in case “river front” option is chosen.
- 70.5. Waterways rehabilitation with the objective of infrastructure development needs a comprehensive Environmental Management and Monitoring Plan.
- 70.6. Potential environmental impacts and proposed mitigation measures in the pre-construction/construction phase, and operation phase of the various proposed projects will have to be detailed and worked out in the subsequent phase of project development;
- 70.7. Comprehensive Environmental Impact Assessment (EIA) needs to be carried out in subsequent Feasibility Study stage for Environmental Safeguarding.
- 70.8. Capacity Building Programme on integrated watermanagement aspects for all those involved in the project implemenetation and management.



# Pre-Feasibility Study support for Waterways Rehabilitation and Solid Waste Management in Chennai

## Part II: Solid Waste Management

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June 2011  
Executive Summary

Prepared by DHV B.V. Netherlands in association with DHV India Pvt. Ltd.



**A. Background**

1. The prime objective of this project support was to carry out Pre-Feasibility Studies (PFS) to prepare investment plans for infrastructure projects for the sectors of waterways and solid waste in Chennai for potential funding. The JnNURM mechanism forms the fundamental framework for potential funding for the projects identified.

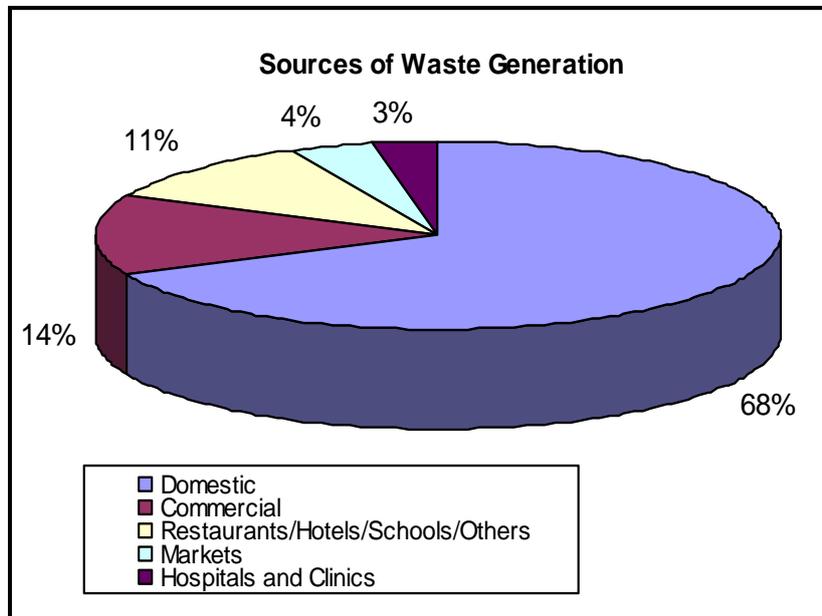
2. The Chennai Waterways Improvement Project has been developed to project pre-feasibility level. The integrated implementation package is likely to be financed by a combination of international and national financing in accordance with the applicable JNNURM infrastructure financing formula. The pre-feasibility work for this project is therefore envisaged to establish the prima facie case to take this project to feasibility level under standard arrangements with a financing institution. This pre-feasibility study report therefore adheres to a standard acceptable to national and international financing institutions, with particular reference to requirements for possible ADB or KfW financing, including flagging potential issues requiring in-depth review in accordance with the various ADB/KfW safeguards guidelines at the subsequent Feasibility Study stage.

**B. Existing Situation**

**Corporation of Chennai (COC)**

Generation of Waste

3. As per the estimates of CDP, 2006, the waste generated in the city is about 3,200 tonnes per day. In addition, the COC has to handle about 500 tonnes of debris (construction & demolition waste) per day, adding up to 1,350,500 tonnes per year. The municipal solid waste (MSW) originates from domestic (68%), commercial (29%) and public service activities (3%). Refer to captured diagram.



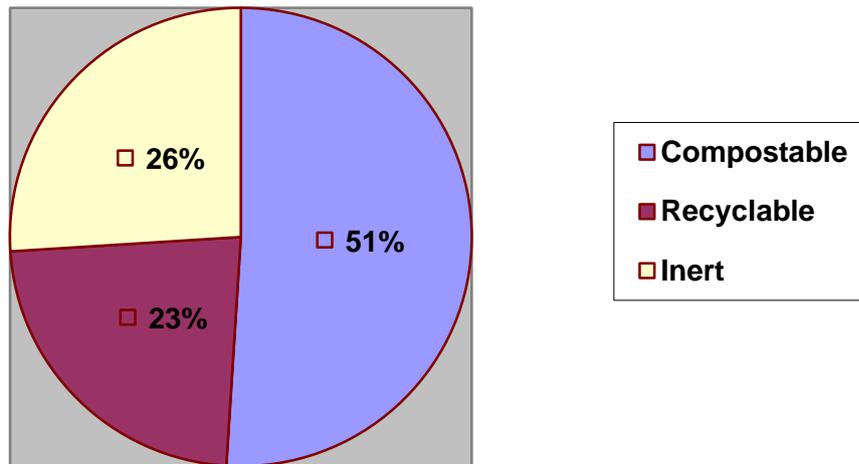
Composition of MSW

4. Earlier studies indicate that the city waste has a very high composition of organic matter (51%). Recyclable waste contributes about 23% including 7.48% plastic. Composition of inert substances is 26%. The waste has a high moisture content (47%), a high C/N ratio (29.25%) and a low calorific value (620 KCal/Kg). High moisture content increases weight of

