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APPLICATION OF GIS FOR MAPPING RAINWATER HARVESTING POTENTIAL: A CASE STUDY OF NIDHAL VILLAGE IN SATARA DISTRICT, MAHARASHTRA, INDIA

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ABSTRACT

Water is an essential natural resource for sustaining life and environment. The available water resources are under pressure due to increasing demands and the time is not far when water, which we have always thought to be available in abundance and free gift of nature, will become a scarce commodity. Conservation and preservation of water resources is urgently required to be done. In many part of India, water supply to communities evidently provides a shortfall in demand. Rainwater harvesting systems can provide water at or near the point where water is needed or used. The systems can be both owner and utility operated and managed. Rainwater collected using existing structures (i.e., rooftops, parking lots, playgrounds, parks, ponds, flood plains, etc.), has few negative environmental impacts compared to other technologies for water resources development. Rainwater is relatively clean and the quality is usually acceptable for many purposes with little or even no treatment. The physical and chemical properties of rainwater are usually superior to sources of groundwater that may have been subjected to contamination. The present study was intends to measure the rooftop rainwater harvesting potential using GIS technique. The GIS analysis employed in this study was essential for a systematic evaluation of roof rainwater harvesting in the selected Nidhal village in Man tehsil of Satara district. With the application of GIS it was possible to estimate the total amount of water harvestable at the household level. It is very tedious work to assess the catchments available for roof top rainwater harvesting, here the roof surfaces are the catchments and with respect to that GIS technique is employed to calculate the area of various types of roofs in the study area for the measurement of its potential and planning for the area under study.

KEYWORDS: Rainwater Harvesting, Potential, Measurement, Rooftop etc

INTRODUCTION

Rainwater harvesting from rooftops of houses used to be an ancient practice in arid zone. It is a welcome practice in the rural areas especially where the rainfall is very scanty and the stress on groundwater has been increasing and recharges area has been decreasing continuously. Roof water harvesting was practiced, as a matter of necessity, mostly in the low rainfall areas of the country, having annual rainfall less than 500 mm per year. The rainwater that falls on the surface / rooftop is channelized to bore wells or pits or new / old abandoned well through small diameter pipes to recharge the underground water, which can be harvested to the extent of 55000 litres per 100 sq.m areas per year (Athavle, 1998).

It has been observed that modern constructed houses both in rural and urban areas no provision for the collection and storage of roof water has been made. The increase population growth and inefficient system of distribution of Municipal Corporation and Grampanchyat water supply have led to seasonal scarcity of domestic water supply in

practically all the rural and urban agglomerates. Traditionally, the rainwater collected from roofs was always stored in sump. In modern days, the roof water is stored in a sump or recharged into the local aquifer. This kind of practice directly used for recharging the local aquifer has been becoming popular both in urban and rural areas. Rrainwater harvesting is the best way for mitigating the water scarcity in semi-arid areas where annual rainfall is hardly 300 to 500 mm (Reddy, 1999). The selected study area is Nidhal village in Khatav taluka of Satara district falls in semi-arid zone of western Maharashtra, where rooftop rainwater harvesting is an economical and eco-friendly method of water conservation and recharging groundwater.

The present paper uses a GIS approach to assess total area of catchments available for rain water harvesting in Nidhal village area of Khatav Taluka in Satara district and calculate the amount of water which could be really harvested or used for replenishing groundwater reserves.

THE STUDY REGION

The selected area fall in Nidhal village in Khatav Taluka in Satara district, located at a distance of about 27 km west from Vaduj. The total area of the village is 240 hectares (ha) out of which, about 55 ha are in the form of hill slopes surrounding the village.

