Urban Sprawl and Problems of Water Resource Management with Sustainable Techniques for more Resilient City

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Abstract: *The urban areas because of availability of different means of earning livelihood in a more or less compact area and availability of necessary facilities for comfortable living in a consolidated area including utilities and services, shopping, recreational and cultural facilities, educational facilities, means of communications and movement, turn as main spot of languishing water resources. This paper focuses on the various problems that Chandigarh is facing at present in relation to water availability and decline of water table mainly, because water is extracted from the deeper aquifers for water supply and natural recharge of confined aquifer is not taking place and yet, water is pumped out from these aquifers. Chandigarh is expanding and turning as a metro city on faster pace, and there is immediate necessity of implementation of water management techniques like "rain water harvesting" and "artificial recharge" as such sprawling cities have to cope with growing pressures, especially for resource supply. For sustaining this precious declining resource, a demonstrative scheme on 'Rain water harvesting and artificial recharge to groundwater covering the entire campus of Panjab University, Sector- 14, Chandigarh' is adopted and is reached in its construction phase. This project aims to utilize the available run-off in the University campus, which otherwise, goes to drains and squatters on the roads to augment the groundwater resources for beneficial use. With proper planning, management and implementation of these techniques, developing cities like Chandigarh can be considered as resource reservoirs and can lessen the stress on available surface water and groundwater resources ultimately by reaching the goal of "Management for Sustainable Urbanization".*

Keywords: *Rain water harvesting, artificial recharge, aquifer, confined aquifer, resilient, run-off, sustainable.*

1. Introduction

Almost half of the human population of our earth is living in urban areas and this population growth is expected to increase more as the availability of necessary facilities for comfortable living in such consolidated area including utilities and services, shopping, recreational and cultural facilities, educational facilities, means of communications and movement, can be availed at ease so these urban areas turned as main spot of languishing water resources.

Ultimately these urban areas, mainly cities have to cope with undefined growing pressures, especially for resource supply and maintenance in relation to the public use. Already, humans use more than one half of all accessible surface water runoff. This proportion is expected to increase to 70 percent by 2025, thereby reducing the quantity and quality of water available for aquatic ecosystems [1]. The main reason for these untenable water resource problems are due to its excessive usage beyond the natural supply and recycling limit and are raised due to urban sprawl.

Urban sprawl is the unplanned, uncontrolled spreading of **urban** development into areas adjoining the edge of a city. Urban sprawl, and the economic and regulatory systems which create it, not only produce an inefficient and unpleasant environment on the urban fringe, but adversely affect the inner city and the rural areas as well [2]. "There will be constant competition over water, between farming families and urban dwellers, environmental conservationists and industrialists, minorities living off natural resources and entrepreneurs seeking to commodify the resources base for commercial gain" as per UNICEF report on Indian water [3].

Table 1: Estimated annual requirement of water in India in BCM (by different uses)

Sl No.	Sector	2000	2025	2050
1	2	3	4	5
1	Domestic	42	73	102
2	Irrigation	541	910	1072
3	Industry	8	23	63
4	Energy	2	15	130
5	Other	41	72	80
	TOTAL	634	1093	1447

(Source: Central Water Commission, 2000) [4]

Union territory of India- **Chandigarh,** one among the pre- planned and designed cities is also facing the burden of urban sprawl. The exploding urban sprawl has created many unprecedented challenges, among which the provision for water resource conservation and management that is in term of quality and quantity have been the most pressing and painfully felt when it is being focused for our sustainable future.

This paper focuses on the various problems that Chandigarh is facing at present in relation to water availability and decline of water table mainly, because water is extracted from the deeper aquifers for water supply and natural recharge of confined aquifer is not taking place and yet, water is pumped out from these aquifers. The technique of "Rain water harvesting" and "Artificial Recharge" to groundwater is proposed and implemented by government in various buildings and institutes as a management tool to lessen the impact of problems being faced by water resource management strategies for following the path of more resilient cities to achieve sustainability goals.

2. Location of the study area

Chandigarh is a Union Territory (U.T.) located at the foothills of the Siwalik about 250 Km north of Delhi. The city also has the distinction of being the joint capital of Punjab and Haryana states even though it does not form part of any of the two States. It lies between north latitudes $30^{o}40'$ and $30^{o}46'$ and east longitudes $76^{o}42'$ and $76^{o}51'$and falls in Survey of India topographical sheets no. 53B/13 & 53B/14.Total area of Chandigarh is 114 Km^2, out of which 36 Km^2 is rural and remaining 78 Km^2 is urban and well developed area. The city is divided into 55 dwelling sectors. As per census 2011, the population density of Chandigarh is 9252 persons/ Km^2 (that makes it the second most densely populated city after Delhi).