solid waste and thus increases cost of its transportation. C/N value is important factor for determining sustainability of composting. Generally, C/N value for Indian Cities varies from 21 to 31. High calorific value is an indicator for better prospect of energy and Chennai's reported solid waste calorific value being on lower side may not be favourable for energy generation

Collection, Storage and Transfer of MSW

5. It is reported that door-to-door primary collection of waste exists in about 95% of the CMC area. However, no segregation of solid waste at source is in practice except informal segregation by the un-organized rag pickers at the secondary storage points and at the disposal sites.



Disposal of Waste

6. Solid waste generated in the CMC is mainly disposed to the existing two designated disposal sites located at Kodungaiyur and Perungudi. Approximate areas of these two sites are 182 hectares and 142 hectares respectively. Generally, solid waste of the northern part of the city is disposed at the Kodungaiyur disposal site and of the southern part at the Perungudi site. Kodungaiyur and Perungudi disposal sites are located at a distance of about 25 km and 15 km respectively from the city centre. No scientific method of disposal of waste is followed in the city. Open dumping of waste in these two sites is in practice. The sites are in operation for more than 20 years.



7. The captured picture shows the existing disposal site at Perungudi. In addition to these two designated sites, solid waste is also found to be disposed haphazardly into the open area, low lands, waterways, drains and in the side of roads.

### Institutional Set Up

8. MSW management is an obligatory function of COC. Solid Waste Management Department of COC is mainly responsible for day-to-day management of the MSW. The department is headed by a Superintending Engineer supported by two Executive Engineers; one is for the North and another for south Chennai, two Assistant Executive Engineers, 30 Conservancy Supervisors, 225 Conservancy Inspectors and a number of Sanitary Workers. Corporation of Chennai has around 10,130 permanent sanitary workers and around 1,157 permanent drivers for management of solid waste in the city.

### **Urban Local Bodies (ULBs)**

#### Generation of Waste

9. The major sources of generation of solid waste in the ULBs are in principle the same as in the CMC (domestic, markets and commercial establishments, hotels/restaurants, and institutions). According to the estimates of the municipalities and town panchayats, average per capita waste generation varies from 0.2 to 0.45 kg/day (average of 0.32). At a current population of about 4.2 million people in the CMA outside of CMC this implies 1,336 tonnes per day and 487,640 t/yr.

#### Composition and Characteristic MSW

10. No recent study has been conducted for the individual ULB to assess the composition and characteristics of the solid wastes except for 3 Municipalities. However, physical analysis of solid waste was carried out for the CMA and the results of the analyses show the following characteristics:

- 10.1. Very high composition of organic matter (59%);
- 10.2. Recyclable waste and inert substances contribute about 12.5% and 27% respectively;
- 10.3. Medium moisture content (27%);
- 10.4. High C/N ratio (31%), and
- 10.5. Low calorific value (1097 kCal/kg).

#### Collection, Storage and Transfer of MSW

11. Door-to-door primary collection of solid waste exists in most of the ULBs. Normally, the waste collected from primary collection is transferred to the secondary collection point. The waste is then transported to the disposal site. Although door-to-door collection system exists, households often throw the waste onto the streets, drains and open spaces within the locality, creating unhealthy conditions and clogging of stormwater drains.



#### Disposal of Waste

12. Scientific disposal of solid waste is absent in all the ULBs. Though some efforts have been made for local composting, these have not been successful because of lack of proper waste segregation at source. Solid waste is mainly dumped into open lands, water bodies etc. Some of the ULBs have designated solid waste dumpsites whereas others do not have

such facilities. Sometimes the disposed waste is burnt in the open causing environmental pollution.



13. An existing ULB solid waste dumping site is shown in the captured picture.

#### Institutional Set Up

14. Scientific and safe disposal of the MSW from their respective town/village panchayat is an obligatory function of the municipalities, town panchayats and panchayat unions. There is no separate department in the ULBs for exclusive management of MSW. The Health and Sanitation department manages MSW of the town among other things.

#### **C. Identified Gaps**

15. Major “Gaps” identified in comparison with the aforementioned ongoing and firmly planned activities can be summarized as follows.