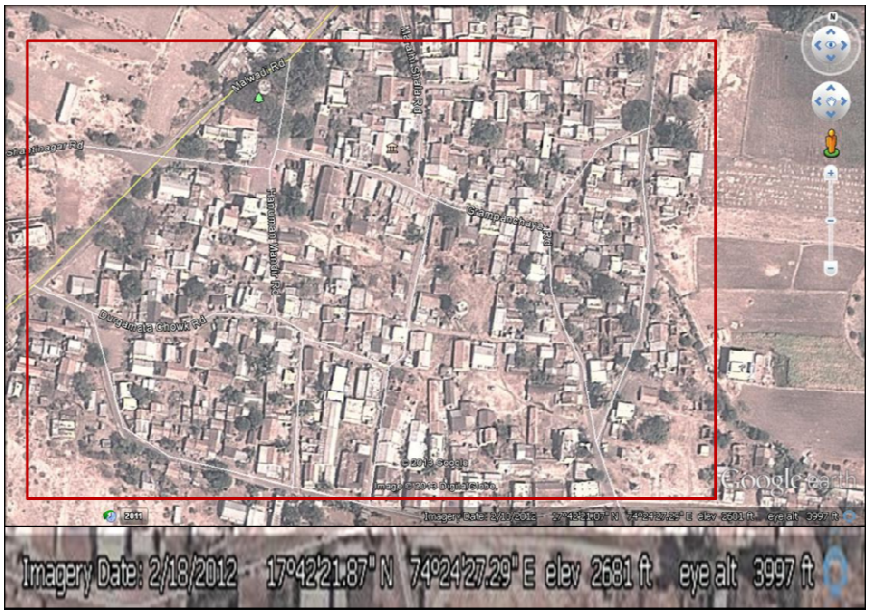

Figure 1: Downloaded Image from Google Earth: Nidhal Village in Khatav Tahsil

This area falls in the rain shadow zone of western Ghats receiving an average rainfall of 500 mm. Nidhal village has been experiencing severe drought once in ten years. About 250 houses are located at the gaonthan (settlement) area of village. The population of village is 1054 persons only (2007).

OBJECTIVES

- To develop a geospatial database of the rainwater harvesting potential for the study area.
- To assess the total volume of water collected through rain water harvesting technologies with respect to different types of catchments that is roof tops, roads and open spaces.

DATABASE AND METHODOLOGY

The database and methodology have based on the review of literature of **Satya Raj** (2011). This is a Geographic Information System (GIS) based method further the estimation of annual rainwater harvesting potential of the Nidhal village some selected area of Khatav Taluka in Satara district. Google satellite images were downloaded for the purpose and geo-referenced with the help of Arc GIS 9.2. The different types of catchments included rooftops, roads and open spaces. Arc GIS 9.2 was also used to digitise all the different catchments their respective topology was created. Finally, the area of catchments was calculated to find the total rainwater harvesting potential of the study area.

The selected areas of Google earth images were further combined and georeferenced in Arc GIS 9.2 versions. Then the geo referenced images were digitised in Arc GIS 9.2 and different entities were captured like rooftops, roads and streets and open spaces. The rooftops were captured as polygons. Nidhal Village consists of few sub-localities like Durgamatachowk, Hanuman Mandir and Grampanchyatchowk. The village of Nidhal is a bit unplanned and has built up structures and roads which are not very much suitable for rainwater harvesting. So only proper rooftops were digitised and the dilapidated and uneven ones were ignored. In Nidhal we have some of the housing plots in continuity without any spaces between them. So, in such cases roof of houses were captured in the form of one big polygon consisting of all the connected houses. The roads were captured as arc while the open spaces or parks were again captured as polygons. After digitisation, the map was further cleaned and the respective topology was created with the help of same software. Then the area of all the catchments were calculated thus giving the total rainwater harvesting area available in the Nidhal village locality. The information was useful in calculating the annual rainwater harvesting potential of the area.

The Nidhal village comprising of 60 households and 425 persons have been selected for comprehension of roof top rainwater harvesting potential where the average rainfall is hardly 500 mm (0.5m). Water demand is gives 60 liters per person per day.

