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Integrated Water Resource Development Plan for Sustainable Management of Tigaleru Watershed, Dornala Mandal

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Abstract : Integrated watershed management requires a host of inter-related information to be generated and studied in relation to each other. Remote sensing techniques provide valuable and up-to-date information on natural resources. Geographical information system (GIS) with its capability of integration , multi layer information obtained both from remote sensing and other conventional sources has proved to be an effective tool in planning for watershed development .

In this study area and locale specific watershed development plans were generated for Tigaleru watershed, Dornala Mandal Prakasam district A.P. adopting IMSD guidelines, suitable sites for artificial recharge structures were suggested using lithology, geomorphology, ground water potential, structural maps.

INTRODUCTION AND BACKGROUND

Groundwater is an important natural resource, especially in arid and semi-arid regions, for the developmental activity of a region. For the integrated sustainable development of the every area the basic inventory of the natural resources is a must for that area. Remote sensing and GIS and present day satellite technology helps is bringing out the regional picture. Groundwater potential mapping also depends on the regional frame work .

As Tigaleru watershed, Dornala Mandal forms part of the western Prakasam district which falls in arid and semi arid region area, which is a well known drought area and a need for the assessment of its natural resources inventory. Dornala mandal normal annual rainfall for the year is 872 mm.

Watershed is defined as a Geo hydrological unit which starts from the highest point (ridge) and drains the entire runoff to the single outlet or natural Stream. Watershed comprises non-arable lands and drainage lines. Human beings and live stocks depend for their survival on natural resources therefore need to be protected, developed, used and maintained on watershed basis since the watershed is natural area of operation.

Groundwater is considered as the preferred source of water for meeting domestic, industrial and agricultural requirements, due to its longer residence time in the ground, low level of contamination wide distribution, and availability within the reach of the consumer. The present paper deals with the effort made to bring out the occurrence and movement of groundwater in an area is governed by several factors such as topography, lithology, geological structure, depth of weathering, extent of factures, drainage pattern, climate conditions and inter relationship between these factors. For delineation of groundwater prospect zones, it is therefore, necessary to integrate the data on these terrain characteristics the natural resources inventory of that area. This can be best achieved through a geographical information system (GIS). References to integrated approach for extracting groundwater prospect zones using remote sensing and GIS techniques are many in recent times (Chi and Lee. 1994)

This paper present the results of a study to generate a groundwater prospect map by integrating of various thematic maps derived from both remote sensing and conventional methods using geographical information system. These studies have given an overall picture of the Hydrological, Hydrogeomorphological Maps

OBJECTIVE

The objective of the paper is to prepare the ground water prospects maps corresponding to Survey of India toposheet on 1:50,000 scale, covering all the habitations.

- Prospective ground water zones.
- Studies involved in selection of sites for implementation of artificial recharge schemes
- Help in planning for recharge structure (Prioritizing the areas for water harvesting through different types of recharge structures).

STUDYAREA

The study area has been carried out in and around Tigaleru watershed, Dornala Mandel Prakasam district Andhra Pradesh. The extent of the watershed stretches from between 13°38È20À and 13°22È40À North Latitudes and 79°08È18À and 78°30È17À East Longitudes Elevation 493 feet and is covered in the Survey of India Toposheet number 57M\01 on a scale of 1:25,000 and covers an area of 873.99 heacteres,70.769 sq kilometer

