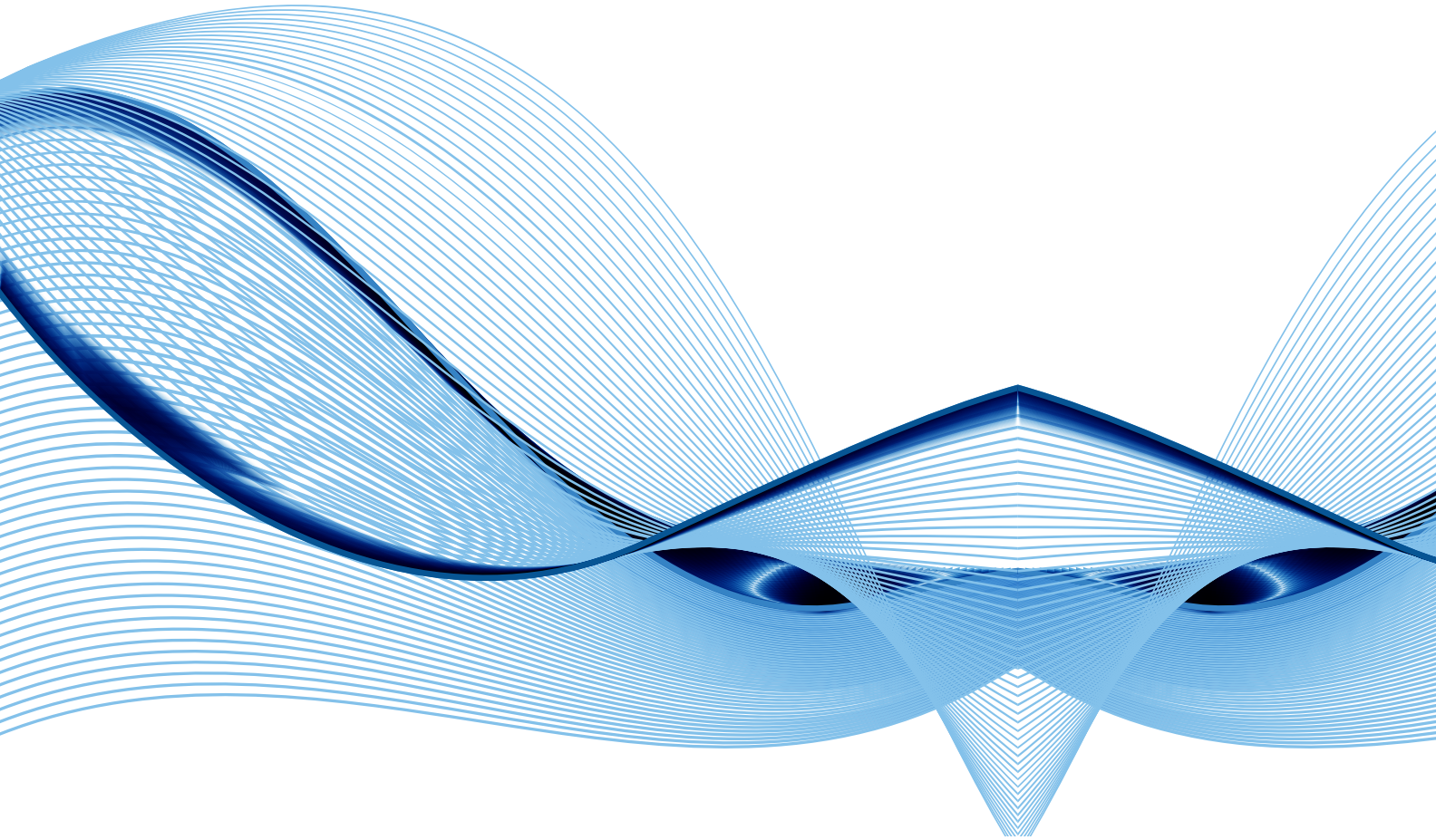
# Sustainable Groundwater Management in Lucknow City