RESULTS AND DISCUSSIONS

The area of the catchments was already calculated with the help of Arc GIS software. Based on the various factors, the annual rainwater harvesting potential (ARHP) of the study region is estimated by using the following formula given by Pecey, Amold and Cullis, Adrian (1989):

Area of Catchments in sq.m x Rainfall in Metres x Runoff Coefficient

Runoff Coefficient

Runoff coefficient is the factor, which accounts for the fact that not all the rain falling on catchment have collected, some amount of rainfall lost from the catchment by evaporation and some amount has retained by surface itself. Accordingly, Table 1 shows the runoff coefficient for various surfaces of rooftops.

- **Annual Rainwater Harvesting Potential from Rooftops**
  - Concrete rooftop = 4240.67 x 0.5 x 0.6 = 1272.20
  - Corrugated Iron Sheets = 3987.94 x 0.5 x 0.7 = 1395.78

- Brick Pavement = 1385 x 0.5 x 0.5 = 346.25

Total Potential from Rooftop = 3014.23 cubic metres(3014230 litres)

So the total rainwater that would be collected from rooftops was calculated to be **3014230**liters.

- **Annual Rainwater Harvesting Potential from Roads Catchments**

6754.76 x0.4 x 0.5 = 1350.95 cu.m. (1350950 litres)

The roads between the houses as well as main roads in Nidhal area is made up of concrete. So the run-off coefficients of roads were also taken as 0.4. So the total rainwater that could the collected from roads were found to be **1350950**litres.

- **Annual Rainwater Harvesting Potential from Open Spaces Catchments**

10231.25 x 0.3 x 0.5 = 1534.68 cu.m. (1534680 litres)

The average run-off coefficients of open spaces were taken as 0.3. So the total rainwater that could be collected from open spaces was found to be 1534680 litres.

- **Grand Total of Annual Rainwater Harvesting Potential is all the source catchments were found to be:**

3014230 +1350950 + 1534680 = 5899860 litres

Annual per person water available = 5899860 / 425 persons

= **13882.02litres**

Per person per day water available = 13882.02/ 365 days

= **38.03litres**

Daily water availability in only dry days = 13882.02/ 243 days

(8 months or 243 days) = **57.12litres**

CONCLUSIONS

It is scientifically proved that through rooftop rainwater harvesting method water scarcity can be minimized to certain extent and water collected can be used for drinking and domestic purpose. With this is can be inferred that Nidhal village has huge potential and can make above 38.03litres (63.38%) water available per person per day throughout the year. It could be more than 57.12 litres per day per person if computed only for 245 dry days. In this way above 95.2 % requirement can be met as the entire village can collect 5899860 liters of water per annum.

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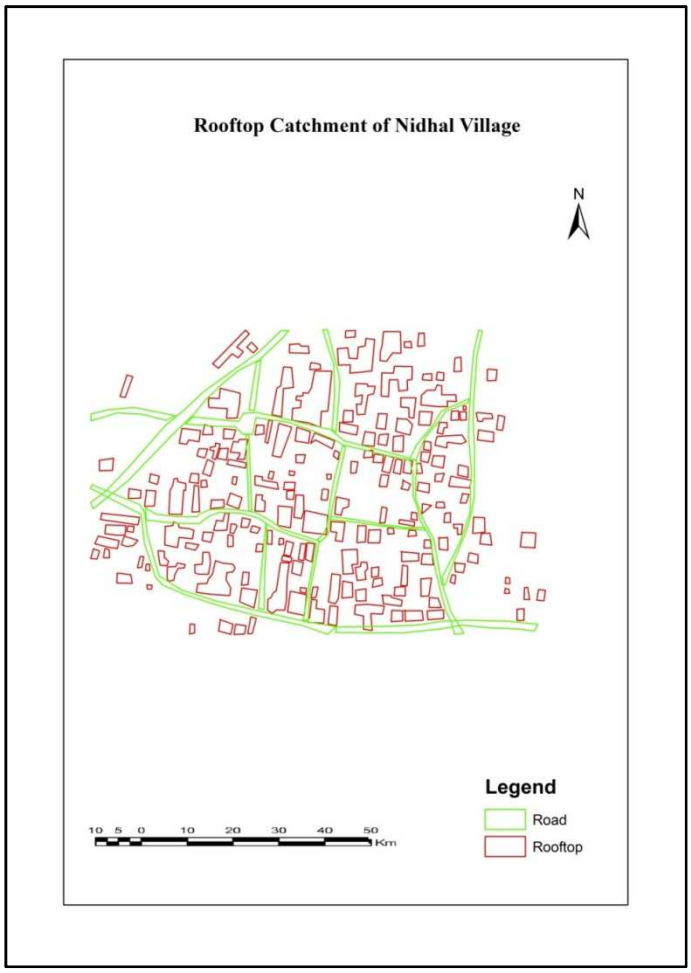

