CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 SUMMARY

The dependency on groundwater has increased due to the rapid growth of population, urbanization and competition for economical development. In many parts of the developing countries, especially in arid and semi-arid regions, due to the failure of the monsoon and scarcity of surface water, dependence on the groundwater resource has increased tremendously in the recent past. In India, groundwater resources play a very critical role in meeting the ever increasing demand of the agricultural, industrial and domestic sectors.

Many cities in India experience water shortage and the authorities are not able to provide adequate quantity of protected water, particularly in summer or periods of monsoon failure. During these periods, the aquifer of the peri-urban areas or villages acts as a source, and a huge amount of water is transferred to the city formally and informally. The increase in demand and scarcity of water, both surface and sub-surface sources, build the market mechanism from the supply area to demand area in the form of rural-rural, rural-urban or peri-urban to urban etc. to meet out agricultural, domestic and industrial demands.

Tamil Nadu State in India is an agrarian state basically depending upon its water resources, for the agricultural activities, food production and

domestic use. Agricultural production is the basis of the economy and the viability of agriculture is closely linked to reliable access to water. Induced urbanization and profitable non agricultural employment opportunities in peri-urban areas distorted the rural livelihood and the land and water resources are highly demanded for urban usage.

Chennai, one of the major metropolitan cities in India with a rapid industrial, commercial and population growth including floating population, needs huge quantity of clean and safe water to cater to the domestic and other requirements. The recent developments have put tremendous pressure on the water supply demands of the city. The deficit is met by draining and transferring the groundwater through tanker supply as well as packaged water supply particularly from the peri-urban villages.

Development of groundwater for commercial purposes without any quantification and recharging activities have all resulted in a rapid fall and leads to deterioration of its quality. Though the demand for groundwater is increasing, formulation and implementation of guidelines for its exploration are not commensurate with the demand. Groundwater depletion and degradation in terms of quantity and quality have created environmental, economic and socio-political challenges now as well as in the future.

Groundwater trading for meeting the urban water needs is emerging in the Western, Northern and Southern peri-urban areas of Chennai city. The present study focuses the transfer of treated (packaged water) and untreated groundwater (extracted from agricultural wells and transferred by tankers) from the Southern peri-urban area of Chennai and its techno-socio-economic implications on the land and water resources and people in the peri-urban areas (source area). Further it ascertains the socio-economic status, perceptions of groundwater dependents and economy of groundwater market in the study villages.

Studies carried out by Janakarajan (2006), Nisha (2008) and Veeralaxmi et al (2009) have highlighted the socio-economic impacts of formal and informal groundwater markets in Chennai and its peripheries. This continuous water transfer from the villages to the city has resulted in the lowering of water levels, deterioration in the water quality, and a decreasing trend in agriculture and agriculture related employment opportunities as the peri-urban village is already stressed due to urbanization impacts.

The literature survey revealed that majority of the studies are about the water market issues, either surface/groundwater or rural-rural/rural-urban, conducted against the socio-economic background. They conclude with assessments of the social and economical impacts. Similarly, groundwater management studies in various arid and semi-arid environments, which are under threat, investigate only the technical issues of the basin or watershed or administrative boundaries rather than looking at the social issues for the explanation or motivation of the causes. The proposed transdisciplinary study on "**Groundwater market and its techno-socio-economic implications"** tries to merge the gap between the analysis of the social aspects of water marketing qualitatively and quantitatively with the technical measures such as the hydrogeological condition, groundwater quality and potential of the watershed for the sustainable development of groundwater resources.

Mambakkam miniwatershed in Kancheepuram district of Tamil Nadu, India, located South of Chennai city was selected for conducting the study. The aerial extent of the study area is 224 km^2. The study area stretches from East to West for a width of 18 km from the sea coast towards inland and a length of 16 km along the North-South. As much as 50% of the villages in the study area are involved in groundwater marketing. In order to assess the status of the aquifer and its potential, a boundary has been delineated on the watershed basis, which aims to cover the southern water marketing villages.

In this watershed, settlements are growing rapidly due to urban sprawl. Two villages were selected for conducting the social survey to know the significance of groundwater market. The villages of Perumbakkam in Tambaram taluk located close to the city limit and Ponmar in Chengalpet taluk located farther away from the city boundary (15 km) which are experiencing the groundwater market by tanker and packaged water supplies have been selected for conducting the survey. The data collected from the interview schedule conducted with the village people were analyzed using the Statistical Package for Social Sciences (SPSS).

