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Integrated watershed studies of Naigaon Odha (sub tributary) of Karha River, Purandhar taluka, Pune –A case study.

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Abstract-
Water is a key driver of economic and social development and is one of the fundamental elements in sustaining the integrity of the natural environment. It is the major renewable resource amongst the various natural resources. Water being an vital constituent for all life supporting processes, its assessment, conservation, development and management is of great concern for all those who manage, facilitate and utilize, issues related to water resources development and management .These studies should not be carried out in isolation but should be coupled and inter-related with other human activities. The water shed programmes would benefit immensely from systematic hydro geological studies as groundwater resources form an important aspect in most watershed development programmes (Kulkarni, 1998). Effective watershed management can prevent community water shortages, poor water quality, flooding and erosion. The expense of undertaking watershed management is far less than the cost of future remediation.
In the present study morphometric analysis have been carried with reference to their order and arrangement in watershed. The linear, aerial and relief aspects were studied in detail for interpreting the systematic description of drainage Morphometry and results are presented in this paper. The prime objective of this study is to understand the heterogeneity in Deccan Basalts rocks in hydrogeological investigation of such aquifers.
Key words: watershed, Morphometry, social changes; sustainability.

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I. Introduction

Water exists within a certain physical framework of a watershed. This framework is largely controlled by the local geological conditions. Hence, the planning of a watershed development programme can be rendered more effective if the physical system taking the impact of the measures is correctly understood. Large areas of India are covered by "hard rock's" that are mostly of igneous and metamorphic origin. Many arid and semi-arid regions of India obtain water supplies from groundwater stored in these rocks. This is especially true for large rural tracts that obtain water for agriculture and domestic supplies entirely from the groundwater stored in these rocks. It is a well-known fact that groundwater forms a very crucial source of water supply in the national water resources scenario. And yet, it continues to remain a resource that is grossly misused! Many watershed projects in the country still suffer from insufficient inputs (especially in the form of systematic hydrogeology to address the problem(s) of ground water from within the watersheds, despite the fact that this resource is precisely the focus of most watershed activities. The objective of a watershed development programme is to conserve water within the 'hydrological' unit, both as surface water and groundwater.

The groundwater system in this study area consists of a shallow unconfined system and some deeper aquifers formed through a complex relationship between the heterogeneous geological units in the subsurface. Vesicular amygdaloidal basalt units on the surface help mobilize recharge to the groundwater system. Although there is hardly any groundwater abstraction from the system, base flow discharges are nearly perennial and would tend to constitute a large component of the water balance, groundwater storage in the lower compact basalt units being relatively limited.

LOCATION OF THE STUDY AREA

The study area is the common synonym for the Karha river basin. The largest village in the river basin is Romanwadi. This River Basin is included within the Survey of India Toposheet number 47 J/7 and 47 J/3.

GEOLOGY OF THE STUDY AREA-

The Naigaon Odha in Pune district of Maharashtra state is located on the Deccan basalt setting and offers a unique opportunity to study groundwater in its various dynamics: physical, social, institutional and economic. Understanding these dynamics is the key to describing how the livelihood aspects in typical Deccan basalt settings are linked to groundwater resources, and consequently to recharge, both natural and artificial. The simple flows equate to classic flood basalts formed by quite effusive eruption of very large quantities of low viscosity lava from open fissures. The compound flows are either the product of explosive activity from more viscous lavas or can be formed at the distal portion of simple flows where there is an increased viscosity from cooling and de-gassing. The interconnectivity between units and the fracture openings within each unit control the storage and transmission of groundwater in these basalts. Compact basalts have very little storage and transmission capability, except when jointed or fractured. Even then, the permeability of the fractured portion of compact basalts is quite limited as compared to that of weathered vesicular-amygdaloidal basalts / compound basalts. Hence, due to the horizontal sheet jointing (related to the degree of weathering) and greater lateral interconnectivity, the vesicular-amygdaloidal portions of such units usually form good locales for storage and transmission of groundwater.

