AN INTEGRATED APPROACH OF GEO- SPATIAL MODELING AND WEIGHTAGE OVERLAY ANALYSIS FOR WATER RESOURCE MANAGEMENT AND ACTION PLAN- A CASE STUDY OF PAMPAWA WATER, JHABUA DIST MADHYA PRADESH IN INDIA

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Abstract

By the use of Geo-Spatial technology, suggested plan has been proposed for water resource management with the analysis of spatial layers along with allotment of their different weightage which used for the overlay and modeling purpose, on the basis of Geospatial modeling and overlay methodology prospecting the ground water for entire study area, with the help of ground water prospect suggested to artificial recharge structure for the water harvesting and ground water recharge. Poor and Moderate category covered an area around 86% of the total study area in which Poor 21.8 % and moderate is 65.05. Suggested water harvesting structure is total 164 in which 13 Stop Dam, Bolder bund 74, Nala bund 64 and Lake/pond

Introduction

Natural resources are very much valuable for the supporting of agriculture, forestry, mining and human settlement. These are also having social, ecological and cultural uses and values. As with most environmental concepts, natural resources cannot be considered in isolation from other components of the environment. Comprehensive information about the status of the natural resources and their utilization is essential for any area treatment and management.

Data used

Satellite data, Toposheet (SOI), GIS, Geo- Spatial Technology, Watershed.

Study area

The study area is Pampawa Watershed which is located in Petlawad tehsil of Jhabua district of Madhya Pradesh state, India. Pampawa Watershed located between Longitude 74°42'10.361" to 74°55'18.536"E and Latitude 22°51'24.406"N to 23°5'17.836" with covered an area 233.11 Sq/km. The study area extends from North to South covering 25.5 km and east to West covering 22.5 km with covering of Survey of India toposheets No. 46J/13, 46J/9, 46I/16 and 46I/12.

The study area is located to in the north and eastern part of Jhabua district, Jhabua district lies on the south-west corner of Madhya Pradesh. It is bounded by Alirajpur District of Madhya Pradesh on south, Dahod District of Gujrat in west, Ratlam District in north and Dhar district of Madhya Pradesh in east. Jhabua is one of the tribal dominated District of Madhya Pradesh. It's covered an area of 3596.00 Sq/km. The northern and eastern boundaries of the study area are well defined by the rivers. The Mahi flows along the eastern boundary separating from Ratlam and Dhar District of Madhya Pradesh.

Methodology

The broad methodology adopted during the present investigation for terrain characterization, different thematic maps such as Drainage map, Geological map, Geo-morphological map, Landuse/Landcover map, and Soil map has been prepared. Derived maps were generated for Watershed, Slope and Groundwater prospect in the area. Socioeconomic profiles and amenities and facility maps were generated for obtaining data from Directorate of Census Operation, Government of India (GoI). The data were used to generate maps of Population profiles, village wise population density and amenities and facilities maps of the study area.

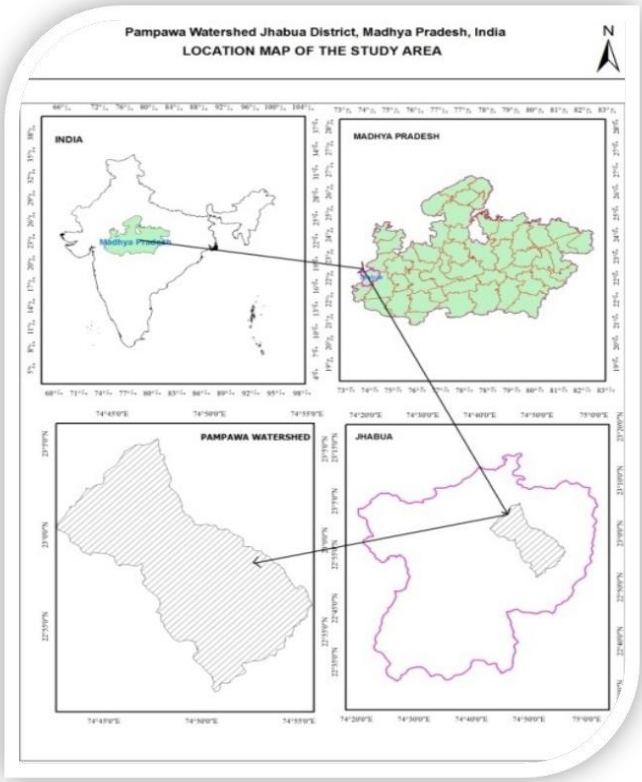


Figure -1:- Location map of the study area

Etc. Primary data generated using satellite data and secondary data then integrated in Geographical Information system (GIS) along with the ground survey information to generate Land and Water resource management plan.

