Rainwater harvesting (RWH) potential assessment for micro-watersheds in highly urbanized city using geo-spatial techniques

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***Abstract*—Rapid growth of cities across the world is leading to heavy pressure on water resources with many urban centers facing crisis in water supply. Still, the water quality supplied is not-potable, services are irregular, water wastage is high, with much of the poor strata not having access to piped water, and corporations do not collect the funds needed for maintenance and operation. To address this crisis, many urban centers are investing in expensive water supply rehabilitation and expansion projects, often with the assistance of the World Bank and other agencies. However, little is being done to protect the sources of water. Urban watersheds and their biodiversity are being degraded by uncontrolled use, resulting in poorer water quality; threats to human health, seasonal water shortages & aquifers are being polluted and depleted.**

As the water crisis continues to become severe, there is a dire need of reform in water management system and revival of traditional systems. Scientific & technological studies need to be carried out to assess present status so as to suggest suitable mitigative measures for the revival to traditional system/wisdom. Revival process should necessarily be backed by people's initiative and active public participation.

In order to properly manage the changing conditions, knowledge and estimation of the available resources and applying their relation with the population is of utmost importance. The paper deals with extraction of such information with the help of spatial techniques. This paper deals with estimation of the amount of rainwater harvesting potential for micro watersheds of Nag river watershed using geo-spatial techniques.

***Index Terms*—Geo-spatial, Micro-watersheds, Rainwater harvesting, Urban Area**

I. INTRODUCTION

In India, the paradigm of managing water has followed two interconnected routes – firstly, the state took upon itself the role of sole provider of water. Among other things, this led to communities and households being no longer the primary agents of water provision and management secondly, the earlier use of rainwater and floodwater declined. In its place, there came a growing reliance on surface water (primarily rivers) and groundwater.

Today, the effects of this way of managing water are clearly visible. There is complete dependence on the state for any kind of water provision. It is a kind of fostered parasitism since the state, via its bureaucratic machinery, does not seem to possess the will to alter such a situation. Such has been the level of extraction from rivers that most of India's river basins have degraded and the rivers are polluted. Large dams are the major source of water storage, and canals are the major distributary route. The former have caused large - scale community displacement and ecological havoc. The latter, large-scale land degradation via soil salinization is responsible for migration of population. (2)

Groundwater resources have been heavily over-used. Thus water availability, both in terms of quality and quantity, has declined to such an extent that many parts of India, rural and urban, today face a drought-like situation. Urban centers in India are facing an ironical situation today. On one hand there is the acute water scarcity and on the other, the streets are often flooded during the monsoons. This has led to serious problems with quality and quantity of groundwater.

This is despite the fact that all these cities receive good rainfall. However, this rainfall occurs during short spells of high intensity. (Most of the rain falls in just 100 hours out of 8,760 hours in a year). Because of such short duration of heavy rain, most of the rain falling on the surface tends to flow away rapidly leaving very little for recharge of groundwater. Most of the traditional water harvesting systems in cities have been neglected and fallen into disuse, worsening the urban water scenario. One of the solutions to the urban water crisis is rainwater harvesting - capturing the runoff (12).

Advantages of Rainwater Harvesting

- In areas where there is inadequate groundwater supply or surface resources are either lacking or insufficient, rainwater harvesting offers an ideal solution.
- Helps in utilizing the primary source of water and prevent the runoff from going into sewer or storm drains, thereby reducing the load on treatment plants.
- Reduces urban flooding & recharging water into the aquifers help in improving the quality of existing groundwater through dilution (11).

II. METHODOLOGY

Rain Water Harvesting is a way to capture the rain water when it rains, store that water above ground or charge the underground and use it later. This happens naturally in open rural areas. But in congested, over-populated and concretized metropolitan cities / towns, methods need to be created to capture the rain water. In Nag river urban watershed, built up area has made an severe impact on the quality of surface as well as ground water, but still the rainwater harvesting can improve the quality and quantity of surface and ground water to certain level.(10)

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As per the GSDA-Maharashtra published watershed reference map, the Nag river catchment forms a part of Kanhan river catchment i.e. WGKN – 4. Overall two sub-watersheds were delineated for Nag River up to its confluence with river Kanhan. i.e. WGKN-4/1- WGKN-4/2. The sub-watersheds were further divided into three mini-watersheds i.e. WGKN-4/1A–1B-WGKN-4/C. For the rainwater harvesting assessment, the study was conducted for WGKN-4/1A (Fig. 1), with mini-watersheds further divided into ten micro watersheds namely WGKN-4/1A1 - WGKN-4/1A10 (Table – 1) (Fig.2). The existing and historical (1989) land use / land cover pattern for each micro-watershed was then compared & studied to understand the overall impact of urbanization on Nag river watershed(4 ,6).

Demarcation of sub-watersheds and delineation of micro-watersheds was done on the basis of the hierarchical delineation system developed by Groundwater and Surveys Development Agency (GSDA), Govt. of Maharashtra. The delineation of watershed boundaries involved deriving information on drainage network – first order stream onwards. This was achieved by picking up, initially, some details on both natural as well as cultural features from Survey of India topographical maps of 1:50000 scale followed by modifying them with the help of information available in the IRS-1C LISS – III image 2003 (5).