In order to estimate the approximate quantity of marketed water, enumerators were appointed at important road intersections for counting the tankers going from the peri-urban villages to urban areas. The total number of packaged water industries located in the villages was also counted. The secondary data, such as the groundwater level data collected from the State Groundwater Resources Data Centre and agricultural data, have been used to analyse the status of agriculture and the trend of fluctuation in the groundwater levels in the peri-urban water marketing villages. The characterization of the groundwater market and its quantification (Quantity of marketed water), the present status of the groundwater and agriculture have all been analysed by conducting frequent field surveys, stakeholders meetings, focus group discussions and interviews.

Land use maps were prepared for 2004 and 2008, using satellite data. The Survey of India Toposheets 66D/1 and 5 were used to delineate the drainage and road networks. Remote sensing data in the form of satellite imageries of IRS P6 LISS III + PAN of 2004 and IRS P6 LISS IV MX of 2008 were used for land use mapping. These latest satellite imageries were helpful and effective in the planning and management of land and water

resources. The land use/land cover details were mapped using visual interpretation techniques supported by other collected data.

As per the GEC-97 methodology, groundwater recharge was estimated based on the groundwater level fluctuations and specific yield approach. This method takes into account the response of the groundwater levels to the input and output components, and as such appears more scientific, realistic and directly measurable, unlike other approaches where assumptions need to be made for most of the components. In order to study the hydrochemistry and hydrogeology of the aquifer in the watershed, water levels and samples were collected from June 2009 to June 2010 and two sets of observations fall in pre monsoon periods and one set of observation falls in post-monsoon period.

For the identification of the groundwater potential zones in Mambakkam mini watershed, Remote Sensing and GIS techniques were widely used. It has been prepared by integrating the thematic information on geomorphology, geology, lineament, rainfall, pre-monsoon water level, depth to bed rock, soil, land use and slope by giving appropriate weightages.

Village level comparative survey was conducted to analyse the issues of groundwater market and its implication, agriculture and on peoples' livelihood in two selected peri-urban water marketing villages of Perumbakkam and Ponmar. The strategy of selecting samples was mainly based on farming and non farming households, with the duration of their total number of years of living in the particular village (i.e. recent settlers or long term settlers). Stratified random sampling technique has been chosen for selecting the respondents for the study. As much as 186 households from Perumbakkam and 82 households from Ponmar were selected and the sample

survey was ensured to cover all the settlements in the villages to know the socio-economic implications due to the groundwater market.

An economical evaluation has also been carried out to understand the value of water in the process of marketing and to find out who the greatest beneficiaries are. Economy and profitability of groundwater market were analysed using the data collected from focus group discussions and interviews conducted with the water selling farmers, non selling farmers, tanker owners and owners of packaged water industries. Governance issues related to groundwater development and management were also discussed and measures were suggested for safeguarding the land and water resources in peri-urban villages.

Though the analyses presented in this study are specific to Chennai, cities in developing South Asian countries generally faces challenges similar to Chennai. The prevailing informal nature of groundwater market especially for non agricultural uses is very common in the water scarce cities in developing as well as under developed countries in the world. Detailed review of literature for groundwater market in the same geographical region for urban uses demonstrates how it affects the peri-urban resources. Declining trend of agriculture and the depletion of water table force the people to move out in search of employment opportunities and vice versa. An identical impact has been analyzed by Diwakara and Nagaraj (2003) in adjacent areas of Karnataka. They argued that informal groundwater market has severe negative impacts on local food security and related employment opportunities. Over-drafting of groundwater induces the possibility of saline water intrusion and degradation of water quality in the aquifer due to its proximity to the coastal aquifer (Easter et al 1999 and Ruet et al 2007). In several places, farmers and local people have agitated over round the clock pumping of

groundwater from the agricultural wells to the city needs (Janakarajan 2004). Urbanization and people's reduced interest towards agriculture impacting the water resources severely. The prevailing groundwater market aggravates to this process in the peri-urban areas. Thus the presented study is confirms the same findings. In addition to that, by using the technical components, it quantifies the impacts such as reduced recharge and increased discharge of groundwater, percentage of reduction of recharge areas and economy behind the various activities of groundwater marketing.

6.2 CONCLUSIONS

The following are the major conclusions arrived at from the present study:

(i) The study to assess the techno-socio-economic implications proves that prevailing peri-urban informal groundwater market has induced high stress on land, water, agriculture and people in addition to the effects of urbanization.