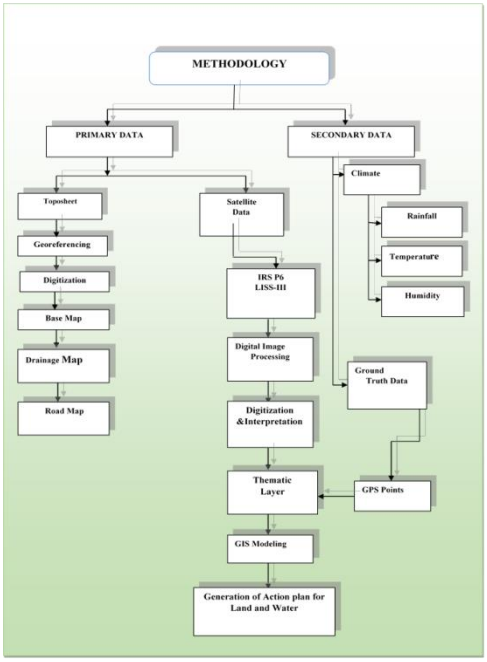


Figure-2:- Flow chart of Methodology

Result and Discussion

Drainage Network Analysis

A **stream** is a body of water that carries dissolved ions and rock particles, it flows down the slope along a well-defined path, called a **channel**. Thus, streams may vary in width from a few centimeters to several tens of kilometers.

Drainages develop along the zones where easy erosion of rock type and structures occur the most. Because of the erosion and weathering of the rocks various types of drainage patterns is developed in the region. Dendritic drainage patterns are most common among them. It is developed on a land surface where the underlying rock is in a uniform and constant struggle against erosion. The study area has fully drained by dendritic drainage pattern which comes from plain to undulating areas.

In the drainage basin analysis the first step is to determine the steam orders. In the present study, the channel segment of the drainage basin has been ranked according to Strahler's stream ordering system. According to Strahler, 1964, the smallest fingertip tributaries are designated as order 1. Where two first-order channels join, a channel segment of order 2 is formed; where two of order 2 join, a segment of order 3 is formed; and so forth. The trunk stream through which all discharge of water and sediment passes is therefore the stream segment of highest order. The study area is a 6^{th} order drainage basin. The total number of 1350 streams were identified of which 1151 are 1^{st} order stream, 158 are 2^{st} order, 31 are 3^{rd} order, 06 are 4^{rd} order, 3 are 5^{rd} order and one is indicating 6^{rd} order streams. Drainage patterns of stream network from the basin have been observed as mainly dendritic type which indicates the homogeneity in texture and lack of structural control. This pattern is characterized by a tree like pattern with branches that intersect primarily at acute angles. The drainage density of the Pampawa Watershed is 3.17 km/km2 and total length of the stream is 740.83 KM.

Table No. 1:- Detail of the drainage network analysis

Stream						
Stream Order	I	II	III	IV	V	VI
No. of Stream	1151	158	31	6	3	1
Length(KM)	467.25	136.56	75.42	27.28	22.54	11.78
	I/II	II/III	III/IV	IV/V	V/VI	
Bifurcation ratio	7.47	5.09	5.16	2	3	