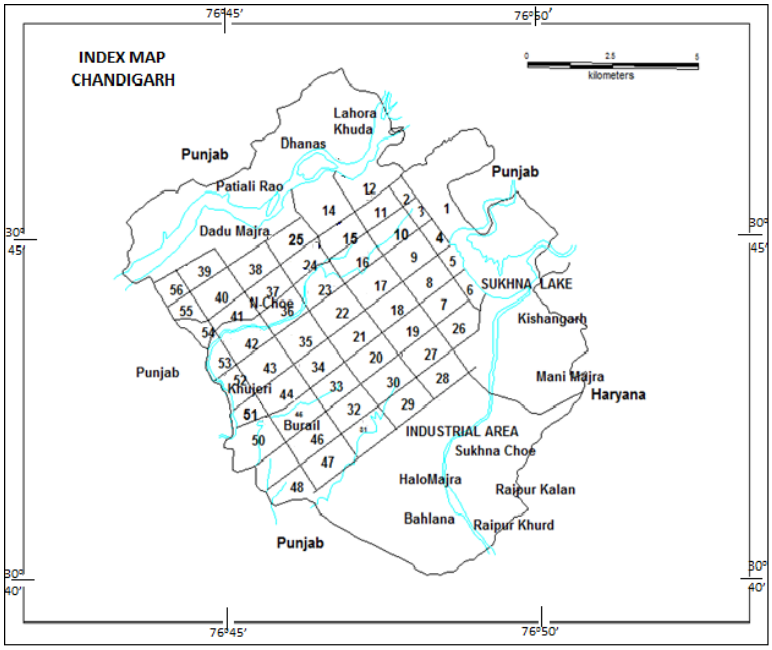
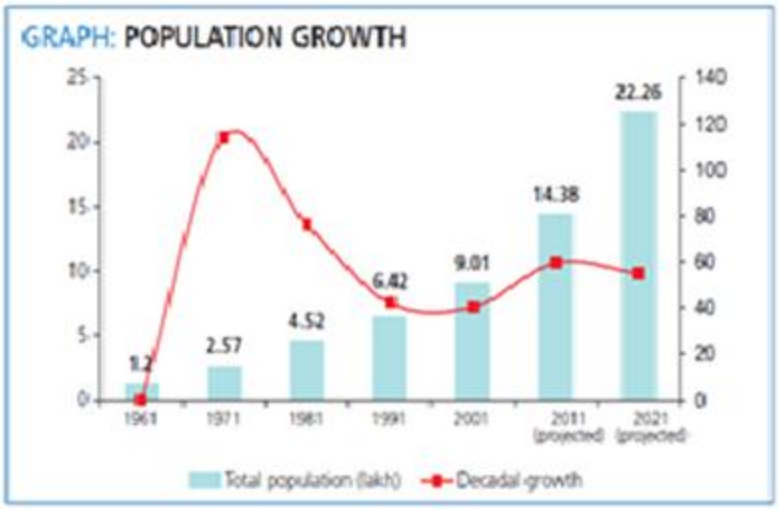


Figure 1 : Map of Chandigarh

The city was originally planned for 1.5 lakh people and the first 30 sectors were planned for this population. Later additional sectors were planned as the population increased to 5 lakh and this population growth is directly linked to the urban sprawl and this is expected to grow more which is ultimately increasing problems in this region.



(Source: Centre for Science and Environment 2010) [5]

Figure 2 : Graphical representation of decadal population growth in Chandigarh

Chandigarh is emerging as a regional hub in areas like education, health, information technology, food processing and service industries. Several new initiatives are being planned such as the Medi City, IT Park for the coming years that can increase pressure on land and water availability and also on their quality.

3. Problem observed

Against the background of envisaged economic growth and the resulting population, the water needs of Chandigarh will grow at faster rate. But water availability will not grow parallel leading to water stress and resultant conflicts. In the present scenario, Chandigarh administration is unable to cope up with the demand of water resource as Chandigarh does not have any surface water source and the available groundwater source is declining. Tube wells are present in almost every sector of the city but the requirement of increasing their depth in ground is observed to establish balance between supply and demand. The tubewells in Chandigarh are tapping only the deeper aquifer system which causes fall in piezometric head of deeper aquifer system; whereas water level in the shallower aquifer system is rising [6].

Water scarcity in the tricity at the beginning of summer season often left residents high and dry and this problem is more marked in southern sectors where numerous housing societies are located. The water shortage is likely to get worse in the coming years as the sprawl is occurring on faster pace. In addition, there is a large floating population and a slum population is being rehabilated along with future plans for the city. Hence the demand of water for other purposes such as industrial and commercial will also increase concurrently with the demand for domestic water demand [5].

The present assessment of groundwater quality in the study area indicates that it is fit for drinking purposes except for a few locations but it may deteriorate in future, as is evident from the very high percentage of water samples falling beyond the desirable limits taken from the shallow aquifer and almost approach the maximum permissible limit [7].