GIS database of Rain Water Harvesting (RWH) potential in Nag river urban watershed was developed using ArcGIS software by utilizing available vector and raster databases. Major themes identified for prioritizing RWH in the GIS were rainfall, land use / land cover, slope, soils and population density. In general, the database comprised of baseline thematic maps and composite processed maps (7, 8).

Table 1 - Nag River watershed Delineation

Watershed Codification	Sub Watershed	Mini Watershed	Micro Watershed
WGKN-4	**WGKN-4 / 1**	**WGKN-4 / 1A**	**WGKN-4 / 1A1**
	WGKN-4 / 2	**WGKN-4 / 1B**	**WGKN-4 / 1A2**
		WGKN-4 / 1C	**WGKN-4 / 1A3**
			WGKN-4 / 1A4
			WGKN-4 / 1A5
			WGKN-4 / 1A6
			WGKN-4 / 1A7
			WGKN-4 / 1A8
			WGKN-4 / 1A9
			WGKN-4 / 1A10

Fig 1. Satellite Data for Nag river urban watershed

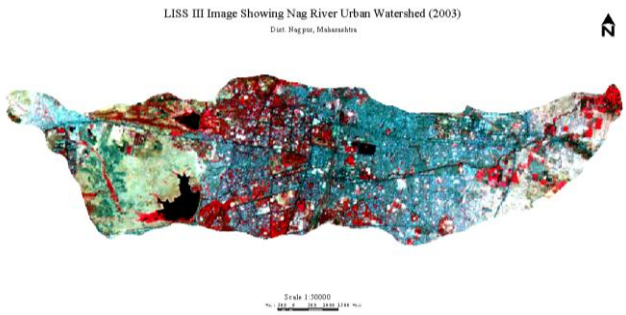
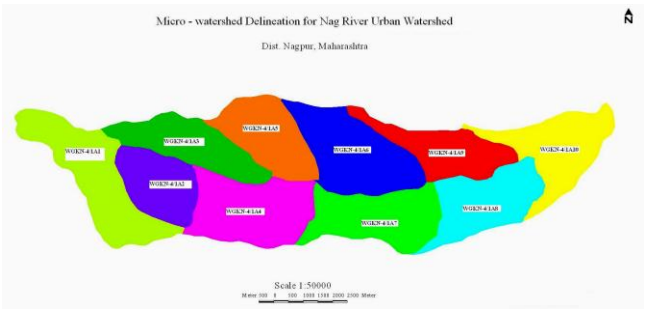


Fig 2. Micro-watershed Delineation Nag river urban watershed



III. Results & Discussions

As per the study, rainwater harvesting potential was calculated for each micro watershed (Table 2), apart from the total demand for water on some defined assumptions (9).

Rainwater Recharge Potential per sq. ft for Nag river urban area is assumed as 106.46 L / Sq. ft.

While, *total demand for water per sq. ft. is assumed as 102.85 L / Sq. ft.*

Micro watershed	**Area of Sub basin (Sq. Km.)**	**Area of Sub basin (Milln Sq. ft.)**	**Total Rainwater recharge Potential (ML) (Area X 106.46L)**	**Total Demand for water (ML) (Area X 102.85)**
WGKN-4/ 1A1	9.81	105.59	11241.11	**10859.53**
WGKN-4/ 1A2	5.65	60.82	6474.90	**6255.34**
WGKN-4/ 1A3	6.68	71.9	7654.47	**7394.92**
WGKN-4/ 1A4	9.07	97.63	10393.69	**10041.25**
WGKN-4/ 1A5	6.69	72.01	7666.18	**7406.23**
WGKN-4/ 1A6	7.97	85.79	9133.20	**8823.5**
WGKN-4/ 1A7	9.29	100	10646	**10285**
WGKN-4/ 1A8	6.02	64.8	6898.61	**6664.68**
WGKN-4/ 1A9	7.32	78.79	8387.98	**8103.55**
WGKN-4/ 1A10	7.61	81.91	8720.14	**8424.44**
Total	76.11	819.24	87216.28	**84258.84**

IV. Conclusions

The study suggests that spatial techniques can be effectively used for assessment of huge untapped potential for rainwater harvesting. This information is also required for awareness creation and as a decision support tool for targeting RWH plans. The reason for using spatial techniques for this type of advocacy is due to the versatility of the tools. Remote sensing provides spatial data at regular interval and aids as a powerful tool for making inventory and monitoring water resources, while spatial analysis is done to get an idea about the terrain, to identify water logging area (seasonal and annual), and to identify sites for rainwater harvesting. Unique feature of GIS

is its ability as decision support system and provides answers to the queries through rational and systematic analysis of the situation. Geographic Information Systems (GIS) has a role and application, in promoting a system and methodology for rain water harvesting and for providing the data needed to enable its large scale implementation in the context of water scarcity facing regions(1).

From the above results, it can be concluded that rainwater harvesting may be very useful in improving the water availability status in Nagpur city. Even, if the harvested water is used for domestic purposes other then drinking, it will substantially reduce the burden on Nag River. From the study, it can be concluded that a geographic information system (GIS) along with remote sensing (RS), limited field survey and GIS can be successfully utilized to identify & assess the potential sites for rainwater harvesting (RWH) technologies in all the water scarce regions of the world, it will also help in assessing and minimizing the impact of population burden on existing natural resources.

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