Eco. Env. & Cons. 30 (1) : 2024; pp. (304-307)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i01.055

Identification of Suitable Sites for Rainwater Harvesting by using Geospatial Techniques in Halayapura Micro-watershed of Tumkur District

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(Received 17 August, 2023; Accepted 10 October, 2023)

ABSTRACT

Geospatial technique were used for land and water management action plan for Halayapura micro-watershed in Tumkur district of Karnataka. Arc GIS software was used in evaluation of morphological characteristics in micro-watershed. The main objective of this study was to define a general method for selecting suitable RWH sites in Halayapura micro watershed. Rainwater which is harvested using structures of varying types and sizes was used for either supplemental irrigation or recharging open-wells. In many cases, the farm level rainwater harvesting structures were highly effective for rain fed farming and had a multiplier effect on farm income. The use of farm ponds in Halayapura, for example, resulted in a significant increase in farm productivity (12–72%), cropping intensity and consequently farm income. The recharge factor found is 7% and utilizable groundwater is 41.7 mm (70% of 59.6 mm recharge estimated). This means the total available water resource combining the soil moisture store and utilizable runoff plus recharge is 256.0 mm. Currently about 19.4% of the utilizable runoff is being used and 9% of runoff excess is promoting by harvesting and conservation structures.

Key words: *Rain water, Structures, Ground water and runoff*

Introduction

India covers 329 mha of geographical area, which makes up 2.40 per cent of the world's land area and provides 1/25th of the world's water supply. The total useful water resources of the country are estimated at 1086 km^3.

The National Commission for Integrated Water Management Growth estimated the average annual drainage flow in Indian river systems at 1953 km^3 and the accessible annual surface water in India is 690 km^3. Estimated potential natural groundwater recovery from rainfall in India is 342.43 km^3, which constitutes 8.56 per cent of the country's total annual rainfall. The annual potential groundwater recharge enrichment from canal irrigation scheme estimated to be nearly 89.46 km^3.

Total water resources in seven river basin regions are about 7663 TMC. Currently 58 per cent of water sources occur in west flowing rivers where, a larger percentage of water could not be harnessed for any effective use. It is estimated that in the state only 1695 TMC of surface water could be economically utilizable for irrigation purpose.

In case of ground water, it has been predicted that 485 TMC of groundwater is available in the state. However, the allocation of groundwater and the usage for irrigation is not consistent across the state. A substantial amount of groundwater is found in the coastal areas, which cannot be effectively utilized. The surface water capacity of Karnataka is approximately 102 km^3, of which about 60 per cent is from the rivers flowing west, while the remaining comes from the rivers flowing to the east. The total annual yield of the Karnataka Rivers was estimated to be approximately 3475 TMC

In 1971, the National Commission for Agriculture (NCA) estimated that it was impractical to provide irrigation for more than 40 per cent of the land cultivable in India and to use all available water supplies in the form of large and medium-sized irrigation projects / systems. The remaining 60 per cent of the area will remain dependent on available monsoon rains as a source of water to crops. Current studies aim to study the crop production which can be significantly improved by providing one or two life-saving irrigations during dry spells for utilizing the harvested rainwater collected in some of the water harvesting structures.

Ponds and check dams, terracing, percolation tanks, and Nala bunds are the most common types of RWH techniques in watersheds. Ancient evidence of the use of rainwater harvesting (RWH) techniques has been found in many countries around the world, including Jordan, Palestine, Syria, Tunisia, and Iraq. The earliest signs of RWH are believed to have been constructed over 9000 years ago in the Edom Mountains in southern Jordan.

Materials and Methods

The study area is a part of the Southern Transition Zone of Karnataka. December is the coldest month with mean daily minimum temperature of 18.30 ºC, while May is the hottest month with mean daily maximum temperature of 38.10 ºC. Relative humidity of over 87 per cent is common during monsoon period. The Survey of India (SoI) toposheet 4B3C5N1a of 1:50,000 scale with a contour interval of 20 m were used for the analysis.