4. Research significance

The greatest threat to maintaining freshwater supplies is depletion of the surface and groundwater resources that are used to supply the needs of the rapidly growing human population [8].
This paper focuses on the various problems that Chandigarh is facing at present in relation to water availability and decline of water table mainly, because water is extracted from the deeper aquifers for water supply and natural recharge of confined aquifer is not taking place and yet, water is pumped out from these aquifers. Groundwater in the area occurs under water table, confined as well as semi-confined conditions. Water table elevation study reveals that the flow of ground water is from north to southwest and southern directions. Chandigarh is expanding and turning as a metro city on faster pace, and there is immediate necessity of implementation of water management techniques like “rain water harvesting” and “artificial recharge” as such sprawling cities have to cope with growing pressures, especially for resource supply.

Urbanization brings the water from streets and rooftops directly into drains instead of filtering it naturally through the soil and thus recharging the aquifers. In short, in Chandigarh though the natural recharge to the aquifers is very less but water from the deeper aquifers is being pumped out. To ensure the long term sustainability of the water resources of the city rain water harvesting system is recommended and care should be taken to avoid further contamination and degradation of shallow aquifer system and overexploitation of groundwater from deeper aquifer [7].

For sustaining this precious declining resource, a demonstrative scheme on ‘Rain water harvesting and artificial recharge to groundwater covering the entire campus of Panjab University, Sector- 14, Chandigarh’ is adopted and has completed its construction phase and now reached in first stage of working phase. This project aims to utilize the available run-off in the University campus, which otherwise, goes to drains and squatters on the roads to augment the groundwater resources for beneficial use.

5. Methodology

To identify the soil profile, integration of thematic layers i.e land use, geomorphology, geology, hydrogeology, storm water and sewage network have been done. These layers are derived from conventional methods through geographic information system(GIS) application.
The work on mapping is divided into three parts:

- Collection of data related to land use, land cover, commercial areas, parks and important buildings, schools etc. is done through maps. Borehole logs have been collected to get an understanding of the soil profile below surface.
- Geo referencing of all maps is done for the projection of geographical latitude and longitudes with best softwares available.
- Digitization is the third step after the geo-referencing of maps and transferred to illustrator

for final map work in which different layers according to preferences of visibility is marked.

After the preparation of the thematic layers decision about the solutions are taken to solve water crisis and the flooding problems according to the sites.

6. Conclusions

Decline in water level is due to over exploitation of ground water resources from the potential aquifers and pay back to these aquifer is almost nil. Natural infiltration or seepage of water is limited only up to shallow aquifer zone and this is leading to water logging in many areas of Chandigarh region. Whereas water is extracted from confined aquifers, which is causing fall of piezometric head of these deeper confined aquifers; it is essential that pumping from the deeper aquifers has to be reduced and that from the shallow aquifers to be increased.

Chandigarh is a highly urbanized city and the rooftop of the buildings can be suitably used for artificial recharge of the rainfall falling in Chandigarh. There is lot of green area too and some areas that can also be effectively utilized for recharging the rainfall runoff to augment groundwater resource.

Artificial recharge of the deeper aquifer should be taken up to arrest the decline in the piezometric head. With proper planning, management and implementation of these techniques, developing cities like Chandigarh can be considered as resource reservoirs and can lessen the stress on available surface water and groundwater resources ultimately by reaching the goal of "Management for Sustainable Urbanization".

7. Recommendations

For the urban areas specifically where whole locality is dependent on groundwater as the only water supply resource, water resource management with sustainable techniques is the only alternate left itself. There is a need to put in place system for the following:

- Rainwater harvesting : Storage and Maintenance
- Artificial recharging to groundwater
- Recycle and reuse water, both at the centralized and at decentralized levels.
- Demand side management measures: Reduce demand through the use of water efficient fixtures, water conservation measures.

It should be made mandatory for all the buildings having a roof area of more than 250 sq. meters. Routine water quality samples have to be obtained from the water supply wells and monitoring wells located between the water supply wells and the recharge basins to assess whether the artificial recharge may be adversely impacting water quality. Furthermore, basic water quality parameters such as specific conductance, hardness and alkalinity can be measured in the recharge basin and in water derived from the wells to estimate the percentage of artificially recharged water that is being recovered. In addition, water level monitoring in near-basin monitoring wells should also be obtained on a fixed frequency. This will allow the project manager to measure the effectiveness and potentially optimize the operation to artificially recharge the aquifer.

There is also a need to put in place a number of measures to create awareness among the people about the importance of water conservation and incentivize them to use water carefully and wisely. The structural maintenance and proper management in these Artificial Recharge techniquessss is impossible without people's participation. It is also the responsibility of planning and governing authorities to monitor and guide groundwater development to promote its sustainable management, promote environmental awareness and water quality consciousness, impart training and promote applied research.

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