16. **Legislative Gap:** Non-compliance with Municipal Solid Waste (Management and Handling) Rules, 2000

#### 17. **Service Delivery Gaps**

- 17.1. No pertinent Solid Waste Quantification and Characterization of ULBs
- 17.2. No primary collection of waste in many ULBs
- 17.3. Limited segregation of waste at source in CMA
- 17.4. No secondary Storage Facilities in CMA
- 17.5. Inadequate solid waste transportation system in many ULBs
- 17.6. No safe disposal of waste (e.g. no sanitary landfills) in CMA
- 17.7. Poor Health and Hygiene conditions of Sanitary Workers in CMA
- 17.8. Limited Community and Private Participation (e.g. PPP) in CMA

#### 18. **Public Awareness Gaps**

- 18.1. Limited and piecemeal initiatives of CoC and few ULBs for building public awareness and community mobilisation
- 18.2. No long term planning for public awareness campaign program covering the entire CMA.

#### **D. SWM Design Options and Recommendations**

19. Municipal Solid Waste Management involves four major activities. These are segregation, collection, transportation, and processing and safe disposal of MSW. There are various managerial and technical options for handling these activities.

20. Among the various options described in this report, the recommended options for different SWM functions along with their benefits are summarised in the following table.

**Recommended Managerial Options for SWM and Benefits**

Function	Option	Recommendation	Benefits
Reduction	<ul style="list-style-type: none"> <li>Producers</li> <li>Retail</li> <li>Consumers</li> </ul>	Voluntary or mandatory food and utensils packaging regulations e.g. for plastic bags and 'blisters', and public awareness campaigns, aiming at ultimate 'Zero Waste' scenario.	<ul style="list-style-type: none"> <li>Reduction of waste volume</li> <li>Reduced capacity of (future) disposal sites</li> <li>Reduction of O &amp; M Cost</li> </ul>
Segregation	<ul style="list-style-type: none"> <li>Source</li> <li>Intermediate</li> <li>Disposal Site</li> </ul>	Maximum at source e.g. households and retail outlets (glass, plastics and paper collection containers at shopping areas). Remaining at Disposal Site.	<ul style="list-style-type: none"> <li>Better recuperation of valuable waste fractions</li> <li>Reduction of O &amp; M Cost</li> <li>Compliance of MSW 2000 Rules</li> <li>Increased employment and livelihood of the informal sector ('rag pickers')</li> </ul>
Collection	<ul style="list-style-type: none"> <li>Primary</li> <li>Secondary</li> </ul>	Individual house & shops door-to-door primary collection. Remaining through community bins (secondary collection)	<ul style="list-style-type: none"> <li>Mitigation of indiscriminate littering</li> <li>Environmental Protection</li> <li>Improved cleanliness &amp; aesthetics</li> <li>Compliance of MSW 2000 Rules</li> </ul>
Transportation	<ul style="list-style-type: none"> <li>Direct to Disposal Site</li> <li>Via Transfer Station</li> </ul>	Direct, if disposal site is within 10 km, otherwise via Transfer Station	<ul style="list-style-type: none"> <li>Optimum utilization of resources</li> <li>Reduction of SW Transportation cost and time</li> </ul>
Disposal	<ul style="list-style-type: none"> <li>Centralized                             <ul style="list-style-type: none"> <li>Single ULB</li> <li>2-3 ULBs</li> <li>Group of ULBs</li> </ul> </li> </ul>	One common site for a group (Cluster) of ULBs	<ul style="list-style-type: none"> <li>Considerable reduction in number of disposal sites</li> <li>Lesser land area due to common infrastructure facility.</li> <li>Easier to manage.</li> <li>Better scope for transforming waste to energy</li> </ul>
	<ul style="list-style-type: none"> <li>Decentralized</li> </ul>	Support ongoing decentralized composting activities and encouraging further extension of the same to new areas.	<ul style="list-style-type: none"> <li>Reduction of volume in the main waste stream</li> <li>Reduction in overall Capital &amp; O&amp;M cost for transportation, staff and waste disposal</li> <li>Better opportunity for public – private participation</li> </ul>

21. Various technological options for namely Composting, Incineration, Refuse Derived Fuel/ Pelletisation and Sanitary Landfill are normally considered for processing and safe disposal of MSW. Basic principle of these technologies, type of wastes for which these technologies are useful and the technologies that are recommended for the MSW under PFS are furnished in the following table.

**Technological Options and Recommendations**

Technology	Basic Principle	Suitability for Waste	Recommendation
Recycling: <ul style="list-style-type: none"> <li>Paper</li> <li>Textiles</li> <li>Plastics</li> <li>Glass</li> <li>Metals</li> </ul>	Reclaiming (secondary) raw materials for processing of new consumer or industrial products	All primary and secondary segregated waste fractions consisting of the named materials	Promotion of industrial recycling options by regulation and financial and economic incentives

Composting: - Anaerobic - Aerobic	Decomposition of organic matters through microbes	Organic waste with medium to high moisture, medium to high temperature & high C/N ratio	<ul style="list-style-type: none"> <li>• Because of medium to high moisture content (27-47%), high C/N ratio (29-31) and low calorific values of MSW for both CoC &amp; the remaining ULBs "<b>Composting</b>" is recommended for the organic fraction of the MSW.</li> <li>• For non-biodegradable &amp; inert fractions of the MSW "<b>Sanitary Landfill</b>" is recommended for both CoC and the remaining ULBs</li> </ul>
Incineration	Thermal decomposition of organic matter	Waste with low moisture content & high calorific value (>1200 kCal/kg)	
Refuse-Derived Fuel (RDF) /Pelletisation	Thermo-Chemical decomposition of organic matter	Combustible Organic Waste	
Sanitary Landfill	Scientific disposal of waste material by filling of designated land with adequate environmental protection measures	Inert/Mixed MSW/processing rejects	