II. Material And Methodology

Reconnaissance survey was carried out using Survey of India Topographic sheets (mainly 47 J/7 and part Of 47 J/3), on the scale of 1: 50000. Study of Geological Survey of India (2001) District Resource Map for Pune district.

Detailed Geological field surveys to determine the nature and disposition of basalt lavas in the basin and to map these units on a map. In addition, these surveys also included determining the type of lineaments identified from the study of remote sensing data through detailed ground survey undertaken by us.

A detailed inventory of water features including drainage lines, wells and boreholes, habitations, land-use features and watershed development measures including recharge structures.

Regional mapping (on river basin and watershed scales) was undertaken. Various recharge structures such as wells and ponds were built in the village. The wells were approximately 30 to 50 feet deep and provided sources for consumption and washing purposes.

III. Result And Discussions

Morphometric Analysis

The drainage pattern in the Naigaon Odha watershed is mostly dendritic to sub-dendritic. Many streams originate in the northern basaltic ridges and drain south into the Khara River.

The morphometric analysis of study area have been studied under linear, aerial and relief aspects.

Linear Aspects

Stream order (u),Stream Number (Nu),Bifurcation Ratio (Rb),Stream Length (Lu),Mean Stream Length (Lsm),Stream Length Ratio (Lsr)and Main Channel Length (Cl).

Aerial Aspects

Basin Area (A),Basin Length (Lb),Basin Perimeter (P),Drainge Texture(Dt),Texture Ratio(T)
Stream Frequency(Fs),Elongation Ratio (Re),Form Factor(Rf),Length of Overland Flow(Lg)
And Constant Channel Maintenance (C)

Relief Aspects

Basin Relief (Bh),Height of Basin mouth(Z),Max. Height of Basin (Z),Relief Ratio(Rh),
Relative Relief (Rhp),Ruggedness (Rn**)**,DEM and Slope map.

GEOMORPHOLOGICAL STUDIES

The geomorphology studied for the Purandhar taluka have been undertaken and a geomorphic map has been prepared using the available satellite imagery obtained from the lSRO site. Geomorphologically, the satellite imagery has been classified into four geomorphic units based on visual interpretation and by tonal differences. These include denudational hill, highly dissected plateau, moderately dissected plateau and upper plateau. These geomorphic units and its areal extent in the Purandhar taluka are displayed in Table 1.

Table 1: Distribution of Geomorphic unit and its percentage.

Geomorphology Units	Area Sq.Km	PERCENTAGE
Plateau Top	1.20	2.21
HDP-A, With exposed rock, negligible soil cover	1.28	2.36
HDP-B, With thin soil cover and weathering	45.46	83.72

MDP-A, With exposed rock and thin soil cover	3.42	6.29
MDP-B, With moderate soil cover	1.44	2.65
Settlement	0.55	1.01
Water body	0.96	1.76
Total	**54.30**	**100.00**

The Geomorphologic map has been prepared for study area and is enclosed as figure XXX. The Plateau top account for 1.20 sq.km and contribute 2.21% of the total area. Highly dissected plateau take up 46.74 sq.km of the area and contribute to 86.08% of the area. On the other hand, moderately dissected plateau takes up a larger area up to 4.86 sq.km and accounts for 8.94 % of the total area. The plateau top is comparatively flat areas of great extent and elevation and extensive land region considerably elevated about the adjacent country having a flat or nearly smooth surface. The settlement accounts for 0.55 sq.km (approximately 1.01 % of the total area). The water bodies comprise of 0.96 sq.km and account for 1.76 % of the total area.

Sustainable watershed Development Action Plan for the study area:

Water management should be sustainable to prove effective, in line with the present study objectives of watershed development. The best option, therefore, was to establish a methodology of water use that is systematic enough to consider the specific watershed characteristics. Based on the present investigation and the findings herein, a broad strategy is being suggested as an attempt towards effective watershed development management. The same is summarized as follows--

1. There is scope for mobilizing some recharge to the groundwater system. Hence, a few feasible sites for percolation tanks are been considered. *It is also known that there are a sufficient number of existing structures in the watershed. Some of these are being revived through desiltation and repairs to render them effective.*

2. Groundwater resources development is possible in the middle reaches of the watershed. Deepening of existing wells and sinking a few new wells to optimize pumping is being taken up in this zone. Care is also taken, that the proposed well sinking does not result in haphazard development of additional (numerous) wells and uncontrolled abstraction of groundwater. Low discharge, high head pumping systems are most suitable on such wells so as to build in an automated regulatory mechanism of abstraction, which is in agreement with the hydrogeological properties of the groundwater system.