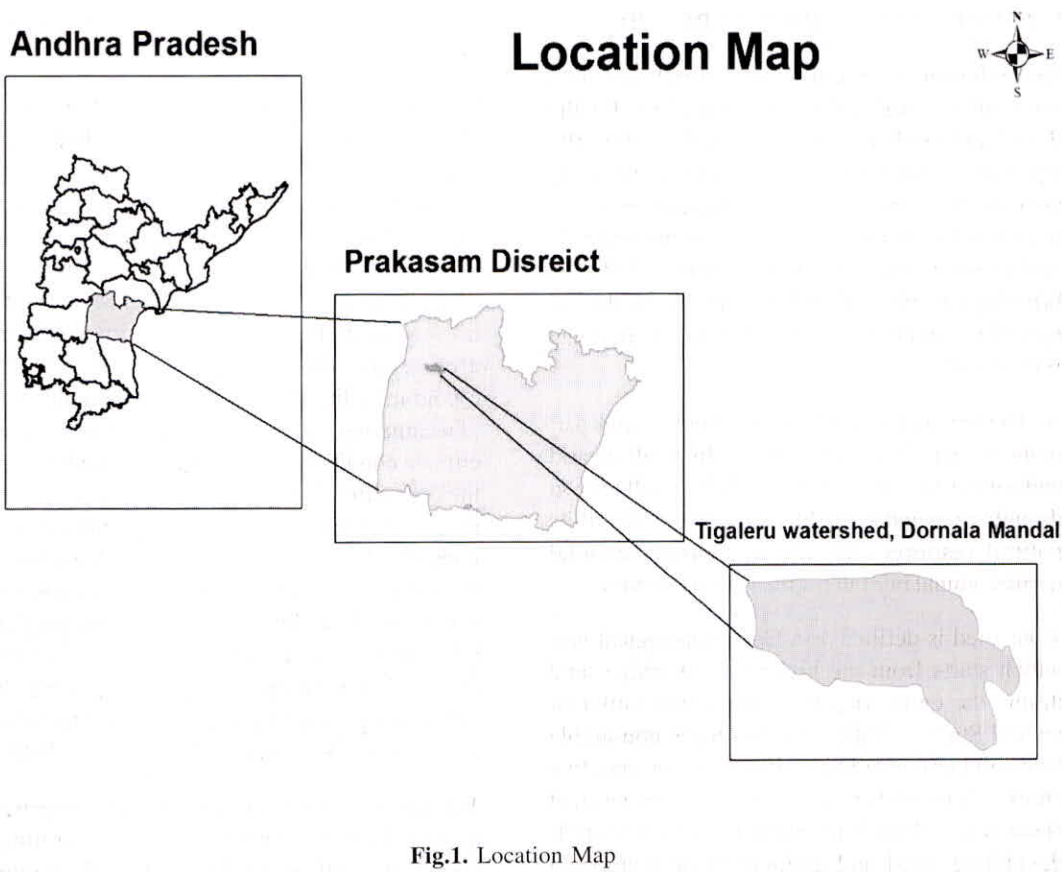

Fig.1. Location Map

DATA USED

- Satellite imagery LISSIII & LISSIV (23.5 m.& 5.8m. resolution data) of 2006, 2009 supplied by National Remote Sensing Centre is used for 1:50,000 scale base line feature data capture covering the proposed study area.
- Ground truth data (photographs, etc.) and GPS control points, collected during field survey in the study area is incorporated into the geo database.
- The map is generated in LCC projection with WGS84 datum.
- 1:50,000 scale grid is generated for the 2D mapping of study area.

METHODOLOGY

The methodology is basically a systematic procedure evolved to prepare a ground water prospects map using satellite data and GIS techniques in conjunction with limited field work. Various steps involved in the preparation of ground water prospects maps are furnished as a flow chart in (Fig.2).

GIS technique is useful to derive and integrate geology, structural and geomorphological details. The various layers generated using remote sensing data like lithology / structure, geomorphology, lineaments etc. are integrated with already available information on slope, drainage density and other collateral data in a Geographic Information System (GIS) framework and analyzed with reference to the groundwater zones as well as artificial recharge sites.

The total methodology can be divided into two main parts. the first part deals with the delineation of hydrogeomorphic units considering parameters influencing the hydro geological properties. It consists of a) preparation of individual thematic maps i.e. lithology, geomorphology, structures, hydrology and base map details based on the visual interpretation of standard false colour combination (FCC) of satellite data in conjunction with limited field/existing data, and b) Derivation of hydrogeomorphic units by integrating the thematic data. The second part deals with the evaluation of ground water condition in each hydrogeomorphic unit. It consists of a) evaluation of ground water prospects based on hydrogeological characteristics of each and every parameter, and b) Semi-quantification of ground water availability by taking into account the well observatory data, and c) Selection of tentative locations for taking up artificial recharge structures.

