PREFACE

Urban development is facing a number of challenges, particularly in the water sector. Rapid urbanization has put tremendous pressure on the extraction of natural water resources. Uncontrolled extraction has created water stress in the urban boundaries. Availability of water for development planning (WDP) must be checked if it has to be sustainable in long terms. In majority of cases, water management has been viewed as an exercise of meeting the requirements of domestic and industrial demands from surface and ground sources. The increasing population in urban areas requires large-scale infrastructure development. Development initiatives based on significant use of water must start from a realistic evaluation of water supply sustainability (WSS) within its boundary. Whereas production of water, its supply, and wastewater collection have come in the mainstream considerations, treatment of wastewater, reuse of reclaimed water and storm water management are yet to be internalized in the process of development planning to ensure long-term sustainability. An overview of available literature indicates that although a number of works have been done for integrated water resources management (IWRM) on river basin scale, there are relatively very few attempts for an integrated urban water management (IUWM) and evaluation of sustainability in given geographical conditions.

The objective of the present study is to develop a spatial decision support system for integrated urban water management (SDSS_IUWM) which may be used as estimating and forecasting tool to plan and coordinate between options to achieve long term water sustainability.

The developed SDSS has been named "SDSS_IUWM", precisely defining its applicability in environmental decision making for urban water management. A user friendly graphical user interface has been developed for SDSS_IUWM using the object oriented programming language, MS Visual Basic (VB.NET). An ActiveX control, ArcGIS Engine 9.3 is used to access and analyze the spatial data in the SDSS. Spatial data for the input purpose was prepared on ArcGIS 10.2 and QGIS 3.04.

Based on the need of the integration the quantitative estimation of urban water system components (water demand, water supply, wastewater, and storm water) has been done. Six modules in SDSS_IUWM have been named as "Water Demand (WD)", "Water Supply (WS)", "Wastewater Management (WWM)", "Storm Water Management (SWM)", "Water Supply Sustainability (WSS)", and "Water for Development Planning (WDP)".A reuse based wastewater treatment technology selection (WWTTS) has been introduced. The final result is expressed as a single index, named "Water for Development Planning Index" (WDPI). This index is a number on 0-10 scale indicating the condition of availability of water for new developments and expressed as Poor, Critical, Fair, and Excellent for WDPI less than 3, 3-5 , 5-8 and >8 respectively. WDPI has been formulated on the lines of Pressure-State-Response (PSR) framework, used by Organization for Economic Cooperation and Development (OECD). The PSR framework is based on the concept of causality: human activities exert "pressures" on the environment including natural resources and change its quality and quantity ("state"). Society responds to these changes through environmental, economic and sectoral responses ("societal responses").

The developed application of SDSS_IUWM has been tested with data for four cities of India, namely Varanasi, Allahabad, Lucknow and Kanpur, taking 2015as base year. The results of various modules and calculation of WDPI show that except Kanpur, all other

cities are presently in critical condition (WDPI <5) of water availability and it will be moving towards lower side of critical situation in future decades, if no corrective measures are taken. With target based improvements in the urban water supply using selected options, all cities improve to fair condition (WDPI : 5-8) and Kanpur improves to higher side of the fair condition.

It is believed therefore that the developed software of SDSS_IUWM fulfills a much desired need of integration in urban water management and planning in an urban setup. Potential use of GIS and DSS in integrated urban water management is yet to be fully appreciated by planners and decision makers especially in developing countries. The developed SDSS_IUWM in the form of user friendly software is expected to be useful for various government and non-governmental agencies working in the field of urban water management. It is hoped that with more tight coupling and better reliable data, the SDSS_IUWM may be developed as a commercial tool for integrated urban water management planning.