3. The unique feature of this watershed is in the form of the groundwater discharge area. This is an extremely good indicator of the 'environmental health' of the watershed. It is imperative to maintain the base flows for long-term, water resources sustainability, the use of community wells in this zone;although the well-yields from this zone are bound to be limited, but sustainable in the longer run.

SOCIAL IMPACT OF THE PRESENT STUDY

Impact assessment under this project was attempted on the basis of social and economic status of the villagers as well as on the basis of their living conditions. Watershed projects need to adopt a sustainable livelihood approach of improving productivity and reducing poverty, even though such projects often present conflicting challenges. Ownership of groundwater sources like wells, in the watershed, is fragmented and is owned by different sections of the society. There are private wells and bore wells along with community wells. With the implementation of our proposed measures and structures suggested in the study area; eradication of ownership of groundwater sources like private wells etc. would be possible to some extent. Watershed development in this area can improve the livelihood opportunities for communities of these villages. In the present study an attempt has been made to look into some of the aspects that contextualized water and livelihoods, especially from the artificial recharge point of view.

Watershed development is a complex activity. Its success is a function of not only technical perfections but also attitudinal and behavioural changes. Watershed works done in the project areas not only benefit the project area but the benefits are passed on to the adjacent downstream and upstream villages in some way or the other.

Village consists of a number of vastis (small hamlets) with each vasti having its own source of irrigation, usually in the form of springs. They have been using this water for protective irrigation for years and are not using any other sources of irrigation. Due to the topographical constraints of village, they cannot cultivate a variety of crops and so benefits in the form of improved or increased irrigation remain limited.

Changes in Access to and Use of Groundwater

Traditionally, river, dug wells and springs were the main source of irrigation in the valley. All these sources were not perennial and so the villagers faced severe water scarcity during Summer. Women had to walk almost few km daily, to fetch water. There was not enough water for livestock. Farmers could not even think of the second crop (rabi crop).

After the watershed intervention suggested by our study, the situation will improve in the villages. Due to efforts like construction of continuous contour trenching (CCT's), check dams and land treatment in the catchment area, the water table in the area can show a significant improvement. Water will be readily available for the farmers and their problem of availability of domestic water and the water for livestock etc. will be solved to a large extent if the suggested measures are implemented with utmost priority.

Changes in Livelihood Outcomes

Due to the easy accessibility of water resources, there will be a change in the social and economic condition of the farmers. The standard of living will improve and thus the farmers will live a dignified life. Due to improved income and lifestyle there will be development of schools, colleges and hospitals. This would in turn increase the literacy rate of farmers.

Farmers and their livestock would be benefitted as there would be ample availability of water as well as green fodder. There was no fixed source of water previously for livestock in the area. Traditionally all the cattle used to drink water from the river Karha, whenever water was available in the river. Otherwise water was made available for the livestock through the domestic water fetched for the household purpose. The river Karha would become perennial and other sources like dug wells and springs will have water throughout the year so that there is ample water available for the mankind and livestock.

The average household income would also show an increment. The implementation of this proposal would show a substantial increase in service income, livestock income and family business income.

Social Changes

Most of the farmers in the villages are small to medium land-holding farmers. Watershed development in this area can improve the overall economic conditions of the people. There will be a considerable increase in the number of 'pacca' houses. In future there will be development of proper road network and railway network connectivity may be possible.

Migration that may take place due to employment opportunities and good communication Sources to the nearby towns like Pune and Mumbai can be minimized if the watershed development is implemented and monitored properly.