The map depicts major roads, minor roads, railway line, major and minor settlements, tanks, etc. The data is collected from Survey of India toposheets and updation is done using satellite data, integration and correlation of the field observations (Fig.3).

Geology

Tigaleru watershed is underlain by Nallamalai Group comprising Cumbum (Pullampet), Bairenkonda (Nagari) Formation and Srisailem Quartzite represent the Cuddapah Supergroup, the Proterozic age . The Bairenkonda formation Consists of slate and quartzite. The Cumbum formation dominantly comprises shale with minor phyllite, and intersection of dolamite, limestone and quartzite.

Geomorphology

The main geomorphic units in the study area are Pediment, Pediment Inselberg Complex (PIC), shallow weathered pediplain (PPS) and moderately weathered pediplain (PPM), Structural hills (SH), Bazada (BZ), and valley fill (unconsolidated sediments) landforms in (Fig.3).

Lineaments

Lineament analysis for ground water exploration in Peninsular granites and gneisses are has considerable importance as joints and fractures

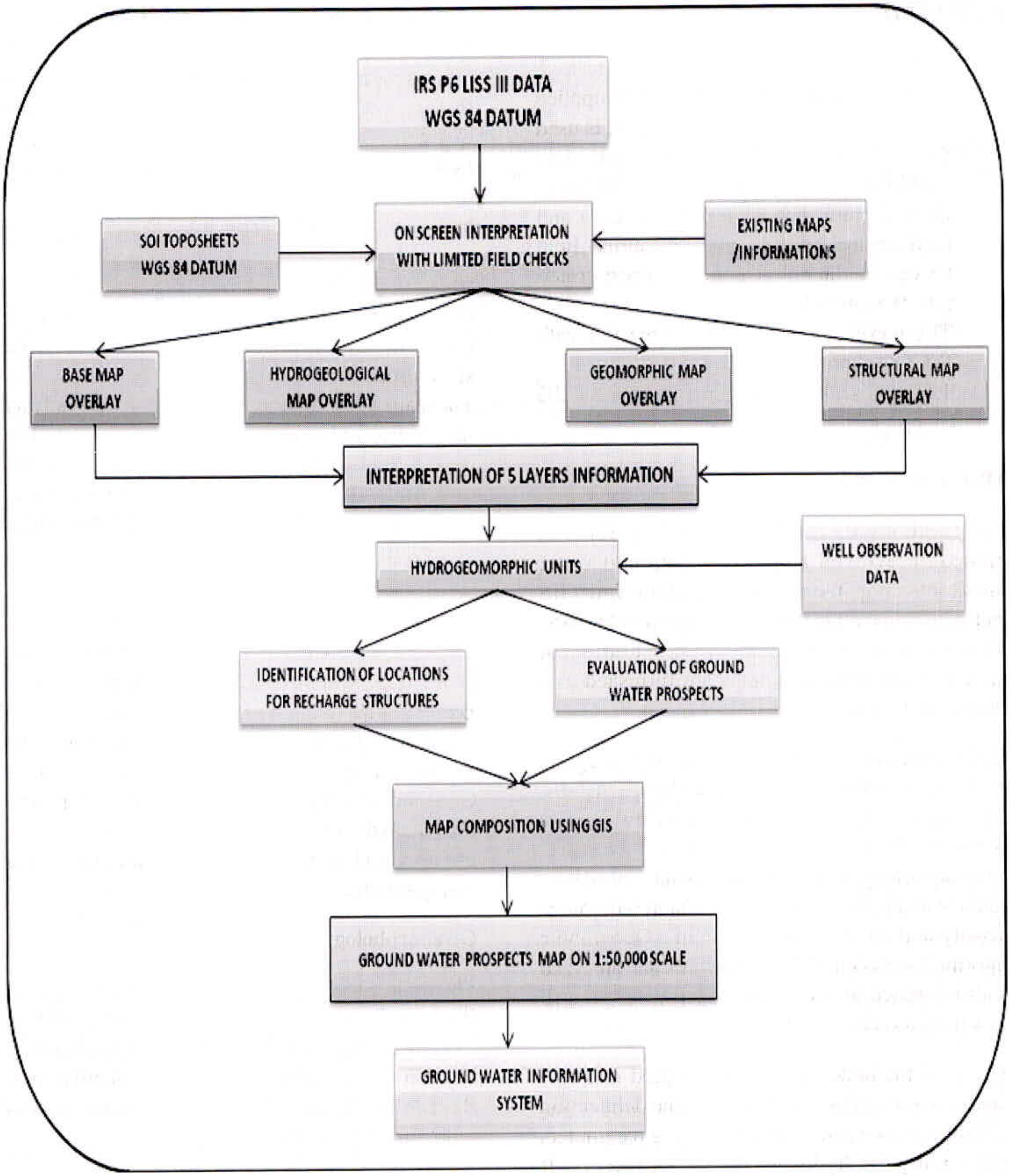

Fig.2. Flow chart showing the salient features of the methodology

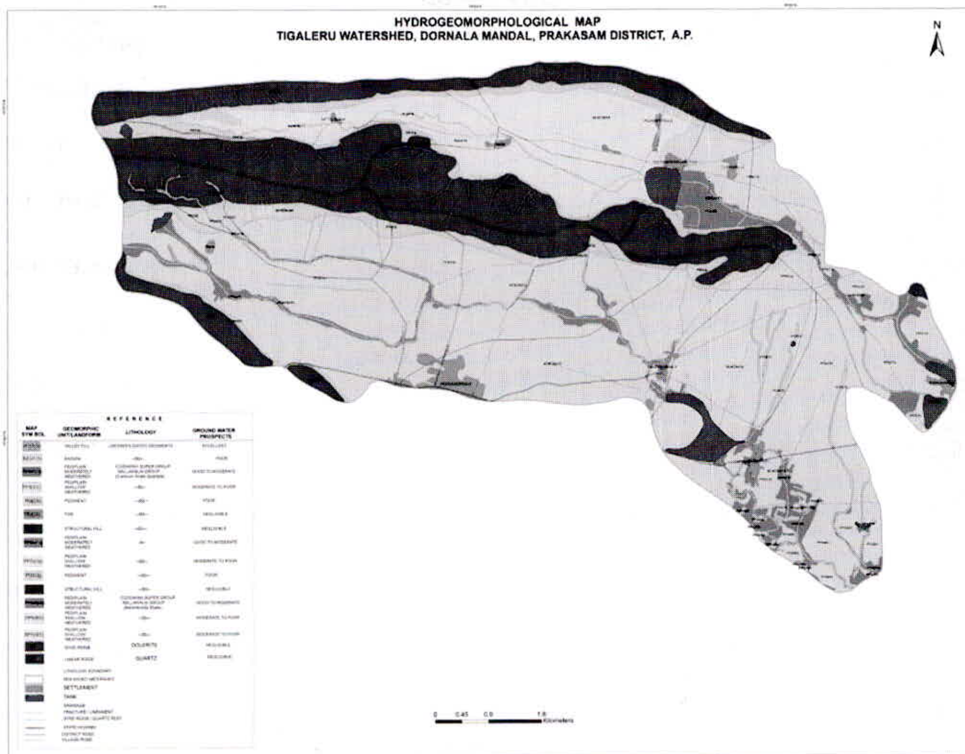

Fig.3. Hydrogeomorphological Map

serve as conduits for movement of groundwater. For extraction of lineaments, procedure of Moore and Waltz (1986) has been followed (Fig.3)., linements act as conducts for ground water recharge in the hard rock areas where only secondary porosity expected.

Hydromorphology

Ground water potential zones have been demarcated integrating the structural information with geomorphology, geology and well inventory data. General fall in the slope is from east to west in the eastern portion and north to south in the western portion. The study area is well drained by a number of 1st, 2nd, 3rd and 4th order streams(fig. 4).