22. One of the most critical deficiencies in the existing SWM system in the CMA is lack of safe disposal facilities of the MSW generated in the ULBs. In almost all the ULBs within the CMA, MSW is either dumped or burned in the open. As per the Municipal Waste (Management & Handling) Rules, 2000, GoI, none of these practices for MSW disposal is acceptable. Two major challenges that are being faced by the city managers in the CMA in terms of addressing the MSW disposal problem are Rapid Urban Growth and non-availability of Land for waste processing and safe disposal. According to the Second Master Plan for CMA, 2026, population in the CMA has been doubled during the period from 1971 to 2001. This has further been projected to increase another 79% by 2026. The continuous increase of population has resulted in a significant increase of MSW generation. It is estimated that MSW generation will increase from the present (2009) 4536 TPD to 7105 TPD by 2026. Availability of adequate and suitable lands separately for individual ULB for processing and safe disposal of MSW in long term perspective has been a genuine problem for most of the ULBs.

### E. Cluster Approach for MSW Management

23. In order to mitigate the existing gaps in the SWM system, an integrated clustering approach has been adopted in the design of the SWM for the CMA. The main objective of such clustering is to have a common disposal facility of the MSW generated within a cluster at reasonable distances from the urban centres.

#### Objectives of the clustering:

- Minimize number of MSW disposal sites
- Reduction in overall land area requirement for waste processing & disposal
- Reduction in O & M cost of transportation of the waste
- Better management of the processing and disposal sites
- Avail scope for energy recovery from waste

#### Criteria for Clustering:

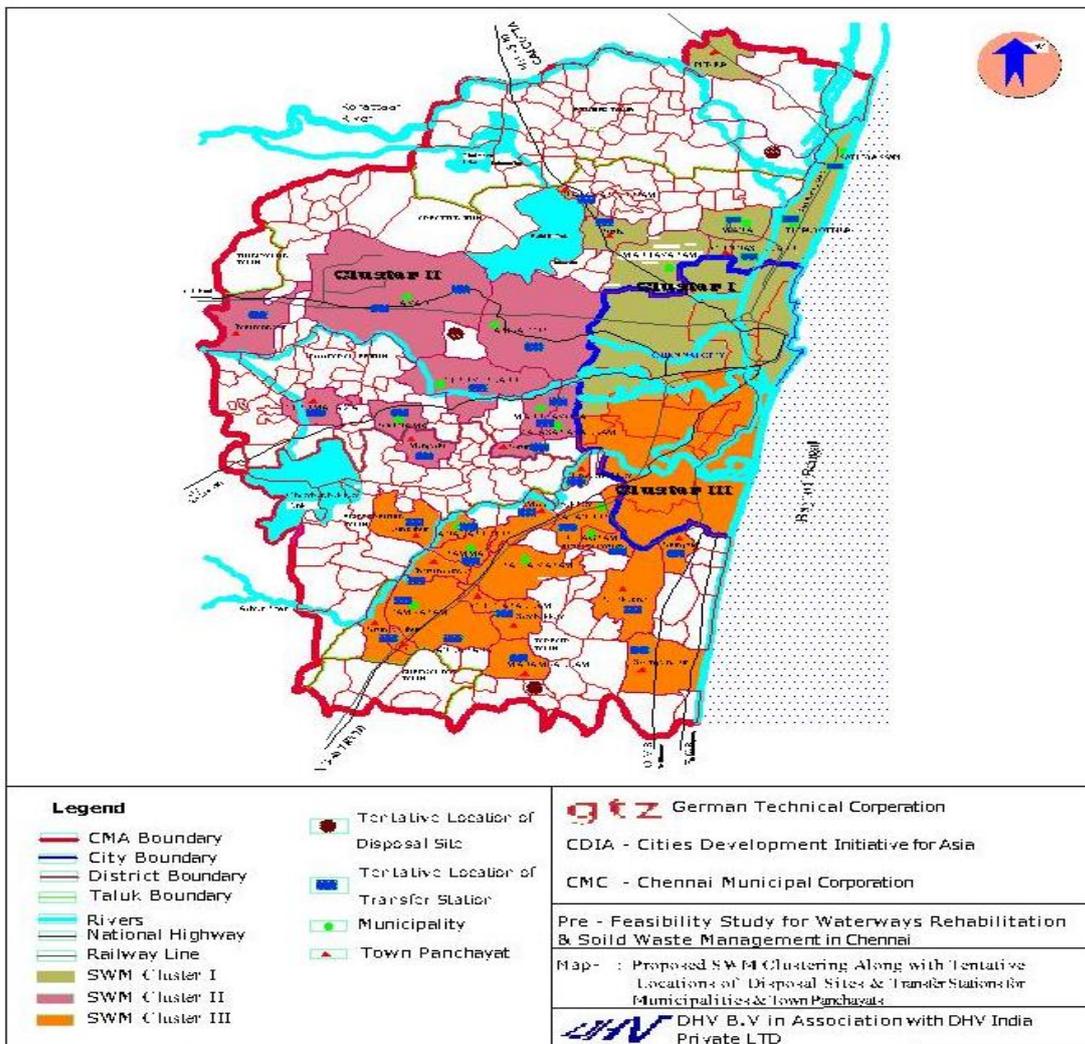
- Type of Agglomeration: Urban or Rural
- Geographical Location: Close Proximity

