CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSION

There is growing literature linking urbanization and environmental quality. Some regions of the globe are better represented than others. Trends of change between the population growth rate and water quality suggest the involvement of multiple factors (Duh et al 2008). In the present thesis, we can see the driving force behind the environmental changes observed in the peri-urban water bodies bear multiple relations to the population growth rates in study villages. The pattern of suburbanization we noticed in the study area is mainly through proliferation of the IT related institutions that made people to migrate towards job opportunities available and consequent sub urbanization process. A recent urban agglomeration study of Bangalore city (Sridhar 2007) also provide evidence of similar situation that it is jobs that follows people and not vice versa. The main issues of changes due to the sub urbanization process noticed in the study are summarized here.

6.2 POPULATION INCREASE

The growth in population in the communities around the Lakes between 1971 and 2001 indicated that in the case of peri-urban villages higher growth rates were recorded than in the case of urban Lake and also the highest population density and its rate of increase was noticed in the peri-urban villages than either urban or rural ones. These changes are found to accompany multiple changes in water bodies. Water spread area of the Lakes
decreased considerably; 79% in urban areas, up to 49% in peri-urban villages, except Pallikaranai (2%) which is due to its interior location from the main road and also may be due its proximity to Pallikaranai marsh. Significant changes in water uses occurred in urban and peri-urban villages, but irrigation and domestic uses continued in rural villages. In the urban Lake, disuse of the water body was apparent, and agricultural use of water was nil. Instead the Lake was in use for cleaning of vehicles, washing of clothes and dumping of liquid wastes by unknown users.

6.3 LAND USE

The pattern of land use in the study villages changed significantly. Residential use went up to 88% with dense multistoried buildings in urban area while it was up to 72% in peri-urban villages. The scrub lands or waste lands were mostly converted into residential areas, and to a very lesser extent from other categories. The Rajakilpakkam village leads all the other villages in terms of changes noticed due to urbanization process. Agricultural land area has declined.

6.4 WATER QUALITY

Water quality of the Lakes showed a gradient in response to the urbanization process; with severe changes being noticed in urban and peri-urban Lakes, most often obliterating seasonal patterns normally present in small water bodies, while fewer changes were noticed in rural Lakes. Surface water temperature, pH, and BOD₅ did not differ among the Lakes while DO, TDS, alkalinity, TH, and concentrations of phosphate and nitrate were considerably higher in urban and peri-urban Lakes and the increase was more than two fold in the case of major ions and tenfold in the case of nutrients concentrations in urban and peri-urban Lakes compared to rural Lakes, indicating a decline in water quality. Biochemical Oxygen Demand (BOD₅)
and Chemical Oxygen Demand (COD) were higher in peri-urban Lakes compared to urban and rural Lakes. However, BOD₅ did not show relatively wider variations among the Lakes.

Significant differences in TDS among the Lakes can be seen which varied from 399 to 542 ppm in rural Lakes to a higher range of 763 (WIN) to 1401 (SWM) ppm in peri-urban Lakes. In urban and peri-urban watersheds, concentrations of both inorganic and organic pollutants including faecal bacteria may have been higher, which might have further been exacerbated by rainfall, leading to a significant but unquantifiable dissolved and suspended load added to the receiving water bodies. The high mineralization and increased concentration noticed in the case of Velachery Lake may be due to this phenomenon. The pH indicated a neutral range of 7 to a mildly alkaline value of 8.5. Increase in pH was noticed in urban Lakes during SWM season (8.24) while a decrease in seasonal average can be seen in rural Lakes. Surface water pH of the unpolluted Lake is generally connected to the carbonate system (Wurts and Durborow 1992) but enhanced photosynthetic activity by algae which use free carbon dioxide in summer, with increase in temperature and transparency, may have increased the pH in urban Lake.

A general trend of increase in DO in SUM compared to WIN values were noticed which is followed by a decline in SWM and NEM seasons and can be seen in all the Lakes. Dissolved oxygen is an important factor that influences the health of the aquatic ecosystem. The increased DO levels noticed during the monsoon season may be due to fresh inflows of rain water into the Lakes and the photosynthetic production of oxygen by phytoplankton. Total alkalinity values are also high in urban Lake (> 200 ppm) while low in rural Lakes (<100 ppm) and Chlorides also indicated a similar pattern in variations, but with sharper differences in peri-urban Lakes as compared with urban and rural Lakes. The hardness of the water is classified from medium
in Agaramthen to very hard in Velachery which also showed a higher average alkalinity value of 283.67 mg/L, compared to 107.17 mg/L in Agaramthen.

