CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 Conclusion

Urban water management has multiple dimensions and large spatial coverage. The available literature on the subject indicates that there is definite need to develop a comprehensive Decision Support System (DSS) covering all aspects of urban water management with respect to space and time and long term sustainability of developed water supply scheme. The increasing demand of water for various purposes necessitates integration of storm water and reclaimed water management in the whole plan. Till now, various components of urban water system appear to have been integrated only partially. In full spatial expansion of a city, various stakeholders' demand water in different quantity and quality requirements are also not necessarily the same. This provides an opportunity to supply water from different sources. In addition to surface water sources (SWS) and ground water sources (GWS), stored storm water and reclaimed waters are emerging as potential alternate water sources (AWS). The present study is an attempt towards developing a full menu driven user friendly Spatial Decision Support System (SDSS) for Integrated Urban Water Management (SDSS_IUWM). The developed application has been checked with water related data of four cities of Uttar Pradesh (India) and the results have been analyzed with an objective of maintaining/ restoring long term sustainability of water supply infrastructure. Sustainability has been checked though the use of twenty two sub indicators of water supply scheme, grouped in seven categories under Pressure-State-Response (PSR) framework. The PSR scores have been calculated on 0-10 scale, indicating poor to critical, fair and excellent conditions. A new concept of Water for Development Planning (WDP) has been suggested and evaluated though formulating Water for Development Planning Index (WDPI) on a 0-10 scale.

Based on analyses of results, following conclusions may be drawn:

- The developed application SDSS_IUWM is user friendly and capable of handling both the spatial and non-spatial data as input. The software is independent and stand alone system. It runs on Windows operating system.

- Geographical Information System (GIS) functionalities can advantageously be used in taking decisions related with water supply, storm water estimation, roof top harvesting, surface runoff storage and study of ground water depletion.

- SDSS_IUWM has been designed with six modules covering various functional elements of urban water management: i. Water Demand (WD), ii. Water Supply (WS), iii. Wastewater Management (WWM), iv. Storm Water Management (SWM), v. Water Supply Sustainability (WSS), and vi. Water for Development Planning (WDP). Each module is supported with several sub modules. In total, there are 21 sub modules in the entire system.

- Relevant environmental, technical, socio-economic and legislative factors can be incorporated in the decision making process by following properly designed sequential steps. Application of various sub modules in SDSS_IUWM ably demonstrates this possibility.

- The knowledge base of developed SDSS_IUWM software is capable of supporting relevant parameters related with urban water management for planning purpose in case of unavailability of some field based data.

- Apart from technical, socio-economic, and environmental criteria, sustainability has emerged as important consideration in technology selection. Incorporating sustainability as the basis of selection adds a new dimension in multi criteria decision

making. Water for Development Planning Index (WDPI) sub module of SDSS_IUWM has been designed with this additional feature.

- Water for Development Planning (WDP) module includes a sub module of Scenario Analyses for WDP. Five improvement options of Water Supply Sustainability (WSS) have been identified. For the analyses of optimized suggestion, Analytical Hierarchy Processing (AHP) has been considered to assign weights to improvement options.

Application of SDSS_IUWM software has successfully been tested with water related data for Varanasi city (India). The major results of various modules for Varanasi city are as follows:

- The quantitative estimation of each component of urban water system in an integrated approach has been done. For Varanasi city, water demand, water supply, waste water, storm water is estimated as 100375 ML, 101105 ML, 78475 ML, and 51000 ML respectively on annual basis.
- Wastewater treatment technology selection (WWTTS) sub module has been designed to suggest appropriate technology based on reuse of treated wastewater and techno-economic viability. Sequencing Batch Reactor (SBR) is found most suitable technology for common reuse of (1) discharge to water body (2) industrial reuse (3) recreational and (4) firefighting whereas Up-flow Anaerobic Sludge Blanket (UASB) is found suitable for irrigation reuse.
- WDPI has been developed as a single index to evaluate integrated urban water management. WDPI is based on three objective functions: pressure, state, and response. Existing condition of urban water management in Varanasi, based on WDPI is found to be critical and likely to go towards worse, if no corrective or improvement steps are taken.

- Improvement options have been identified for water supply sustainability. Analytical Hierarchy Processing (AHP) has been considered to assign weights to improvement options. A target based prediction for year 2020, 2030, and 2040 have been made. Varanasi city shows an improvement from Critical condition to Fair condition by 2030, if suggested options of actions are implemented.

- Similar analyses for urban water management of Allahabad, Lucknow and Kanpur cities have been done using SDSS_IUWM. The results indicate that without proper planning for better management, the water sustainability in the year 2015 is found in critical condition and appears to be sliding down towards worse side for Allahabad and Lucknow. The Kanpur city is currently in fair condition, but may move to critical state in years 2020 onwards. A trend analysis of PSR scores and WDPI has been performed for all four cities. The State stands higher in all these cities, indicating that the water supply infrastructure and water quality level is reasonably well. The response scores are lower, indicating unsatisfactory condition of wastewater treatment, poor reuse of reclaimed water, less integrated storm water resources and poor water sector governance.
- Thus, all modules and sub modules of SDSS_IUWM appear producing results which are logical and justifiable.

Based on the analyses of results obtained and justification thereof, it appears that the developed software of SDSS_IUWM works excellently well in logical and scientific ways. This fulfills a much desired requirement in the area of integrated urban water management and may serve as a powerful planning and decision making tool.

7.2 Limitations of the Study

There are a few limitations with this study. Availability of data is a major concern for WDPI calculation. Statistical validation of weights of sub-indicator could be done which can improve the accuracy of WDPI. A strong correlation could not be established among the sub-indicators. Moreover, the weights may depend on the geological feature, practices and priorities of the urban area.

7.3 Future Scope

After rigorous analysis about the applicability of SDSS_IUWM, following recommendations may be made for further refining its components/interfaces:

- Enhancing accuracy of data may improve efficiency of the system and can predict when a city may fall in condition of dry-land or dying-city.
- Robustness of the system can be enhanced by defining the correlation among sub-indicators and objective functions of pressure-state-response.
- The developed system is generic and may be implemented over the internet. Web and network version of the SDSS_IUWM may be developed for better accessibility across different user groups.
- Improvement in methodology of weight assigning scheme in development of WDPI may enhance the effectiveness of WDPI to calculate WDP.
- Groundwater modeling of study area is likely to help in verifying the reliability of the developed system.
- The present form of SDSS_IUWM is designed for supporting decisions at planning level. The system may be improved to help decision maker in taking complete and detailed design as well.