- Area Coverage: Area of a cluster should not be very large for better management (Maximum area considered for a cluster is 250 km<sup>2</sup>)
- Population (2009):
  - Minimum 1 million for Urban Cluster
  - Minimum 0.1 million for Rural Cluster
- Quantity of Waste Generation (2026):
  - Minimum 500 MT/Day for Urban Cluster
  - Minimum 50 MT/Day for Rural Cluster
- Distance: Disposal site should be within 10 km from the transfer station

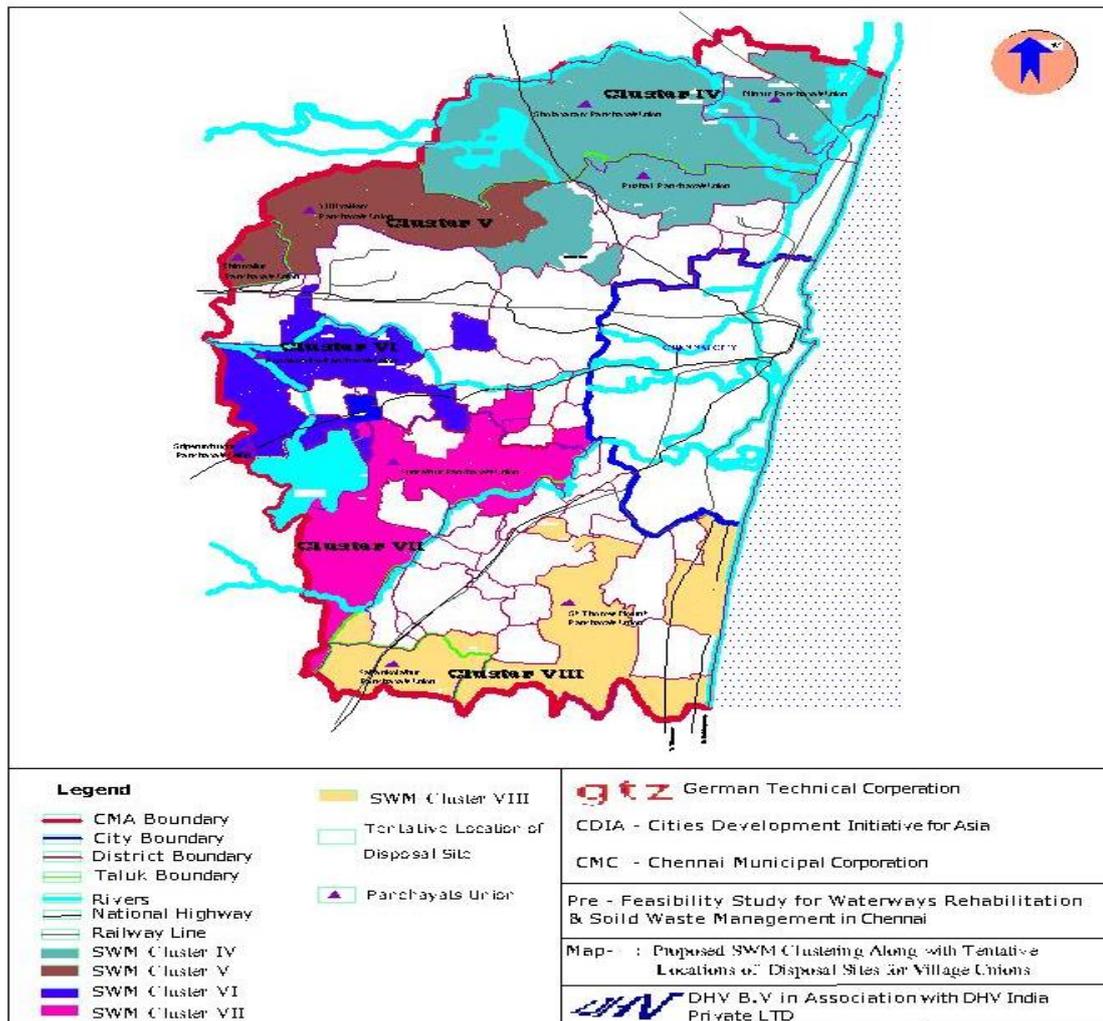
**Classification of Clusters**

- Urban Clusters: 3 Numbers (Cluster I to III)
- Rural Clusters: 5 Numbers (Cluster IV to VIII)
- Total: 8 Clusters

24. The following map of CMA shows the areas of the Urban Clusters.



25. The areas of the Rural Cluster are shown in the following map.



26. Considering the earlier mentioned ongoing initiatives and identified “gaps” of different ULBs in the SWM sector, a number of projects have been identified.