Pearson product moment correlation matrix computed separately for Velachery and Agaramthen Lakes show that significant and highly positive correlations can be seen between TDS and pH, TH, alkalinity, phosphate and BOD$_5$ in Velachery which might indicate the common source for these ions from the urban wash off, while only TH showed a significant correlation with TDS in Agaramthen, and this may indicate the dominance of the calcite minerals present in the catchment area.

Nitrates and phosphates, the macro nutrients for aquatic community showed sharper differences in concentration between the Lakes. The difference between the Lakes were nearly twenty fold in the case of phosphate and eightfold in the case of nitrates and the differences observed are significantly higher than any other water quality variables measured in this study. The huge differences in the concentration of nutrients recorded between Velachery and Agaramthen Lakes points to the direct impact of urbanization. The heavy inflows during monsoon season may have increased the water levels and therefore resulted in decrease of the concentration of nitrates and phosphates noticed in NEM and SWM periods in Velachery and nitrates in Agaramthen Lake. The decrease in concentration of phosphate during wet seasons may be explained by the dilution effect of increasing water levels noticed in the Lakes. Increase in phosphate concentration during monsoon seasons in the Agaramthen Lake can be explained by the nature of water shed (particularly agricultural fields) from which nutrients might have been washed out into the Lake by rain water.

Generally higher BOD$_5$ values were recorded in urban and peri-urban Lakes, but higher COD values were recorded in peri-urban Lakes during monsoon season (749 ppm in NEM and 545 ppm in SWM) than winter
(62 ppm) and summer (60 ppm) seasons. Though higher BOD\textsubscript{5} values were recorded in rural Lakes than peri-urban Lakes, the COD values are much higher in peri-urban Lakes, especially in monsoon seasons. It is therefore likely that the sources of oxygen demand in the peri-urban and rural Lakes are different and related to the type of water use and indicate influence of the land use/land cover of respective catchment areas.

A two way ANOVA performed on the water quality data to assess simultaneously the effect of spatial as well as seasonal differences in water quality and their interaction effects showed spatial differences in average values of TDS, alkalinity, TH, Chlorides, Phosphate and Nitrates to be highly significant (p < .001), while seasonal differences are significant in all variables except pH, TH and COD. However, the effect of urbanization influencing seasonal differences significantly can be seen in the case of alkalinity, chlorides, phosphate, nitrates and BOD\textsubscript{5}. These variables also showed good inter correlation, suggesting their common source, namely urbanization.

6.5 WATER QUALITY INDEX

The water quality class ranged from medium (50-70) to Bad (25-50) during the period of study. In rural Lakes the water quality class was assessed as medium (58.41 to 66.28). In peri-urban Lakes, the quality in Keelkattalai was assessed as bad (48.82 – 50.19) while in the other two Lakes mostly medium class is recorded. In Velachery Lake the quality class was bad (50.54) to medium (56.84).

6.6 BIOLOGICAL DIVERSITY

Algal diversity of the study Lakes was assessed through collection, identification and analysis of phytoplankton community. Bacillariophyceae
group was comprised of 112 species, Cyanophyceae - 117 species and Chlorophyceae - 75 species, and the total number of taxa identified in the study was 304. Among the three groups, the Cyanophyceae was dominant in comparison with Bacillariophyceae and Chlorophyceae when all the Lakes are considered. The order of abundance of groups are as follows: Cyanophyceae>Bacillariophyceae>Chlorophyceae.

In rural Lakes 16% of biomass is contributed by three species (Schizomeris leibleinii, Closterium accutum and Cyano sp.) in Vengaivasal Lake, while two species (Scenedesmus quadricauda and Scenedesmus sp.) contributed 14 % of total phytoplankton composition. In the case of peri-urban Lakes, Keelkattalai and Rajakilpakkam, the dominance by few species on total biomass seems to be significant, while in other Lakes it is not so evident. However, there are differences in the seasonal occurrence of taxa and differences could be noticed between the spatial groups of Lakes. Some genera occurred in all the Lakes and appear to be common taxa. For example, Navicula sp. was identified during all the seasons in the urban, peri-urban and rural Lakes, while Oscillatoria sp., Lyngbya sp. was seen in all the seasons in peri-urban and rural Lakes, and were also present in urban Lake during summer and winter season. Cyclotella sp. is also common, but has seasonal occurrence and found during SWM season in urban, NEM season and summer in peri-urban and during winter in rural Lakes.