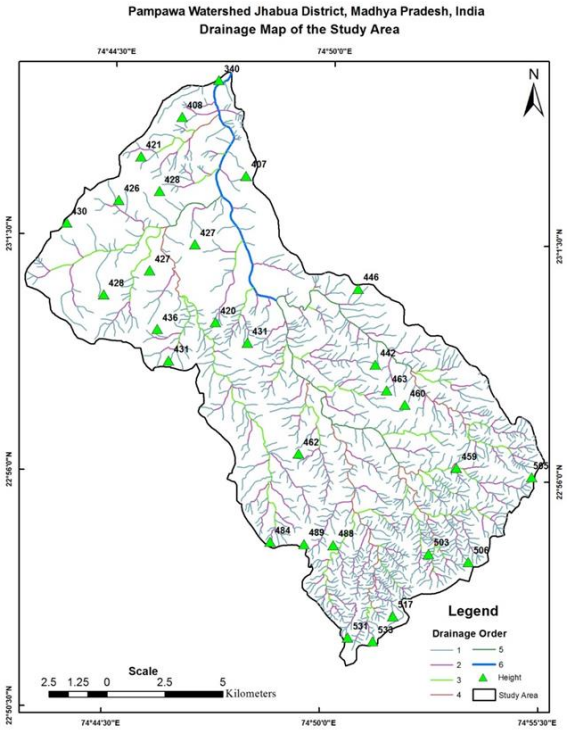


Figure 3:- Drainage ordering map

Drainage Density Mapping

Drainage density is defined as the closeness of spacing of stream channels. It is a measure of the total length of the stream segment of all orders per unit area. The drainage density is an inverse function of permeability. The less permeable a rock is, the less the infiltration of rainfall, which conversely tends to be concentrated in surface runoff (Magesh, at el 2011).

Drainage density of the Pampawa Watershed has been calculated using line density analysis tool in ArcGIS software. The study area has been grouped into five classes. These classes have been assigned to Very low, Low, Moderate, High and Very High. High drainage density is recorded in the Southern parts of the study area because, the southern part has been comprises with hills and plateau along with very high altitude. Drainage runoff is very high and there is no water infiltrate in ground. The suitability of groundwater potential zones is indirectly related to drainage density because of its relation with surface runoff and permeability. During groundwater prospecting, drainage density has played an important role to identify groundwater accessibility sites.

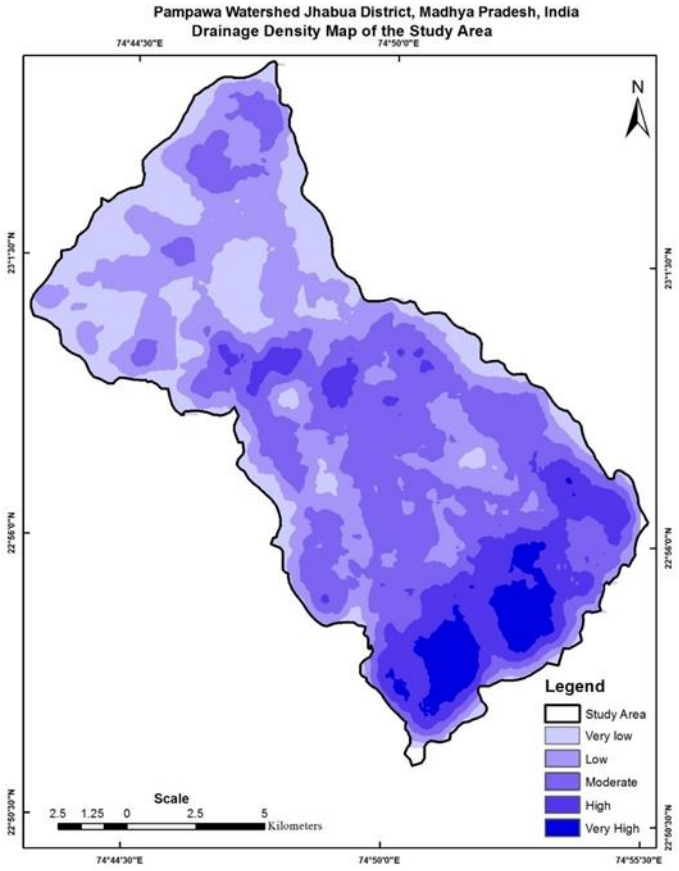


Figure-4:- Drainage density map

Ground Water Prospect Map

The groundwater potential zones for the study area were generated through the integration of various thematic maps viz., drainage, slope, lithology, soil, lineament, rainfall and land-use using remote sensing and GIS techniques. The demarcation of groundwater potential zones for the study area was made by grouping of the interpreted layers through weighted multi influencing factor and finally assigned different potential zones. The groundwater potential zone of this study area has been divided into four grades, namely poor, moderate, good and excellent. The groundwater potential map demonstrates that the excellent groundwater potential zone is concentrated in the north-eastern due to the distribution of alluvial plains and agricultural land with high infiltration ability. Similar results are reported by Shankar, et al 2006. Poor concentration in shouth-east and some patches are found in whole study area. While moderate groundwater condition occurred 70% and good groundwater zone in north-western part of the Pampawa watershed. This indicates that, soil type and slope plays a vital role in groundwater augmentation. Moreover, the concentration of drainage density and lineament density also helps the infiltration ability of the groundwater

system. Finally, the cumulative effect of the weighted multi influencing factors through overlay analysis in GIS platform revealed the mapping of groundwater potential zones in the study area Groundwater prospect map of the study area. Arial distribution shown in table no 2 and thematic map shown in figure no 5.