## Executive Summary

**Project**

Special Studies for Sustainable Ground Water Management and Ground Water Auditing in Stressed urban area of Lucknow under UPWSRP-II



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The Energy and Resources Institute

*Creating Innovative Solutions for a Sustainable Future*

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# Sustainable Groundwater Management in Lucknow City

Ground water has gradually become the main source of water in Indian cities putting tremendous pressure on their aquifers. In Lucknow, River Gomti has been the main source for drinking water, however, the dependence of municipal water supplies on groundwater has increased significantly, making it a predominant source for city's water supplies. During summer season most of the surface water bodies do not have sufficient water and also surface water is not available locally and needs to be transported. On the contrary, ground water is easily accessible throughout the year and can be extracted easily through tube wells. This is leading to excessive exploitation of groundwater and rapidly declining water table.

With this perspective, Groundwater Department, Ministry of Jal Shakti, Government of Uttar Pradesh initiated a study with the support from The World Bank, to conduct a comprehensive assessment of groundwater resources of the city and project the likely groundwater levels by 2030. Key objectives of the study were

- Auditing of Ground Water resources within urban limits of Lucknow City through assessment of availability, demand, extraction, and uses in different sectors.
- Estimate the overall contribution of groundwater to Lucknow's economy
- Assessment of groundwater contribution in meeting the drinking water demand in the different areas
- Project the Groundwater quality dynamics and its impact on health and environment.
- Project different groundwater development scenarios using computer model for next 10 years.
- Recommendation for improved groundwater management and governance involving all the different stake holders.
- Demarcation of hydrogeological setup of Lucknow City.

The Energy and Resources Institute conducted the study in collaboration with Department of Geology, University of Delhi and developed a zone specific strategy for the Lucknow city to manage its groundwater, sustainably.

## Urban Water Audit

Water resources horizon of a city consists of 5 specific dimensions:

i. Water Availability: It involves the quantity of water available through all the sources – surface, rain or ground, for utilization within the city.

ii. Water Quality: It involves the quality of water from all the sources.

iii. Water Demand: It involves the demand for water from different type of user – domestic, industrial, commercial or agricultural within the city limits.


**FIGURE 1:** Key Aspects of Water Sustainability Audit

iv. Supply and Distribution: It involves the system comprising of extraction of water from the source, its treatment, storage and pumping for consumption by end users.

v. Policy and Governance: It involves the various rules, regulations, policies as well as administrative mechanism for governance of water within the city.

To build a comprehensive understanding about the water scenarios in the Lucknow city, all these dimensions were assessed and integrated to develop a Sustainable Groundwater Management Plan. Key results as well as the key recommendations from the study are being presented in this document for a wider dissemination and generate awareness as well as sensitivity towards the depleting water resources in the city.

## Demand for Groundwater

To make a realistic assessment of groundwater utilization, pattern of its demand, trend of its exploitation and recharging/ conservation practices, a survey was conducted across the Lucknow city. The city was divided into specific zones based and their demographic characteristics. Each zone was further subdivided into grids of 2 X 2 km size, depending on the density of population or major type of settlements, type of water users etc. Different water users within the grid were divided into three classes: 1. Domestic users in multistoried buildings; 2. Domestic users in independent houses; 3. Bulk/ commercial users like hotels, hospitals, malls, offices etc. A smart phone based app was developed with the option for three sets of questionnaires, with the feature of collecting coordinates as well as voice recording for survey interviews.

Key results of Demand survey:

» At present, groundwater exploitation in the Lucknow city during pre-monsoon is about 17 times more than the combined recharge from rainfall and Gomti River in to the groundwater system.

» In Lucknow city, 71% households are supplied with water by Jal Sansthan and 72% households use groundwater, indicating that almost 43% households use both the sources.

» Maximum coverage of supply water is in west and north Lucknow and least in south and east Lucknow.

» Survey among different water users indicate that 91% multistory group housing societies

and almost 70% of Lucknow's commercial users - Hotels and Restaurants, Hospitals, Offices, Malls and Schools, are dependent on ground water.