There might be an overall increase in household articles like TV, cupboards, bicycles, two Wheelers and other luxuries etc. The fact that villagers are able to spend on these goods which are not necessity articles will indicate improved income and spending capacities which will enhance the standard of living.

Other Benefits

One of the objectives of present study was to ascertain how villagers perceive benefits from watershed development Projects and also an attempt is made to relate findings from the physical study to perceptions from the community. The major benefits that may be perceived by the villagers would be in the form of:

- Increase in Kharif irrigation (increased reliability of river flows allowing supplementary irrigation when monsoon rain fail) .
- Increase in rabi irrigation
- Increase in water table
- Water recharge
- Possibility of sugarcane crop
- Possibility of multiple crops
- Utilization of wasteland
- Increase in population of medicinal plants and horticulture
- Regular drinking water supply through community taps

Finally a multifarious approach of watershed management and conjunctive use of available groundwater resources with adoption of high tech irrigation techniques coupled with knowledge of local geological and hydrogeological parameters of the area will develop a formal understanding between villagers about water sharing and optimum water use.

IV. Conclusions

- The prevailing agricultural practices in the study area have shown that there is beginning of new area under cultivation with the rising tendency of bi-annual cropping pattern. The increased need of high quantity of water is satiated by the dewatering of groundwater from various depths with the consequences like lowering of water table and scarcity of water. Hence, there is ever-increasing need for water conservation and recharge in the study area.

- The present study brings out the usefulness of modern geospatial tools (GIS) for morphometric analysis of Naigaon Odha watershed.

- In the study area two types of measures have been undertaken viz., erosion control and artificial recharge. Based on the geomorphology, metamorphology, landuse, rainfall etc. It is aimed to arrest and treat the active zones of sheet erosion and intensive gully erosion. Selection of sites for corrective and preventive measures by erecting various structures like, contour trenches, gully plugs, earthen dykes, check dams, percolation tanks, nala bunds, recharge pits, underground bandhara, dabri structure and roof top rain water harvesting structure etc. has been decided.

- The main objective of recharge structures is to impound surface runoff coming from the catchment and to facilitate percolation of stored water into soil substrata. The artificial measures have been suggested in watershed with a view to raise the groundwater level.

- The watershed experiences a tropical to sub-tropical climate,it experiences summers from March to June and winters from November to the following February. The nights during the summers are quite warm, with an average temperature of about 24°C, while the average temperature during the day is about 40°C. During winters, the mean daily temperature is around 30°C and the average night temperature is about 12°C, December being the coldest month. Humidity is very high during the summers with an average of about 70-80%. Climate is reported to change as one travels from the upper reaches of the valley to the lower reaches.

- The study explains the competence of integrated GIS in analysis of artificial recharge and groundwater exploitation sites in the area as well as establishing a relationship between Land use and consequent changes in groundwater regime. Further it exhibits the utility of satellite data in studying surface water and ground water regime.

- On the basis of interpretation of satellite data (Digital Elevation Model), Survey Of lndia Toposheets, field work it is clear that geomorphology of the area comprises of Highly dissected plateau, Moderately dissected plateau, Upper Plateau, Settlement, water bodies.

- The drainage pattern is mostly dendritic to sub-dendritic. Many streams originate in the northern basaltic ridges and drain south into the Khara River.

- The computed value of circulatory ratio is 0.45. The circulatory ratio is influenced by length and frequency of streams, geological structure, land use, climate and slope of basin.

- Elongation ratio is defined as the ratio of diameter of circle of the same area in the basin to the maximum basin relief. In the present study the elongation ratio is 0.66 which reveals the elongated basin shape and wide variety of climatic and geologic features.

- The low value of constant channel maintenance for watershed under study indicates the low permeability, steep slope, high surface runoff in some parts. The value of constant channel maintenance for watershed is 0.38.