The total abundance of phytoplankton taxa grouped zone wise show Bacillariophyceae dominating the urban Lake (39%) followed by rural Lakes (25%) and peri-urban Lakes (19%). Cyanophyceae group dominated in the peri-urban Lakes (52 %) followed by rural Lakes (39%) and urban Lake (35%), while Chlorophyceae group dominated the rural Lakes (36%) followed by peri-urban Lakes (29%) and urban Lake (26%) respectively. Two major sub groups, Bacillariophyceae and Chlorophyceae showed opposite trends in
dominance between urban and rural Lakes. The percent seasonal abundance of phytoplankton subgroups (Fig 5.17) indicate that Cyanophyceae is the dominant subgroup in the peri-urban Lakes during all the seasons and it reached its maximum (86%) abundance during SWM season.

6.7 STAKEHOLDER ANALYSIS

A reconnaissance survey conducted to understand existing field conditions and the attitudes of the community in the villages adjoining the study Lakes towards these water bodies revealed that these communities are mixed, consisting in varying proportions of the natives and recent migrants depending on the location of the Lake in the urban-rural gradient. The perception of the people living in the study area and their attitudes towards the water bodies were variable and appeared to be related to the degree of their interdependence on the Lakes. In the urban area, except few fishermen families who rely on the Lake for fishing as livelihood, people were not interested in the Lake or its maintenance because, more than 90 % of the communities were migrants to the area. In the peri-urban areas, the people were using the Lake water for various purposes such as to meet domestic needs such as bathing, washing clothes, for cattle grazing and fishing and were aware of the utility of Lakes. In the rural area, people were using the Lake water for many of the original utilities such as agricultural and domestic purposes including for drinking, and felt that Lake water is very important for their life and livelihood and it should be maintained properly in terms of its quality and quantity.

A stakeholder meeting was conducted in one of the study villages to understand the perceptions of the people including farmers, officials, NGO’s and others about the issues of contention related to the study Lakes. They covered the physical condition of the Lake systems, water quality, utility of the water bodies, and their management. Encroachment, reduction in water
spread area, lack of maintenance of bund and inflow channels, conversion of agricultural area under the Lake into residential zones, water quality degradation, discharge of waste water into the Lake, seasonal flooding of converted residential areas and consequent breaching of bunds by the encroachers, lack of or reduced dependence of the community on Lake water are the major issues that emerged. These issues were further probed through a structured questionnaire administrated to selected respondents from each of the six villages. The administrators and local officials admitted the availability of legislation to protect the water bodies from encroachers, but its and their implementation is not easy or uniform. They suggested the need for regular monitoring and management to prevent rather than remedy such problems. The NGO’s pointed to the need for community involvement in the upkeep and management, as in the distant past, could be the solution to protect the water bodies. As these water bodies once served mainly as source of irrigation which is no more a function in an urban scenario, the Lakes should still be shown to the community to serve functions of flood moderation, groundwater recharge, centers of socio-cultural and entertainment value besides acting as other important ecological balancer to the benefit of urban population.

6.8 WATER BODIES PROTECTION INDEX

The foregoing results of the study indicated that urbanization and population density are the major forces exerting pressure on the ecology of Lakes and reducing the utility of the water bodies to the lives and livelihood of the people, making the original functions of the Lake redundant. Changes in water quality and changed land use in agricultural lands hitherto irrigated by the Lakes further makes these water bodies to lose their significance as back bone of village economy. On the other hand, such degradation creates concern about environmental sustainability of these water bodies. While six Lakes could be studied in this thesis work, the status of many other Lakes in
the state needs to be studied to provide a platform for the assessment of their present condition and to create awareness among the community. Therefore, an index to assess the environmental status of the Lakes was proposed based on the results of this study. Five factors were considered in the index namely 1) water quality of the Lake, 2) Biological diversity of the Lake, 3) Present water spread area, 4) Role of community/public participation, and 5) Role of Government departments/ NGOs and planning bodies. The weightages for these factors were fixed based on a mini Delphi study. Vengaivasal scored a high 6.30 and Velachery scored a low 2.26 on this index, satisfactorily indicating the present status of the water bodies and their need for protective measures towards conservation. This index was compared with an Urbanization Index (Sethukkarasi 2008) developed for the villages in Tambaram taluk in which the six study Lakes of this study, are located gave good correlation ($R^2 = 0.869$) and a significant linear relationship indicating concurrence.