(ii) Declining trend of agriculture has a direct relationship with the proximity to city. A village which is very near to the city experienced rigorous decline (28.9% to 94.36%) with respect to its proximity to city.

(iii) The land use analysis shows that about 25% of the total area under the category of agricultural land, waste land and water bodies has been changed to either settlements or industries. Areas of settlements and industries are increasing, whereas water bodies, agricultural land and waste lands have been declining during this very short period (2004-2008) proving that the land use changes and related impacts on land and water resources will be very significant in the long term run.

These factors significantly influence the recharge and discharge components that will distort the groundwater balance in the urbanising watershed.

(iv) Among the 42 sampling wells, 17 categorized as notified wells as their non monsoon fluctuation is more than monsoon fluctuation. Nearly 70% of notified wells are located in the water marketing villages such as Perumbakkam, Vengaivasal, Sittalapakkam etc.

(v) From the groundwater balance analysis, the stage of development of the Mambakkam miniwatershed is categorised as semi critical (i.e. where the groundwater resource assessment shows that the stage of development is more than 70% but less than 90%). The continuation of this trend without considering the recharge measures leads to a search for the water in deeper zones.

(vi) The hydrochemical analysis of the study reveals that the groundwater in the Mambakkam miniwatershed is hard to very hard, fresh to brackish and of alkaline nature. In the water marketing villages, which are very close to the urban centres, the quality of groundwater is affected significantly by the changes in land use, increased demand for groundwater and recharge of contaminated water.

(vii) The groundwater potential assessment indicated that most of the water marketing villages are located in the moderate potential area and area that belongs to the “very good potential” category is quite less in the entire study area (12%), which is dangerous to the existing development of the groundwater. It calls for proper monitoring and regulation of the commercial extraction of groundwater to prevent the

vulnerabilities of the aquifer in future. The developed groundwater potential zonation mapping may be helpful for further planning to improve a storage condition of aquifer for future optimal groundwater development.

(viii) The total estimated commercial extraction of groundwater from the Southern peri-urban area of Chennai is 36.3 MLD. Around 120-150 MLD of peri-urban groundwater is transferred and reaches Chennai from the Northern, Western and Southern directions to meet out the demand-supply gap.

(ix) By comparing two water marketing villages, Perumbakkam is significantly affected with the prevalence of groundwater market. As Perumbakkam is located in the immediate vicinity of the urban boundary, the effect of urbanization on land and water is comparatively high. In Perumbakkam, only 25% of the households have used packaged water in 2000. In 2009 - 2010, it increased to 55%. Due to the changes in quality, peoples' dependency on packaged water for drinking has increased significantly not only in the urban areas but also in the water marketing peri-urban villages.

(x) The economic analysis proves that poor (farming and non farming) people are affected more in the peri-urban villages, whereas water sellers (water selling farmers, tanker and packaged water suppliers and other intermediaries) attained remarkable benefits. The opportunity cost for the water selling farmer is very low as sale of water is more profitable than doing agriculture, whereas the opportunity cost for the non selling farmers is significantly high. Thus, the emerging water business is viewed as more lucrative than doing agriculture.

The prevailing groundwater market requires the support of governments to provide legal, social and economic environment and mechanisms will also be needed to ensure that trading does not impose external costs on the environment.

(xi) Even though groundwater related acts and amendments have given the direction to regulate, the governing authorities find it difficult to regulate, since it aids in minimizing the risk of water accessibility and serves to bridge the supply–demand gap.

(xii) Important water marketing and water potential areas should be preserved and protected from sources of contamination. The prevailing informal water market can be institutionalized through effective regulatory and legal mechanisms or by appointing an apex body to regulate the entire process. By this way, traditional users can protect their resource base and enhance the environmental sustainability.

6.3 SUGGESTIONS FOR FUTURE WORK

The conducted research is more reliant on source (peri-urban) area and investigated the marketing scenario, contribution to meet out the demand and its implications on the source area. The linkages such as water supply scenario in urban areas, different types of sources of water and their economy have not been explained. Various supply augmentation and conservation measures and the merits and demerits will be valuable in managing the demand for Chennai as in the cases of South Asian cities. Studies such as water pricing and incentive measures could be supportive to fine-tune the water management plans in water scarce areas. Future research can focus on these issues.