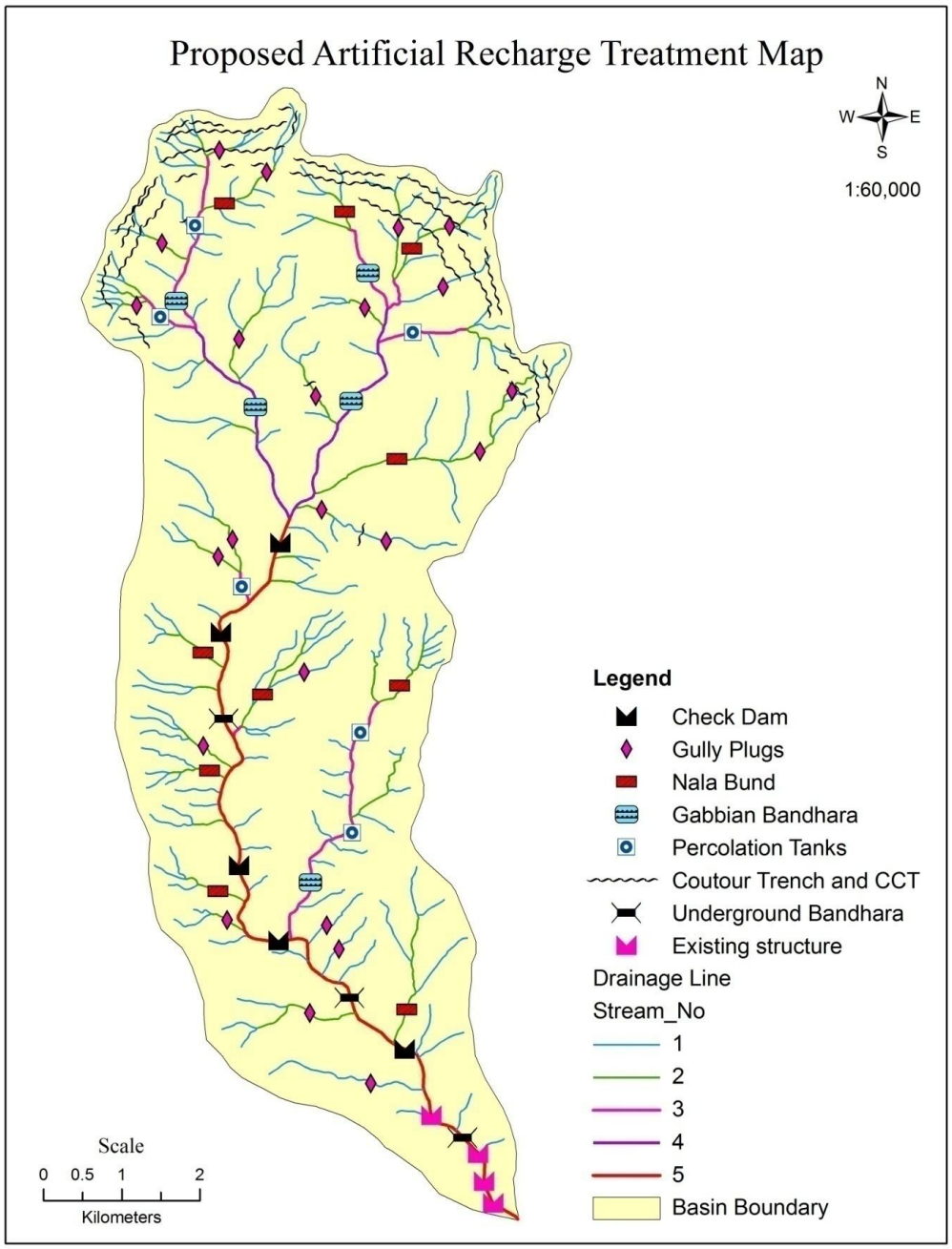
The comprehensive action programme, which aims at optimal utilization of groundwater resource potential in the light of physical, economic, social development represents the groundwater management. Such endeavor encompasses the harmonious development of water resources of an area for the future generations in a sustainable manner in the present investigation input resource data base for the comprehensive action plan to carry out resource management.