Figure 2

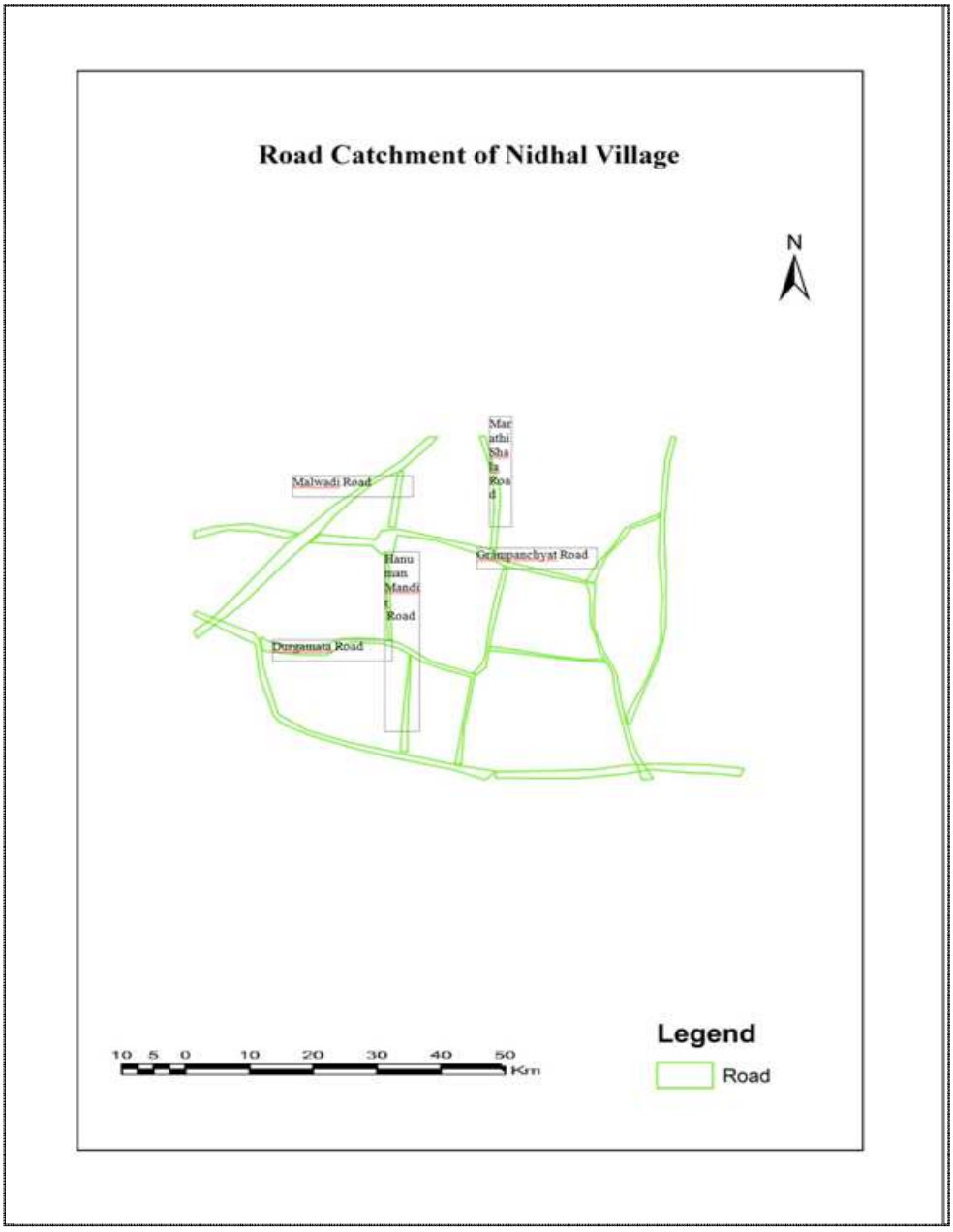
Road Catchment of Nidhal Village
N
Malwadi Road
Marathi Shala Road
Hanuman Mandir Road
Grampanchyat Road
Durgamata Road
10 5 0 10 20 30 40 50
Km
Legend
Road