Artificial Recharge of Groundwater

The term artificial recharge has different connotations for various practitioners. Artificial recharge to ground water is defined as the recharge that occurs when the natural pattern of recharge is deliberately modified to increase recharge (ASCE 2001).

The term artificial recharge refers to transfer of surface water to the aquifer by human interference. The natural process of recharging the aquifers is accelerated through percolation of stored or flowing surface water, which otherwise does not percolate into the aquifers. Artificial recharge is also defined as the process by which groundwater is augmented at a rate exceeding that under natural

MAP SYM BOL	GEOMORPHIC UNIT/LANDFORM	LITHOLOGY	GROUND WATER PROSPECTS
VF(UCS)	VALLEY FILL	UNCONSOLIDATED SEDIMENTS	EXCELLENT
BZ(UCS)	BAZADA	--do--	POOR
PPM(CS)	PEDIPLAIN MODERATELY WEATHERED	CUDDAPAH SUPER GROUP NALLAMALAI GROUP (Cumbum Shale,Quartzite)	GOOD TO MODERATE
PPS(CS)	PEDIPLAIN SHALLOW WEATHERED	--do--	MODERATE TO POOR
PD(CS)	PEDIMENT	--do--	POOR
TR(CS)	TOR	--do--	NEGLIGIBLE
	STRUCTURAL HILL	--do--	NEGLIGIBLE
PPM(Cq)	PEDIPLAIN MODERATELY WEATHERED	-do-	GOOD TO MODERATE
PPS(Cq)	PEDIPLAIN SHALLOW WEATHERED	--do--	MODERATE TO POOR
PD(Cq)	PEDIMENT	--do--	POOR
	STRUCTURAL HILL	--do--	NEGLIGIBLE
PPM(BS)	PEDIPLAIN MODERATELY WEATHERED	CUDDAPAH SUPER GROUP NALLAMALAI GROUP (Bairenkonda Shale)	GOOD TO MODERATE
PPS(BS)	PEDIPLAIN SHALLOW WEATHERED	--do--	MODERATE TO POOR
BPS(BS)	PEDIPLAIN SHALLOW WEATHERED	--do--	MODERATE TO POOR
	DYKE RIDGE	DOLERITE	NEGLIGIBLE
	LINEAR RIDGE	QUARTZ	NEGLIGIBLE
	LITHOLOGY BOUNDARY		
	MINI MICRO WATERSHED		
	SETTLEMENT		
	TANK		
	DRAINAGE		
	FRACTURE / LINEAMENT		
	DYKE RIDGE / QUARTZ REEF		
	STATE HIGHWAY		
	DISTRICT ROAD		
	VILLAGE ROAD		