» Almost all the surveyed societies in central, north and east Lucknow are extracting groundwater, through their own borewells and almost 60% of these borewells are more than 200 feet deep.

» While PVC tanks are the popular mode of water storage, use of overflow bell to indicate the filling of water storage tank was not found to be very popular in the city and majority of people rely on conventional techniques to identify the filling of tank for switching off the pump.

» While majority of household reported no problem with the quality of water but the same is not used for drinking purpose without a purifier. On an average 64% of households reported about the use of water purifier, of which 3/4$^{th}$ are reverse osmosis (RO) systems.

» Atleast 25% of commercial users also reported that since the drilling, they have increased the depth of their borewells by almost 100 m, due to lowering of water table in their area. Majority of hotels and organised sector restaurants were found to be having dual water supply system – they had connection from Jal Sansthan as well as their own borewells to meet up their demand for water.

» There are 61 tubewells within the cantonment board, out of which 45 are mini tubewells with 1 HP submersible pumps. While information about the number of times and duration of pump operation was not available, daily water abstraction within the cantonment board is likely to be in the range of 2.4 MLD.

## Groundwater and Economy of Lucknow city

Study also tried to estimate the footprints of Groundwater in the city's economy. Total contribution of groundwater to the economy of Lucknow is estimated to be atleast 1/3rd of city's GDP.

Borewell drilling, market for submersible pump, PVC pipes and storage tanks, as well as water purifiers constitute direct footprints and contribute close to 2% of city's annual GDP. However, survey among different water users indicate almost 70% of Lucknow's commercial users - Hotels and Restaurants, Hospitals, Offices, Malls and Schools, are dependent on ground water. As such economic contribution of groundwater to the city's GDP is manifold.

» Food Service Industry (FSI) through restaurants/ fine dining etc. comprises almost 60% of commercial users, and contributes around 11% to the city's GDP which is equivalent to Rs. 3000/- Crore.

» Approximately, 42 Lakh tourists visit Lucknow, annually and contribute around 7.9% of city's GDP, which is equivalent to Rs. 2100/- Crores.

» Educational services, Health services and Recreational, Cultural and Sports activities contribute around 8.3% to the city's GDP, which is equivalent to Rs. 2800/- Crores.

Thus, the total contribution of groundwater to the economy of Lucknow can be estimated to be about Rs. 8400/- Crore, which is almost 1/3rd of city's GDP. An inclusion of subsequent indirect contribution from these industries (FSI, tourism and other services) to the city's GDP has the potential to influence the entire economy of the city.

## Groundwater Abstraction and Future Scenarios

Lucknow city has crossed threshold of aquifer resilience at its present level of groundwater exploitation. Currently, groundwater exploitation during pre-monsoon season is about 17 times more than the combined recharge from rainfall and Gomti River in to the groundwater system. Based on the present groundwater abstraction pattern, the city can be divided into 5 specific zones – A to E. Zone A, B and C comprising the central parts of the city, have extremely high levels of groundwater abstraction.

If the present level of aquifer exploitation continues for the next decade up to the year 2031, the groundwater levels in the first aquifer are going to decline to unsustainable levels in many parts of the city. It is predicted that by year 2031, the groundwater levels in the central area of the city comprising localities like Charbagh Railway station, Cantonment, Lucknow University etc., will decline further by about 20 to 25 meters from the present groundwater levels of year 2020. Besides, localities on fringes of the Lucknow city will also have decline of the groundwater level in the range of 5 to 10 meters by year 2031.