### 6.9 CMDA MASTER PLAN

The urban planning authorities are yet to respond to the impacts of degradation and disappearance of water bodies in the urban areas, such as urban flooding, groundwater depletion, environmental degradation and ecological imbalances (Ilangovan 2008).

The CMDA (2008) has proposed for consideration the draft master plan for Chennai metropolitan area, 2026, a document outlining the policy proposal for the integrated development scenario for the Chennai city and later notified. A perusal of the document indicates that the importance given for the water bodies, water supply and drainage considerations is meager. The term “water bodies” have been thrown into “Others” category from 2006, which also includes forest, hills, vacant lands etc. The implication of not providing specifically for water bodies in spatial planning process are
complex and pose a major threat to the urban water resources, as the present study has already shown.

The potential for storage and supply of water from surface water bodies for domestic use in CMA is significant. The surface runoff from the CMA was assessed to be 283.16 Mm³ based on normal rainfall over the area, whereas the average storage capacity of the Lakes in CMA is roughly 42.47 Mm³. Thus, the storage capacity of all the Lakes in CMA accounts only for 15% of the total surface run off. This indicates that, 85% of surface run off from CMA is at present going to the sea. There is a great potential to save some of this water by developing/deepening the existing water bodies and protecting them from encroachment and pollution.

The planning proposals of CMDA do not insist plans for protection and development of the water bodies. The lacuna in the planning is quite evident at Rajakilpakkam Lake area which is deteriorated in all forms due the development of Tambaram-Velachery road through it. In Contrast, Pallikaranai Lake which is nearer to the city than the Rajakilpakkam Lake, have high sustainable status value as it is away from the main road network. This implicates that the CMDA has to do more detailed planning for water resources by providing required spaces and projects in master plan for CMA and formulate guidelines for execution by WRO of PWD, with cooperation of the revenue department. The CMDA should play a positive role in protecting, restoring, preserving and developing these water bodies.

6.10 POLICY NEEDS

The Government (urban development departments) also needs to formulate appropriate policies and guidelines based on the findings of this and similar studies to provide for water sector planning in the urban areas linking urban development authorities, local bodies, WRO of PWD and civil society.
In fact, this water sector planning should precede the city master planning process. The areas that are susceptible for urban development should be identified well in advance and as a first step water sector plans should be prepared and implemented prior to including these areas into the metropolitan development area. The involvement of various stakeholders including the local leadership and civil groups, in the planning and implementation of water sector plans, may have greater influence and is very crucial for realizing the objectives enshrined in the CMDA master plan for Chennai city.

6.11 RECOMMENDATIONS

Suggested Measures for Protection and Conservation of Lakes in Urban areas:

1. CMDA/Planning Authority to allocate land needed for development of water bodies/Lakes, widening/providing supply channels and surplus courses, waste water carrying channels and wastewater treatment plants in its master plan.


4. Forming walking tracks for people all-around the boundary of the water body including over the Lake bund, and developing parks and lawns in the foreshore of the water spread area as
well as rear side slope of Lake bund (Government, Local body, WRO of PWD).

5. Providing for waste water treatment facilities for the domestic waste water entering into the Lakes and making the local body to pay for the establishment and regular maintenance of the waste water treatment facility (Government, Local body, TWAD Board, PCB).

6. Promoting Fish-farming in the Lakes (Government and Fisheries Department).

7. Promoting Lake protection and conservation authorities as independent bodies with involvement of local people and NGO’s for each of the Lake for maintenance and upkeep of the water body in a sustainable manner (Government).

8. Providing for private participation in the above process (Government).

9. Providing for necessary budget allocations in the yearly budget under the urban development/local bodies administration head of account for the above activities. (Government, Urban Development department).

6.12 SCOPE FOR FURTHER STUDIES

1. A rapid study and inventory of peri-urban Lakes in Chennai and Kancheepuram district of Tamil Nadu along the lines of present study would help establish Lake restoration plans.

2. Bioassay/Bioaccumulation of fish varieties in the Lakes under influence of urbanization may indicate health implications.
3. Study of the impact of disappearing and degradation of water bodies on temperature changes in the micro climates.

4. Further work on improving the WBPI as a sustainable index for Lakes

5. Estimation of cost and benefits of sustaining the Lakes in urban areas.

6. Impact of peri-urban Lake water quality on the agricultural crops in the command area