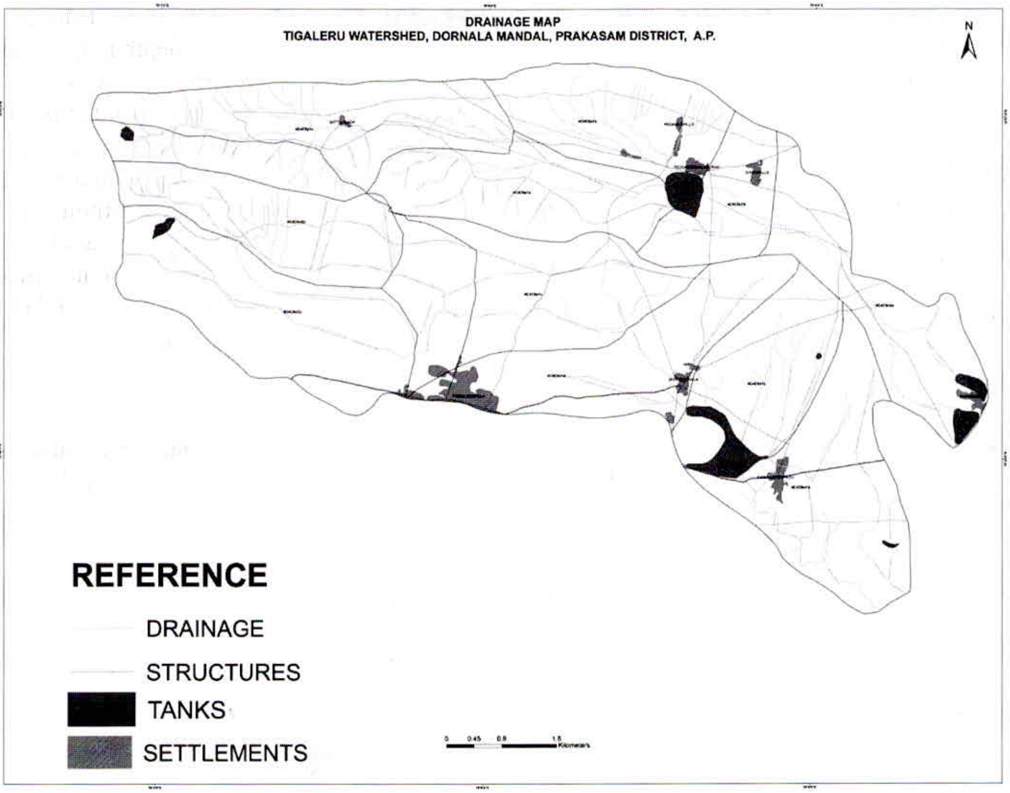

Fig.4. Drainage Map

condition of replenishment. Therefore, any man-made facility that adds water to an aquifer may be considered as artificial recharge (CGWB 1994). Artificial recharge aims at augmenting the natural replenishment of ground water storage by some method of construction, spreading of water, or by artificially changing natural conditions. It is useful for reducing overdraft, conserving surface run-off, and increasing available ground water supplies. Artificial recharge can also be defined as a process of induced replenishment of the ground water reservoir by human activities. The process of supplementing may be either planned such as storing water in pits, tanks etc. for feeding the aquifer or unplanned and incidental to human activities like applied irrigation, leakages from pipes etc.

RESULTS AND DISCUSSION

Artificial recharge structures

The area is arid environment has necessitated over utilisation of groundwater, while concretisation of roads have resulted in the reduction of recharge areas, scanty distribution of rain fall and coupled with over exploitation have further aggravated the problem. The appreciable drop in the water table and ever increased demanding for the groundwater especially during summer has warranted initiation of artificial recharge structures on a large scale. The site specific structures suitability has been evaluated based on the criteria followed in Rajiv Gandhi National Drinking Water Mission. The type of structures proposed area

- Check dams
- Mini percolation tanks
- De-siltation of tanks

While suggesting the above structures the rock type geological structures, drainage, soil type, slope, characteristics have been considered.

Check dams

The check dam locations are given on first order and second order streams with medium slopes. They are proposed where water table fluctuations on the stream is influent or intermittently effluent. The parameters to be considered are slope, soil cover and its thickness and hydrogeologocal conditions such as rock type, thickness of weathered strata, fracture, depth to bed rock etc. There should be some irrigation wells the down Stream of the proposed structures. These structures will serve for dual purpose. Firstly it reduce runoff velocity there by minimising erosion and secondly allows the retained water to percolate and thus results in increased recharge in the wells located downstream of the structures. These locations are to be verified in field before taking up the check dams (Fig.5).

De-siltation of tanks

The tanks which were identified as silted can be recommended for desiltation activity (Fig.5).