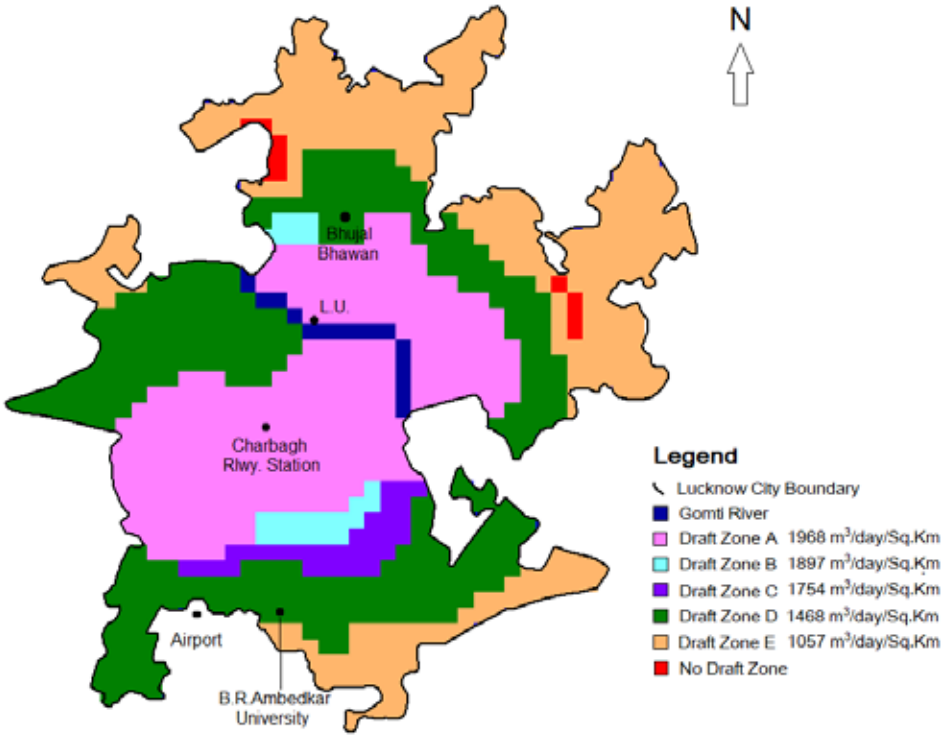


**FIGURE 2:** Groundwater abstraction zones of Lucknow city

| S. No | Zone | Average Abstraction ($m^3$/ day/ $km^2$) | |
|---|---|---|---|
| 1 | Zone A | 1968 | Alambagh, Cantonment, Charbagh Railway station, Gomti Nagar, Lucknow University |
| 2 | Zone B | 1897 | Cantonment Area, Old Lucknow around Peeli Kothi area |
| 3 | Zone C | 1754 | Area adjacent to Cantonment Area in south |
| 4 | Zone D | 1468 | West and South Lucknow, Area around Kathauta Jheel |
| 5 | Zone E | 1057 | Peripheral Area in Norh Lucknow, Area towards south-east of Amar Saheed Path |