27. A justification of the proposed SWM Projects is following:

27.1. Existing solid waste disposal sites at Kodungaiyur and Perungudi are not acceptable from legal, environmental and social point of view. Hence, these two sites need to be reclaimed and restored.

27.2. Distances of the common solid waste disposal site in a particular cluster will vary depending upon the exact location of such site. One TS for one ULB has therefore, been proposed to transfer waste of the particular ULB so that the time and O & M cost for transportation can be reduced.

27.3. Most of the ULBs do not have day to day record keeping facilities by using up to date soft wares. This is important for generating a computer data base for various SWM activities. Hence up gradation and modernization of existing record keeping facilities have been proposed.

- 27.4. ULBs including CoC do not have in-house facility for major repair and maintenance of solid waste transport vehicles/equipment. Also, most of the ULB do not have adequate facility for keeping vehicles/equipment. This reduces life of the vehicles/equipment. Hence, vehicle workshop and depot have been proposed.
- 27.5. Condition of SW collection and transportation equipment/vehicle is poor, obsolete and inadequate. These require replacement. Hence, procurement of these items has been proposed considering long term (10-15 years) requirement.
- 27.6. No scientific processing & disposal of MSW exists except local level composting in some ULBs. This is a primary requirement from legal and environmental point of view. Hence setting up of compost plant & development of sanitary landfill site has been proposed to meet the requirement for next 15-20 years.
- 27.7. Public awareness is necessary to aware people about the ill effects of mishandling of solid waste and also need of public participation in the SWM activities. An extensive and long term public awareness program is therefore necessary.

28. A summary of the proposed projects and the estimated capital investment cost are furnished in the following table.

Cluster	Selected Design Options (packages)	Capital Investment Cost	
		INR (Million)	USD (Million)
<b>Urban</b>	<i>(Numbers and capacities may differ per cluster)</i>		
I	– Restoration of the existing solid waste dumping sites (2 sites)	2,343.78	46.88
II		864.38	17.29
III		2,550.58	51.01
	– Modernization of record keeping		
	– Vehicle Depot and Workshop Facilities		
	– Collection and transportation vehicles		
	– Compost Plants (1 per cluster)		
	– Sanitary Landfill Sites (1 per cluster)		
Sub-Total	– Public Awareness Programs	5,758.74	115.17
<b>RURAL</b>	– Transfer Stations		
IV	– Collection and transportation vehicles	160.40	3.21
V	– Compost Plants (1 per cluster)	154.85	3.10
VI	– Sanitary Landfill Sites (1 per cluster)	115.49	2.31
VII	– Public Awareness Programs	150.41	3.01
VIII		212.38	4.25
Sub-Total		793.53	15.87
<b>TOTAL</b>		<b>6,552.27</b>	<b>131.05</b>

## F. Financing Plan

- 29. The following observations were made:
  - 29.1. Internal accruals of CoC and ULBs is not sufficient to meet the project cost
  - 29.2. Possible assumed external financing by:
    - 29.2.1. Tamil Nadu State: e.g. 15%
    - 29.2.2. National Government: e.g. 35%
    - 29.2.3. International Financing Institutions (IFIs): e.g. 30%
    - 29.2.4. Commercial Banks: e.g. 10%

- 29.2.5. Private sector/PPP projects: e.g. 10%
- 29.3. Probably need to levy user charges to make the loans financially viable
- 29.4. Continuation of borrowing funds for infrastructure projects without considering the committed fund flow to repay the loan may not attain financial viability.

## **G. Implementation Plan**

30. Chennai Metropolitan Development Authority (CMDA) should be the Project Implementing Agency (PIA). Implementation of the SWM project will be followed in line with the standard ADB organizational structure for multi-sectoral projects i.e. by forming a Project Management Unit (PMU) and Project Implementation Unit (PIU). In addition, engagement of Project Management Consultant (PMC) and Design and Supervision Consultants (DSC) is required to support the project. CMDA will form the PMU for managing the project. A PIU will be formed for each SWM cluster. Representatives from the ULBs of the cluster will be part of the PIU. DSCs will provide technical support to the PIUs whereas PMC will provide both technical and managerial support to the PMU for implementation of the project.

31. In addition to the above institutional arrangements, a “Steering Committee” (SC) should be formed mainly to review the financial and technical progress of the project and also decide on the major policy issues. Director/Secretary CMDA could head the SC. Director Municipal Administration (DMA), Director Town Panchayats (DTP), Commissioner CoC will be among other members of the SC.