Table No 2:- Spatial distribution of Groundwater potential zone

Sr. No.	Class	Area in Hectare (ha)	Area in Percentage
I	Poor	5083.48	21.8
II	Moderate	15164.77	65.05
II	Good	2951.43	12.66
IV	Excellent	112.1	0.49
Total		**23311.78**	**100**

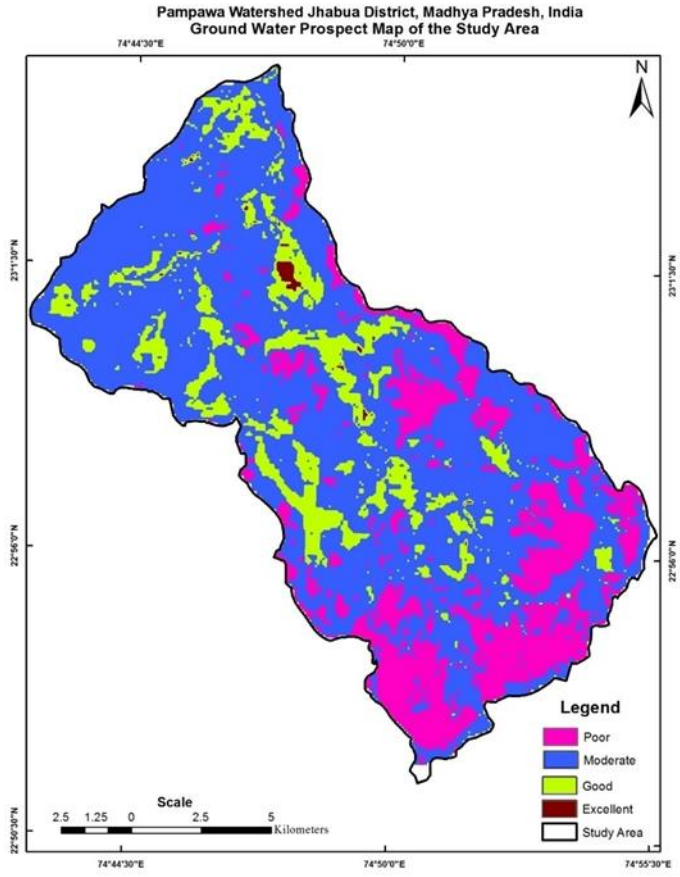


Figure No. 5:- Ground Water Prospect map

Water Resource Action Plan

No national planning and management of water resources is possible without comprehensive assessment of available quantum. Further integrated planning and management of all water resources projects must consider the watershed as planning units. Management of water resources in Pampawa Watershed from the storage of rainfall precipitation to travel the overland flow down below the foot hills. Alluvial deposit along the major rivers also supports good ground water recharge. The Watershed boundary can be broadly described with the Basaltic complex. Basaltic complex are good for surface water harvesting and sandstone support good ground water recharge zone.

Action plan map for water resource development has been prepared based on geomorphological setup and Landuse conditions.

Water harvesting structure have been suggested by using the criteria laid by Integrated Mission for the Sustainable Development (IMSD) for making water resources development plan.

The emphasis is given on the wastelands and priority areas which require immediate management of both surface and groundwater. About 164 sites have been selected in Pampawa Watershed for rainwater harvesting and artificial recharge based on Satellite Image interpretation and field observation.

Water harvesting structure will be used for the purpose of water storage of run off in rainy season. This study proposes four more water harvesting structure; the Check Dams, Stop Dams, Storage tanks and Percolation Tank, this is based on the research by **Harish et al. 2014** in India. These four structure are good for water harvesting for domestic use but also for recharging the ground water and as well as used the criteria for water harvesting structure side from Integrated Mission for making water resource development plan. Below mention the table shown all the criteria which needs during the construction of water harvesting structure. Artificial structure details and criteria is given table no 3.