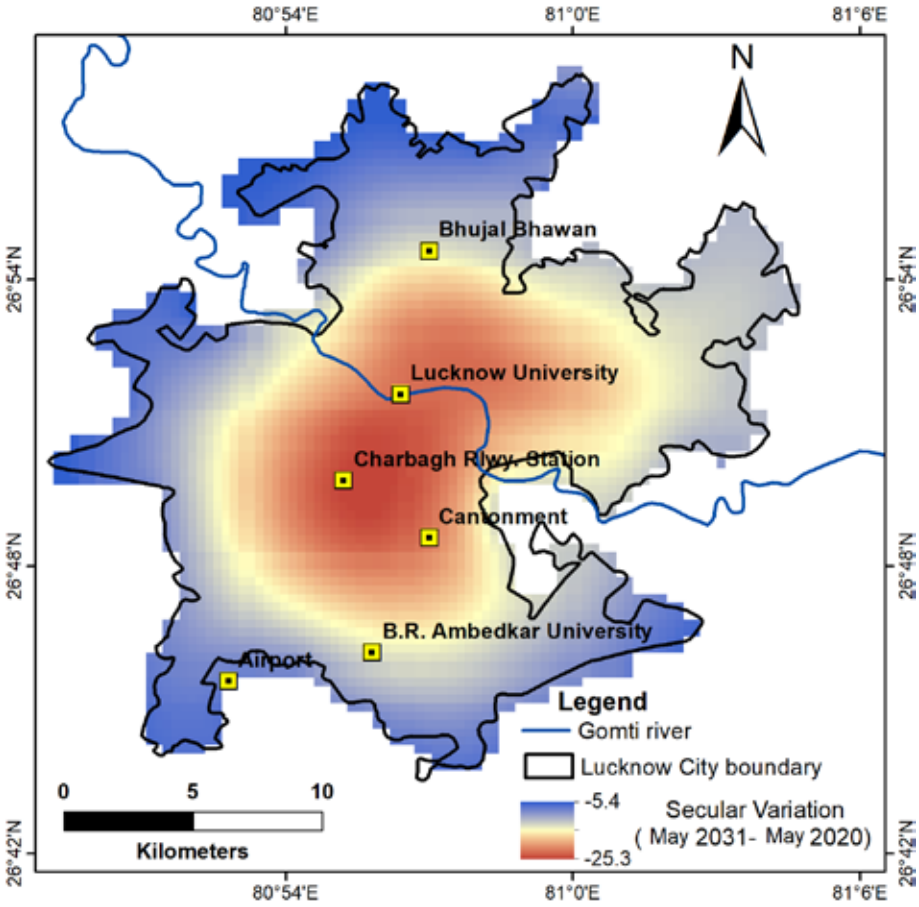


**FIGURE 3:** Map showing predicted decline in the groundwater levels of pre monsoon 2031 with respect to pre monsoon 2020

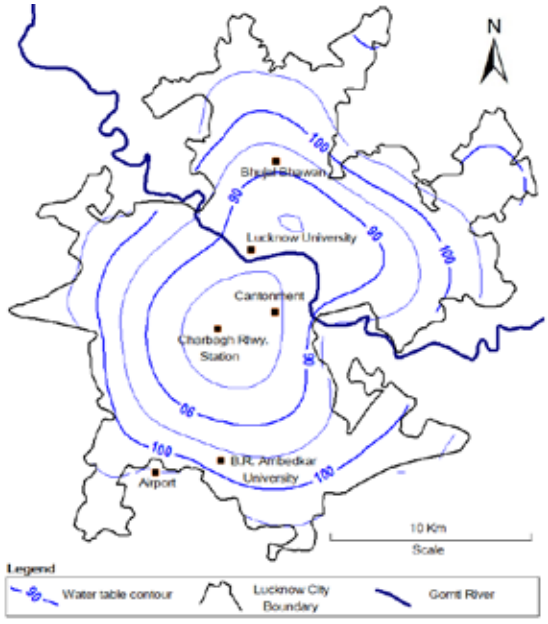


**FIGURE 4A:** Model generated water table contour of the Lucknow city for pre monsoon season of the year 2016

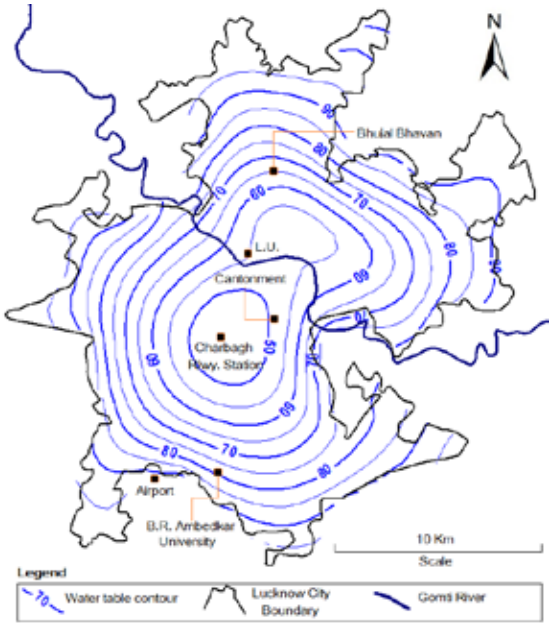


**FIGURE 4B:** Model predicted water table contour map of Lucknow city for the pre monsoon season of 2031 assuming no change in groundwater abstraction for period 2020-2031.