## **H. Economic Analyses of the Proposed Investment Packages**

32. Economic analyses have been conducted of all packages based on the following elements:

- 32.1. Economic Cost, including capital cost and operational cost of the proposed investment schemes
- 32.2. Value of Economic Benefits
- 32.3. Cost-Benefit Assessment: based on the following economic assessment parameters:
  - 32.3.1. Economic Internal Rate of Return (EIRR)
  - 32.3.2. Net Present Value (NPV) at a discount rate of 10%
  - 32.3.3. Benefit/Cost Ratio (BCR) at a discount rate of 10%

33. Sensitivity analyses have been made of the cost-benefit assessment for the following scenarios:

- 33.1. Economic costs go up by 10%
- 33.2. Economic benefits down by 10%
- 33.3. Economic Costs up & Economic Benefits go down by 10%

34. The main results of the economic analyses for all Clusters are:

- 34.1. Satisfactory EIRR (>10% discount rate, ranging from 10 to 21) in all sensitivity scenarios, implying that the SWM packages are economically beneficial to the society including poorer section;
- 34.2. BCR is more than one (>1, ranging from 1.3 to 2.2) in all sensitivity scenarios, hence these proposed packages are economically viable and sustainable.

## **I. Prioritization of Investment Packages and Implementation Plan**

35. The proposed SWM projects have been divided into eight investment packages, one for each cluster. The urban clusters have three investment packages whereas the rural clusters have five. There are a number of project components in each package. The

investment packages have been prioritised in two aspects: (1) prioritisation of clusters (ranking A to E) and (2) prioritisation of components of within the clusters (ranking 1 to 3 in implementation plan).

**Criteria for Prioritization of Clusters**

36. The proposed SWM investment clusters have been prioritised based on the following criteria:

- 36.1. Level of existing service
- 36.2. Continuation of ongoing linked initiatives
- 36.3. Direct relevance to major waterways pollution
- 36.4. Prospective future growth and development
- 36.5. Population benefited.

37. The results of the prioritisation based on the fulfilment of the above criteria are presented in the following table.

Priority	Cluster	Criteria Fulfilled
A	I & III	75% of the CMA population will be benefited 6 out of 8 municipalities and 8 out of 9 TPs i.e. 78% of the towns are located near the major waterways Being in the periphery of the CoC growth prospects of the ULBs are very high Several ULBs of this cluster have a number of ongoing initiatives Level of services in CoC and few municipalities are reasonably good. But it is not satisfactory in other ULBs
B	II	Only 14% of the total population of the CMA will be benefited Only 2 municipalities and two TPs of the cluster situated along the major waterways Most of the towns of this cluster are located in the prospective west growth corridor along the River Cooum Most of the municipalities and TPs of this cluster has initiated outsourcing of primary collection and transportation of MSW to private agencies and SHGs. Level of services is poor in all the municipalities and town panchayats of Cluster-II except the Ambattur and Avadi Municipalities.
C	IV & VIII	Covers about 55% of the total existing population of the five rural clusters. River Kosasthalayar passes through the Cluster-IV which forms a part of the prospective North-East Growth Corridor.
D	V & VII	These two clusters jointly cover about 35% of the population of the five rural clusters. A considerable part of the River Adyar is passing through the Cluster VII. The prospective South-West Growth Corridor falls in between these clusters.
E	Vi	Only 10% of the total population of the rural clusters is in cluster-VI. Only a part of the River Cooum passes through the Cluster. The cluster does not fall under any of the prospective growth corridors

**Implementation Plan for Projects within Clusters**

38. The components of each of the eight SWM packages (3 for urban clusters and 5 for rural clusters) have been prioritised for implementation as 1 (first priority), 2 (second priority) and 3 (third priority) mainly based on the required sequential order of their logistics and construction.

39. Proposed Time Frame for implementation of projects from the initial start of the implementation:

- Priority - 1:** 0 - 5 years
- Priority - 2:** 6 - 7 years
- Priority - 3:** 8 - 10 years

40. An overview of the prioritisation of the project components is furnished in the following table.

**Prioritisation of Project Components for Improvement of Integrated Solid Waste Management**

Project Component	Priority per Cluster							
	I	II	III	IV	V	VI	VII	VIII
Implementation of Reclamation and Restoration of the existing solid waste dumping sites at Kodungaiyur leading to safe closure	1	x	x	x	x	x	x	x
Implementation of Reclamation and Restoration of the existing solid waste dumping sites at Perungudi leading to safe closure	x	x	1	x	x	x	x	x
Construction of Transfer Stations including computerized weighing system	2	2	2	2	2	2	2	2
Up gradation & Modernization of record keeping and communication facilities	2	2	2	2	2	2	2	2
Procurement of collection and transportation equipments/vehicles	3	3	3	3	3	3	3	3
Development of Compost Plant including infrastructure facilities	1	1	1	1	1	1	1	1
Development of Sanitary Landfill Site including infrastructure facilities	1	1	1	1	1	1	1	1
Construction of Vehicle Depot with Workshop Facility	2	2	2	x	x	x	x	x
Public Awareness Programs	1	1	1	1	1	1	1	1

**J. Social Aspects**

41. For assessment of the social aspects a limited public opinion survey has been conducted as part of Pre-feasibility Study. About 1000 respondents have been interviewed in the CMA, proportionally selected based on the clustering of the solid waste service areas. The aggregated results of the survey are presented in this Executive Summary.