Table No. 3 - Water harvesting structure criteria

Sr. No.	Type of Structure	Criteria
1	Stop Dams	I. Drainage 3RD or 4TH order II. Percolation of surface water is very low. III. Open scrub land
2	Check Dams	I. Slope must be gentle (1-10%) II. Drainage 1-3rd order

		III. Loamy Soil IV. Human population should be less in upstream region, Land Use: Forest/Scrub land
3.	Dugout Ponds	V. Slope gentle 1-10%. Close to ephemeral stream VI. Low soil permeability
4.	Nala Bundh	Vii. Slope not more than 5% Viii. Soil with adequate permeability iX. Land use: Forest/Scrub land
5.	Gully Plug	X. Slope more than 35 Xi. Constructed in open forest with soil depth 50 cm
6.	Gabions	Xii. Slope 10-15% Xiii. Soil depth 50cm Xiv. In degraded forest area

Table No. 4 - Proposed Suitable Sites for Artificial Recharge in Pampawa Watershed

Village Name	Stop Dam	Side for Check Dam/ Boulder Bund	Suitable side for Nala Bundh	Suitable side for Reservoir/Lake/Pond	Suitable sites
Ajab_Borali	0	0	1	0	1
Alsaya_Khedi	1	0	1	1	3
Anant_Khedi	1	0	2	0	3
Asaliya	0	1	1	0	2
Babliya_Pad	0	2	0	0	2
Bani	0	1	1	1	3
Bhesgu_Wada	0	0	2	0	2
Bolasa	0	3	1	0	4
Cchapri	1	0	0	0	1
Dhanpura	0	0	1	0	1
Dhanya_Rundi	0	1	1	0	2
Dula_Khedi	0	1	0	1	2
FOREST Area	0	15	17	0	32
Gulree_Pada	0	2	0	0	2
Jamli_Pada	1	3	1	1	6
Jamuniya	1	2	0	0	3
Jhosar	0	2	0	0	2
Juwaniya	1	1	1	0	3
Kachra_Khadan	2	3	2	0	7
Kajbi	0	1	1	1	3
Kalsadiya	0	2	0	0	2
Kana_Kua	1	3	0	0	4
Kardawad	0	0	1	1	2
Kesharpura	0	0	1	2	3
Khoriya	0	0	4	1	5
Kodli	0	1	0	0	1
Lala_Rundi	0	0	1	0	1
Manasya	0	1	0	0	1
Mata_Pada	0	1	0	1	2
Matapada	0	1	0	0	1
Mathuriya	0	1	0	0	1
Nahar_Pura	0	0	2	1	3
Pannas	0	0	1	0	1
Patelawad	1	2	3	2	8
Pithdi	0	3	1	0	4
Raipuriya	1	2	1	0	4
Rampuriya	0	1	1	0	2
Ratamba	0	1	1	0	2
Rupgarh	1	1	1	2	5
Sagdiya	0	1	0	1	2
Saluniya_Bada	0	5	1	0	6
Saluniya_Chchota	0	5	3	0	8
Samli	1	1	3	1	6
Soyel	0	1	0	1	2
Suar_Pada	0	1	0	0	1
Talaw_Pada	0	1	0	1	2
Unnai	0	1	0	0	1
Total	**13**	**74**	**58**	**19**	**164**