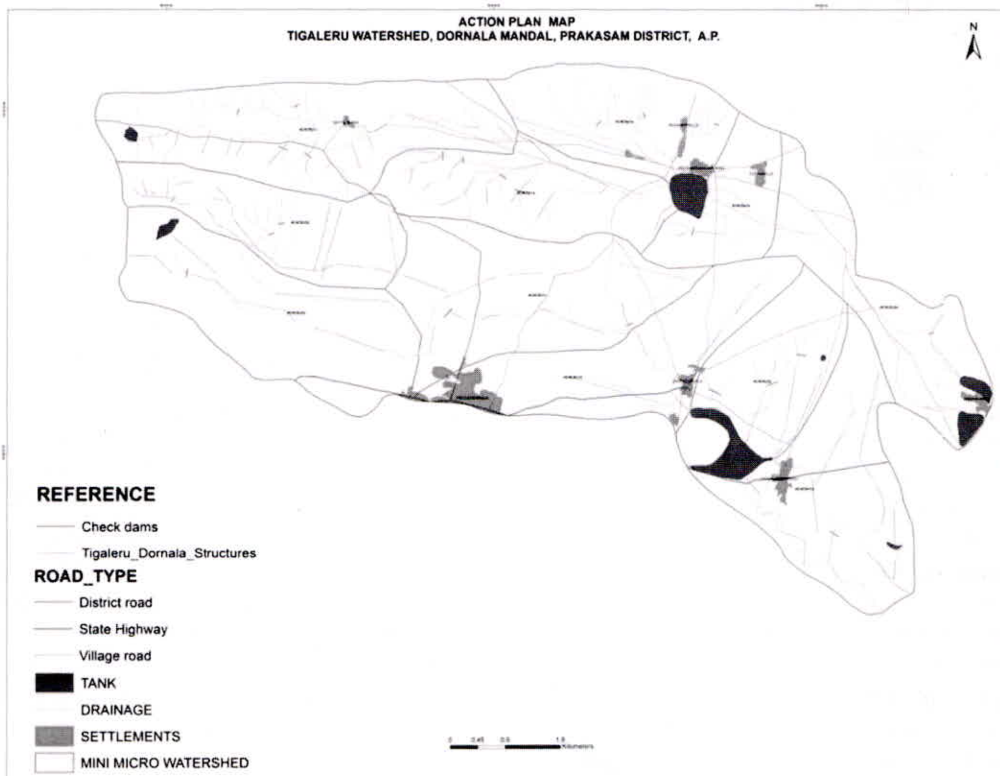

Fig.5. Action Plan Map

Mini percolation tanks

They are normally recommended on 2nd , 3rd or higher order streams. Mini percolation tanks are structures constructed across nalas / streams for checking velocity of runoff increasing water percolation and improving soil moisture regime. The main objective is to impound surface run off coming from catchment and to facilitate percolation of stored water in to the soil sub strata with a view to rise groundwater level in the zone of influence of the percolation tank and also to hold the silt flow which would otherwise reach multipurpose reservoirs and reduce their useful life. These structures are different from check dams by the way of having an emergency spill way in the case of heavy runoff. The location is indicative and actual location may be decided based on field conditions. The size of the structures may be limited to or less than 1mcft capacity (Fig.5).

Advantages of Artificial Recharge

Artificial recharge is becoming increasingly necessary to ensure sustainable ground water supplies to satisfy the needs of a growing population. The benefits of artificial recharge can be both tangible and intangible. The important advantages of artificial recharge are

- Subsurface storage space is available free of cost and inundation is avoided.
- Evaporation losses are negligible, quality improvement by infiltration through the permeable media.
- It has no adverse social impacts such as displacement of population, loss of scarce agricultural land etc.
- Temperature variations are minimum.
- It is environment friendly, controls soil erosion and flood and provides sufficient soil moisture even during summer months.
- Water stored underground is relatively immune to natural and man-made catastrophes
- It provides a natural distribution system between recharge and discharge points.
- Results in energy saving due to reduction in suction and delivery head as a result of rise in water levels.

CONCLUSIONS

Successful implementation of artificial recharge schemes will essentially involve the following major components

- Assessment of source water
- Planning of recharge structures
- Finalisation of specific techniques and designs
- Monitoring and impact assessment

Groundwater occurs under phreatic to semi-confined conditions in the weathered granite mantle and under semi-confined conditions in the fractured zones located at moderately deeper depths.

People may be educated by providing the above tips for maintenance of the system through pictures, handouts and wall posters. The implementing agency should visit the structures as follow-up to monitor and motivate the users in proper maintenance of the systems. There could be informal group discussions among the users on the maintenance aspects of the Roof Top Rainwater Harvesting Systems.

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