ArcGIS is software for creating, viewing, querying, editing, composing and publishing maps. The development of GIS data in the desired format is complex in nature particularly for hydrological analysis. ArcGIS 10.4 version was used to prepare the map layout and to get good output, which was easy to work and integrate the different feature class maps in a single layer.

As per integrated missions for sustainable development (IMSD) guidelines, land use map, soil map, runoff potential map, stream order map, permeability map and slope maps are used for identifying the suitable sites for water harvesting structures by overlaying. Overlaying of these maps are done by using "Intersect" from "Overlay" option of "Analysis Tools" in ArcGIS.

Percolation pond is normally suggested for recharging aquifer and used where surface storage is available for a restricted period. The required site conditions are having high permeability with higher stream order. Check dams are used for surface storage and site conditions are well defined as straight stream channel with level banks. Farm ponds are normally used for livestock storage and for restricted irrigation. Narrow elongated depression, gentle slope and small catchment area are the required site condition for the farm ponds.

Results and Discussion

The experiment is conducted as per the experimental plan as detailed under materials and methods. The results of the experiment are detailed further under the following titles.

Proposed sites for rainwater harvesting structures

Proposing suitable sites for rainwater harvesting structures is made by overlaying Slope, Permeability, Runoff potential and Stream order map and overlaying of these maps are done by using "Intersect" from "Overlay" option of "Analysis Tools" in ArcGIS. The criteria assigned are based on the IMSD (Integrated Mission for sustainable Development) guidelines the structures suitable for the area are check dam, farm pond, percolation dam.

A variety of methods can be used to integrate the different criteria into a tool for the selection of suitable sites for RWH. The proposed sites for check dams, percolation dam and farm ponds, are shown in Table 4.7 and Fig. 4.9, 4.10 and 4.11. The study area reveals that 57.31 per cent of the total area is ideal for constructing check dam, 29.17 per cent for farm pond, 8.57 per cent for percolation pond and 4.95 per cent for others.

It was observed that major part of micro-watershed site is suitable for constructing check dams. Locations of water harvesting structures are suggested by conducting meteorological and topo-