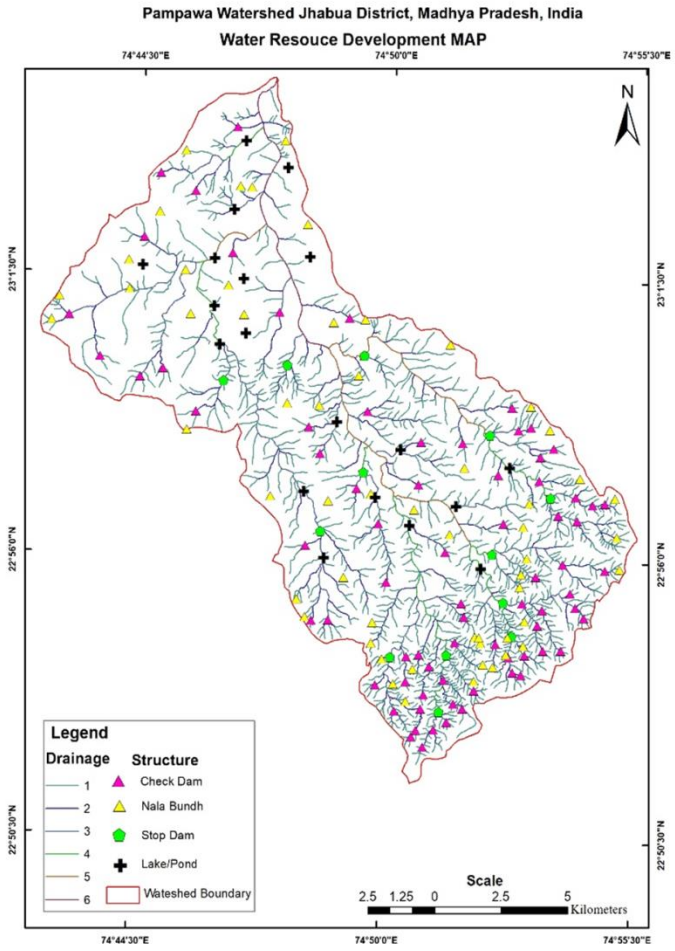
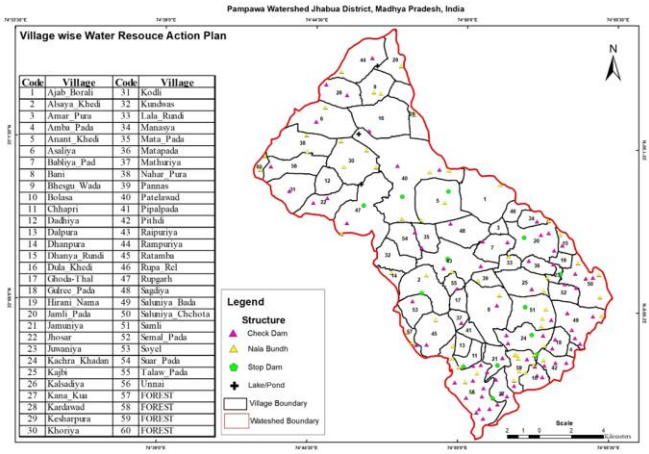


Figure 6 -Water Resource Development Plan



Code	Village	Code	Village
1	Ajab_Borali	31	Kodli
2	Alsaya_Khedi	32	Kundwas
3	Amar_Pura	33	Lala_Rundi
4	Ambi_Pada	34	Manasya
5	Anant_Khedi	35	Mata_Pada
6	Asaliya	36	Matapada
7	Babliya_Pad	37	Mathuriya
8	Bani	38	Nahar_Pura
9	Bhesgu_Wada	39	Pannas
10	Bolasa	40	Patelawad
11	Chhapri	41	Pipalpada
12	Dadhiya	42	Pithdi
13	Dalpura	43	Rajpuriya
14	Dhanpura	44	Rampuriya
15	Dhanya_Rundi	45	Ratamba
16	Dula_Khedi	46	Rupa_Rel
17	Ghoda-Thal	47	Rupgarh
18	Gulree_Pada	48	Sagdiya
19	Hirami_Nama	49	Salmiya_Bada
20	Jamli_Pada	50	Salmiya_Chchota
21	Jamuniya	51	Simli
22	Jhosar	52	Semal_Pada
23	Juwaniya	53	Soyel
24	Kachra_Khadan	54	Star_Pada
25	Kajli	55	Talavi_Pada
26	Kalsadiya	56	Unnai
27	Kana_Kua	57	FOREST
28	Kardawad	58	FOREST
29	Kesharpura	59	FOREST
30	Khoriya	60	FOREST

Figure 7 - Proposed Suitable Sites for Artificial Recharge in Pampawa Watershed

Conclusion

By the use of Geo-Spatial technology, suggested plan has been proposed for water resource management with the analysis of spatial layers along with allotment of their different weightage which used for the overlay and modeling purpose, on the basis of Geospatial modeling and overlay methodology prospecting the ground water for entire study area, with the help of ground water prospect suggested to artificial recharge structure for the water harvesting and ground water recharge. Poor and Moderate category covered an area around 86% of the total study area in which Poor 21.8 % and moderate is 65.05.

Suggested water harvesting structure is total 164 in which 13 Stop Dam, Bolder bund 74, Nala bund 64 and Lake/pond. Details are shown in figure No 6 and table No 4.

Reference

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