Main findings of the Public Opinion Survey

- a. **Quantity of Waste Generated per day:** Sixty percent of the respondents said that they are generating more than 1 kg of solid waste.
- b. **Waste Collection Method:** Waste collection method varied from door to door type (34%), Dust bin collection (29%), and vehicle (18%).
- c. **Waste Collection Agency:** Municipal body (80% in cluster group II, 75% in cluster group I and 68% in cluster group III) and private agency (32% in cluster group III, 23% in cluster group II and 19% in cluster group II) in three cluster groups.

It was observed NGOs and Residents welfare associations' constitute 2% of the collection machinery.

- d. **Frequency of Waste Collection:**  
Daily -57%, Alternate-17%, twice a week -18%, once in a week-7%
- e. **Opinion on entire Waste is collected:**  
Yes-89%, No-11% = 100%

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- f. **Segregation of waste**  
Only 18% follow segregation of waste during disposal.
- g. **Expenses for solid waste removal**  
Thirty eight percent of the respondents said that they spent up to Rs 50 a month for the disposal of waste.
- h. **Current level of satisfaction**  
Ninety percent are satisfied regarding collection of garbage.
- i. **Willingness to pay assessment**  
Sixty three percent sample respondents said that they are willing to pay for better services.
- j. **Willingness to participate**  
Seventy seven percent of the respondents said that they are prepared to participate in the clean city efforts of the local bodies.
- k. **Priorities for SWM**
- The priority for source segregation (organic/paper/glass/rest fraction) is ranked first.
  - Composting facility within the locality is ranked second by respondents in cluster I and third in cluster III.
  - Individual curb-side collection containers introduced is ranked second by more respondents in cluster III (130 out of 425).
  - Common collection containers introduced is ranked one by clusters I (110 out of 380) and III (98 out of 425).
  - Local parks to use the manure/compost developed is ranked fifth by more respondents in cluster I and III.
  - Developing green belt as part of solid waste project is prioritized sixth by the respondents in three clusters
42. The potential social impacts of the SWM project have been assessed as follows.
- 42.1. **Positive impacts:**
- 42.1.1. Improved living environment
  - 42.1.2. Fewer rodents and insects
  - 42.1.3. Less health hazards
  - 42.1.4. New jobs from collection, transport, processing, and disposal of solid waste
- 42.2. **Possible negative impacts:**
- 42.2.1. Involuntary resettlement to make place for the transfer, processing and disposal facilities
  - 42.2.2. Loss of livelihood as rag pickers at landfills and dumpsites
  - 42.2.3. Impacts on educational/social settings
- 42.3. **Mitigating Measures and Social Safeguards:**
- 42.3.1. Resettlement and compensation schemes (RAP)
  - 42.3.2. Livelihood support, and other social development support for the affected families
  - 42.3.3. Comprehensive Social Impact Assessment (SIA) need to be carried out in subsequent Feasibility Study stage

## K. Environmental Aspects

43. A brief environmental assessment has been carried out because the actual locations of the proposed new facilities are not known yet so a full assessment could not be made in this stage. The following major issues have been identified:

- 43.1. Important issue for solid waste processing and disposal facilities is the **site selection** from geological, ecological and population point of view.
- 43.2. Landfills should not be located in areas with high freatic groundwater level, not in permeable soil conditions, and not in earth quake or flooding prone areas.
- 43.3. Recommended distance to residential housing is minimal 500 m.
- 43.4. Measures to prevent contamination from run-off water and leachate to groundwater and surface water need to be taken and maintained.
- 43.5. Sanitary landfills and waste processing sites need a good Environmental Management and Monitoring Plan.
- 43.6. Comprehensive Environmental Impact Assessment (EIA) need to be carried out in subsequent Feasibility Study stage for Environmental Safeguarding.

## L. Recommendations

### 44. Financial Perspective

- 44.1. CoC is capable to borrow from IFIs and capital markets to finance SWM project cost in clusters I to III
- 44.2. Other municipalities' and ULBs' capacity to borrow to finance the project cost is low, hence need to depend on government loans and grants and budgetary support of GoTN, assistance from TNUIFSL and TUFIDCO
- 44.3. Alternative engage public participation in the process, and converging untied funds for investing in SWM activities
- 44.4. Consider to finance the project costs out of user charges
- 44.5. Follow internationally applied regulations concerning the method of levying user charges for SWM and regulate collection of the same

### 45. Recommended Studies for the next phase

- 45.1. Detailed study on Reclamation and Restoration of the existing solid waste dumping sites at Kodungaiyur and Perungudi.
- 45.2. Study for identification and finalization of solid waste disposal sites.
- 45.3. Study on solid waste quantification and characterization.
- 45.4. Preparation of Comprehensive Solid Waste Master Plan.
- 45.5. Further study on SWM tariff setting and collection.
- 45.6. Study on inter-communal cooperation in common solid waste handling functions for municipalities, town-panchayats and village unions with stakeholder consultations
- 45.7. Capacity Building Programme for all municipalities, town-panchayats and village unions in CMA in SWM techniques and practices.