Growing urbanization, improvements in living standards, exploding population are just some of the contributing factors to the water stress in Lucknow city. With climate change and increasing temperature, the problem is bound to be aggravated in the near future. Given the scenarios of depleting groundwater table in the city region, it is necessary to adopt zone specific strategies to ensure sustainable management of groundwater in Lucknow city.

## Key Recommendations

» Accordingly, zone specific strategies have been proposed for sustainable management of groundwater in Lucknow. For overexploited Zone A, B and C, water extraction need to be reduced upto 100 MLD, considering the practicality and cost to be incurred.

## Strategies for Zone A, B and C

Average abstraction in Zone A, B and C is >1750 $m^3$/day/ km, which is unsustainable, given a very low recharge rate for the city. Hence, a uniform strategy need to be adopted for these zones.

**Reduce the groundwater abstraction**

Considering the high volume of groundwater abstraction in Zone A, B and C, it is strongly recommended to reduce its extraction. Alternative scenarios were developed using the calibrated and validated groundwater flow model of the Lucknow city, by reducing the groundwater abstraction by 25% and 50%, respectively, in the target wells. Results indicate an improvement of about 33% in the water table by 2031, under 50% reduction scenario and 15-20% under 25% reduction scenario.

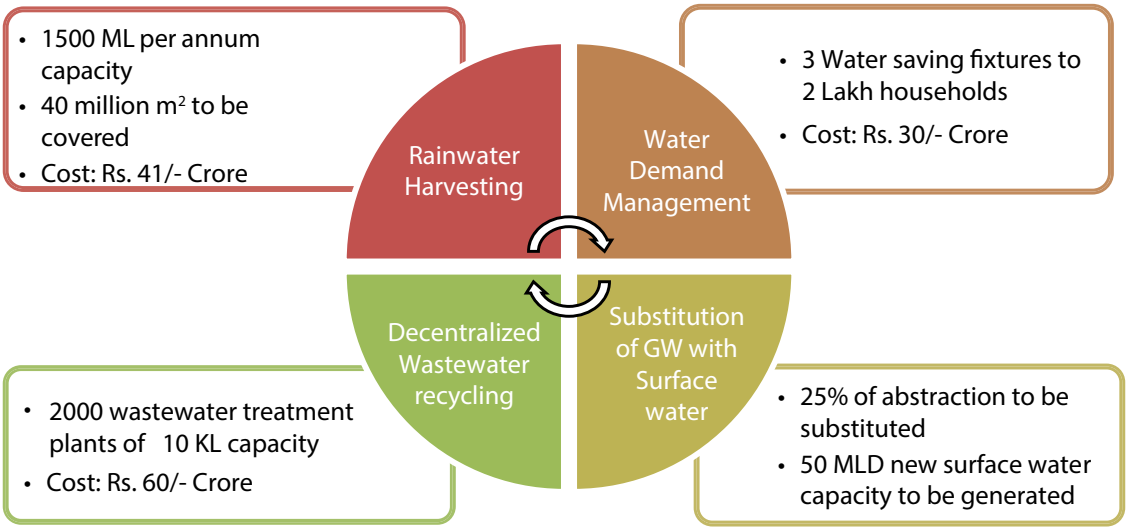


**FIGURE 5:** Strategies for Groundwater Management in Zone A, B and C

The present day abstraction from these zones is about 200 MLD, and reduction by 50% requires it to be reduced to 100 MLD. Future increase in water demand from these zones is supposed to be minimal, considering the Master development plan from LDA and major development being concentrated in the peripheral areas of Lucknow by inclusion of new villages under the city area.