Figure 3

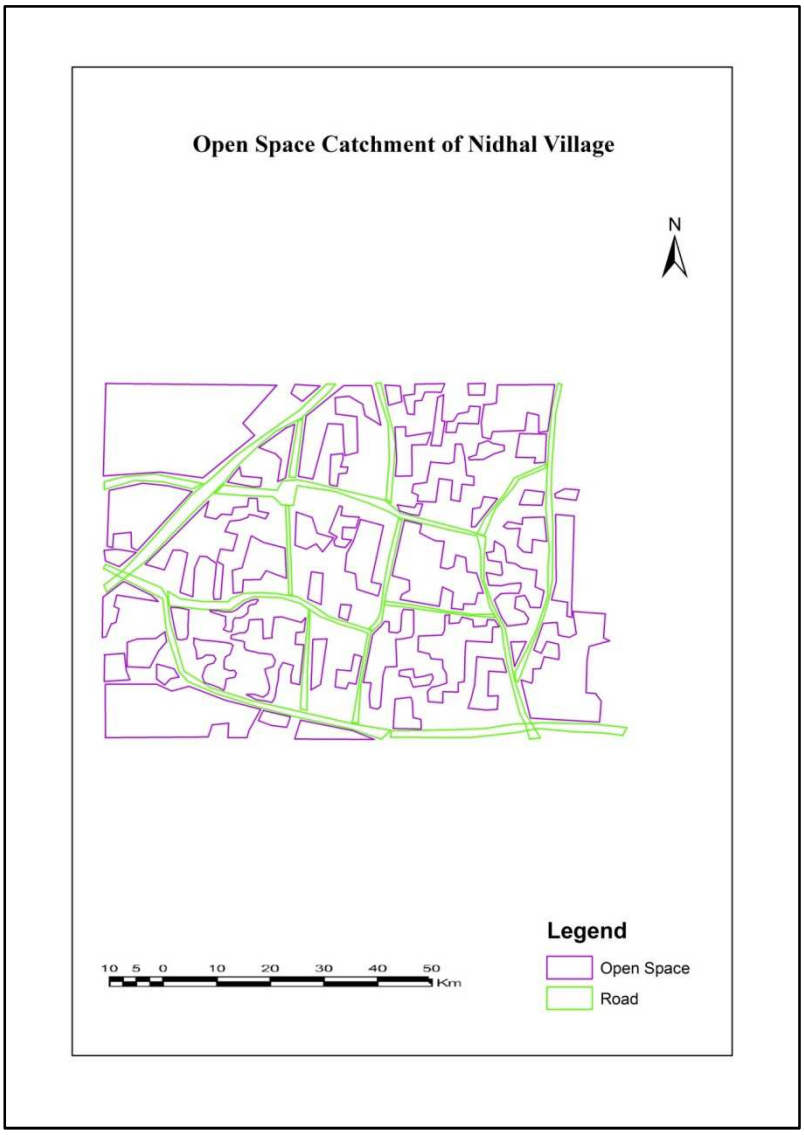
Open Space Catchment of Nidhal Village
N
Legend
Open Space
Road
10 5 0 10 20 30 40 50
Km

Figure 4