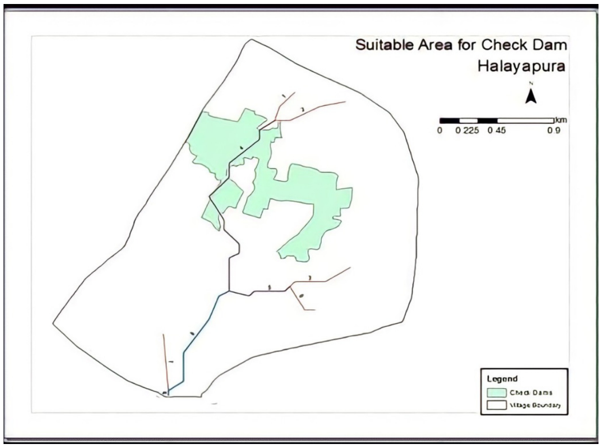

Fig. 1. Proposed site for Check Dam in Halayapura micro-watershed

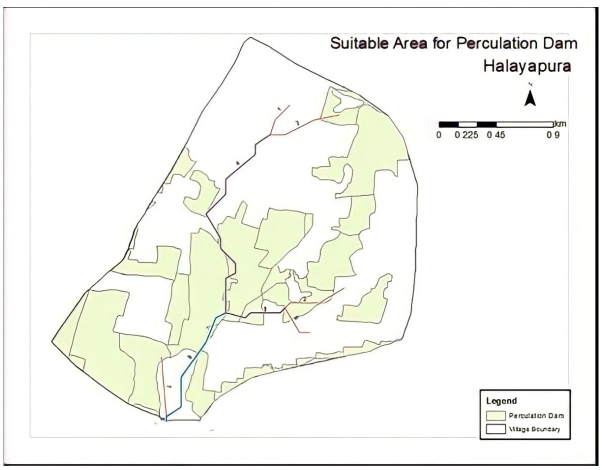

Fig. 2. Proposed site for Percolation Dam in Halayapura micro-watershed

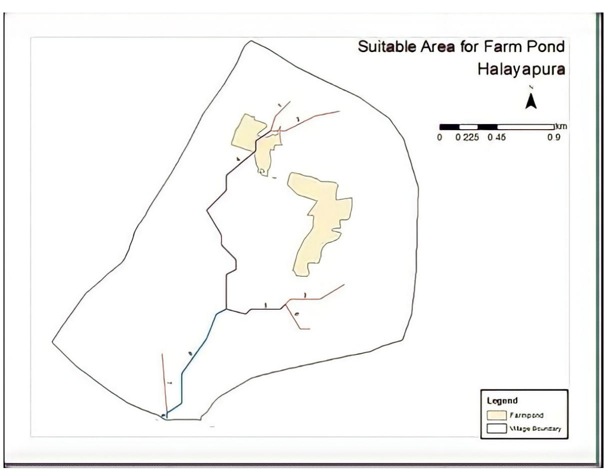

Fig. 3. Proposed site for Farm Pond in Halayapura micro-watershed

graphical analysis. Proposed check dam could be useful for life saving irrigation and percolation pond augment the ground water table.

However, for the practical implementation of these structures, viability of other considerations such as economy, social implications, practical feasibility *etc*. need to be considered. By adopting proper planning for water conservation measures additional surface water resources can be developed by constructing different rainwater harvesting structures under different land use/cover units and also by increasing the storage capacity of the existing major tanks within the micro-watershed area.

The slope map was derived using the DEM for the study area. The entire micro-watershed was classified into three slope classes *viz.,* nearly level (0-1.0%), very gently sloping (1.0-3.0%), gently sloping (3.0-5.0%) according to IMSD guidelines (Table 3).

Table 1. Slope class distribution of Halayapura micro-watershed

Sl. No.	Slope type	Value (%)	Area (ha)	Area covered (%)
1	Nearly level	0-1.0	128.768	25.60
2	Very gently sloping	1.0-3.0	235.404	46.80
3	Gently sloping	3.0-5.0	31.689	6.30
4	Forest area	-	57.342	11.40
5	Hill area	-	18.108	3.60
6	Reserved Forest Area	-	8.048	1.60
7	Restricted area	-	2.012	0.40
8	Others	-	21.629	4.30
	Total	-	503	100.00

Table 4. Rainwater harvesting structures distribution in Halayapura micro-watershed

Sl. No.	Rain water harvesting structures	Area (ha)	Area (%)
1	Percolation Dam	288.27	57.31
2	Check dam	146.725	29.17
3	Farm Pond	43.107	8.57
4	Others	24.899	4.95
	Total	503.00	100.00

Table 5. Number of Rainwater harvesting structures can be suggested in Halayapura micro-watershed

Sl. No.	Rain water harvesting structures	Numbers
1.	Check Dam	15
2.	Farm Pond	8
3.	Percolation Pond	22

From slope map, it was observed that, the major part of the micro-watershed has very gently sloping (46.80%) followed by nearly level (25.60%) land Both very gently sloping and nearly level sloping areas were majorly distributed over the entire micro-watershed. Only fewer parts of micro-watershed have gently sloping (6.30%). Forest covers an area of (11.40%), hill covers an area of (3.60%), reserved forest covers an area of (1.60%), restricted area covers an area of (0.40%) and others places like villages, *etc*., covers an area of (4.30%).

Conclusion

In the present study, an effort was made to highlight the use of remote sensing and Geographical Information System for the water resources conservation planning. Initially, watershed delineation was done using Arc-GIS 10.40 version.The study indicates the vast scope and opportunity of rainwater harvesting structures in Halayapura micro-watershed.

The result shows that 57.31 per cent (288.00 ha) of the total area is ideal for constructing check dam, 29.17 per cent (147.00 ha) for farm pond, 8.59 per cent (43.00 ha) for percolation pond and 4.95 per cent (24.93 ha) for others. Whereas, practical implementation of these structures, viability of other considerations such as economy, social implications, practical feasibility etc., need to be considered.

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