***Strategies for reduction in groundwater abstraction***

A 4-way approach is suggested to achieve the reduction in groundwater abstraction considering the practicality and cost-benefit perspectives:

i. **Rainwater harvesting:** Considering the limited duration of actual rainfall days in Lucknow city, a capacity of 1500 ML per annum of rainwater harvesting can be created. This will require a surface area equivalent to 40 million $m^2$ and an investment of about Rs. 41 crore.

ii. **Reduction in groundwater demand:** Use of water saving fixtures has the potential to reduce daily per capita water requirement upto 1/3rd of the current demand. This will require an installation of atleast 3 water saving fixtures per household for around 2,00,000 households in these zones. An immediate cost requirement for these fixtures will be about Rs. 30 Crore.

iii. **Decentralized wastewater recycling:** Decentralized wastewater treatment plants of 10 KL capacity need to be installed at commercial complexes, multi-story complexes, group housing societies etc. Installation of 2000 such plants of 10 KL capacity each, can reduce the water demand of these zones by 20 MLD. This will require an immediate expenditure of around Rs. 60 Crores.

iv. **Substitution of groundwater with surface water:** To ensure the sustainable

management, it is necessary to substitute current groundwater supply with the surface water. It is estimated that for Zone A, B and C, a quantum of about 50 MLD of groundwater need to be substituted with the water supply from alternate surface water sources. This quantum will be equivalent to 25% of the abstraction in these zones or 14% of the city's total groundwater abstraction. Surface water sources present within these zones like Haidar canal and Moti Jheel could be most promising for the purpose, and can be developed practically to provide requisite amount of water. Total cost for the substitution head can be developed based on the detailed project report for the identified source.

Thus, it is recommended that an immediate allocation of requisite funds for the proposed physical interventions in the RWH, demand side management and wastwater recycling be made from the city/ state's financial resources, and these measures be implemented on an urgent basis. Further, a study for building Detailed Project Report (DPR) for construction of new water works be commissioned on an immediate basis.

### Strategies for Zone D and E

It is estimated that current abstraction of groundwater in Zone D and E is about 150 MLD. However, these zones are more likely to present an increase in water demand under future scenarios due to expansion of city and construction of new housing complexes. Hence, a mix of targeted demand management strategy along with the wastewater recycling need to be adopted for the zone. Mandatory guidelines for new residential/ commercial/ infrastructure projects within these zones should be implemented for rainwater harvesting as well as waste water recycling.

Zone E has comparatively lesser amount of groundwater abstraction and being located on the upstream side/ periphery of the city aquifer, has strong potential to feed the other overexploited zones of the city. Hence, it is proposed to use this zone for the artificial recharge of city's aquifer. With an area of about 200 km2, this zone offers the possibility to install a number of recharge structures and a total capacity of about 7500 ML per annum, can be established in the zone.

Thus, it is recommended that an immediate allocation of requisite funds for the proposed physical interventions in the RWH, demand side management and wastwater recycling be made from the city/ state's financial resources, and these measures be implemented on an urgent basis. Further, a study for building Detailed Project Report (DPR) for construction of a new water works be commissioned on an immediate basis.

## Policy interventions

» Reducing water footprints by commercial/ bulk users and including Water conservation / Watershed management should be made a CSR activity. This will encourage water users to adopt these activities simultaneous to other CSR activities.

» Development of Water Budget and Water Management Plan by commercial/ bulk water users/ group housing societies and societies with multi-storied buildings should be made mandatory.

» City level infrastructure (both water as well as non-water like roads, building projects etc.) as well as programmes should be prepared with due consideration to the micro-watershed profile of the city.

» Metering the water connections and adopt a differential tariff strategy based on various slabs of monthly water consumption. Also, mandatory provision for individual water meters in each flat of the multi storied housing societies shall be adopted.

## Interventions to ensure community participation

Residents expressed their concerns during stakeholder consultation workshops, and suggested for their involvement in the groundwater management plans for the city. Hence, it is proposed that

» A statutory wing under the District Groundwater Management Council be formed along with a recurrent plan on generating and elevating public awareness towards declining water table and conservation of groundwater.

» Form Water Help Groups / Water users association (WUA) with members trained to take care of water conservation activities at the local level. Easy line of credit for implementation of water conservation measures should be made available to the groups.

» Form 'commercial water user groups' and engage commercial and bulk users in groundwater management. Moreover, a mechanism similar to 'fire safety control' need to be placed for water conservation in premises of every commercial user having a specifically designated team of water warriors within the organisation.

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