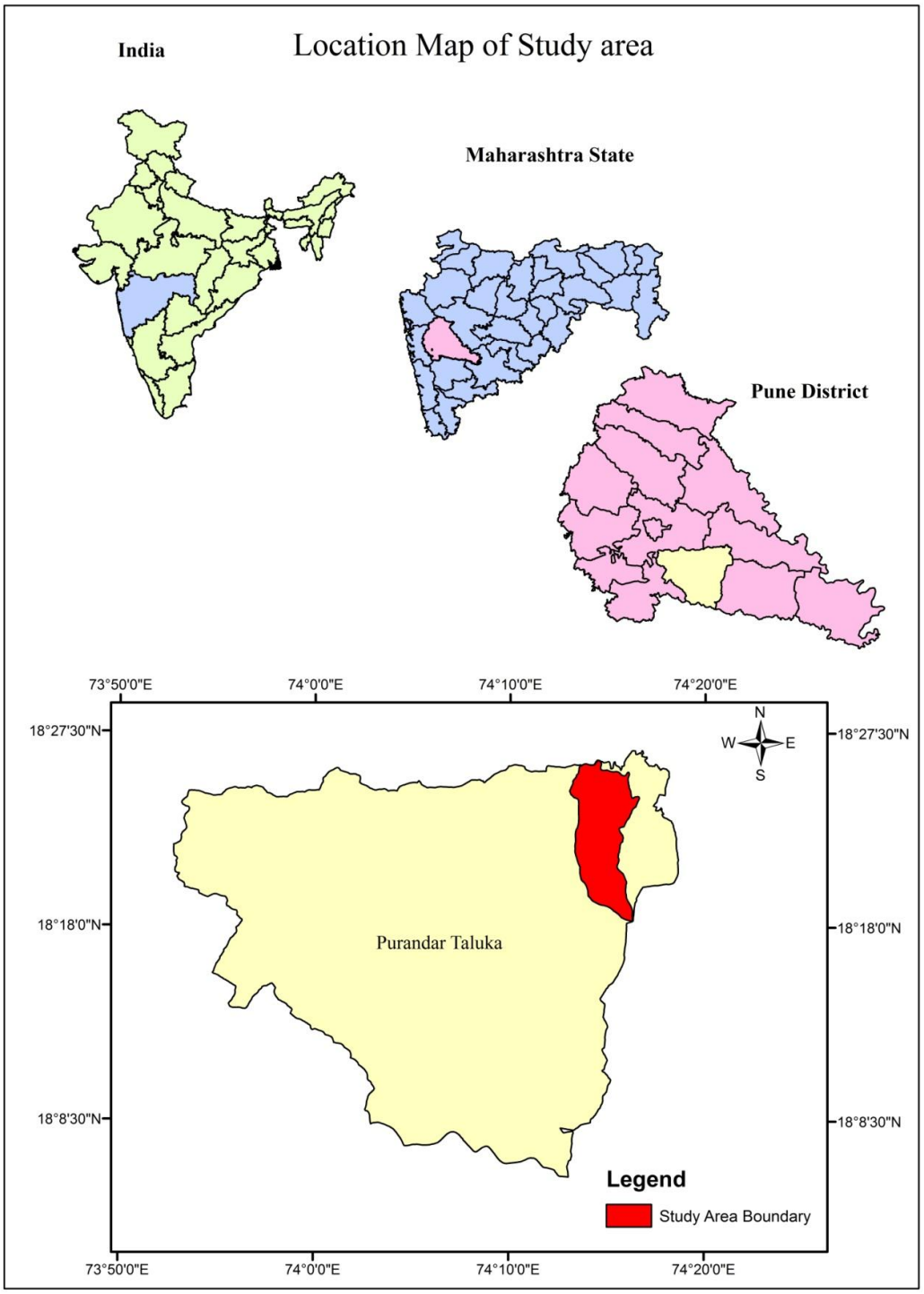
The discussion with farmers brought out the limitations in awareness levels regarding the watershed development programme. Hence continuity in the process of disseminating findings and an increased interaction with communities is desired. The increased interaction will not only help in awareness improvement but also go

a long way in developing an enabling environment for progressively improved perhaps even sustainable management of water resources.

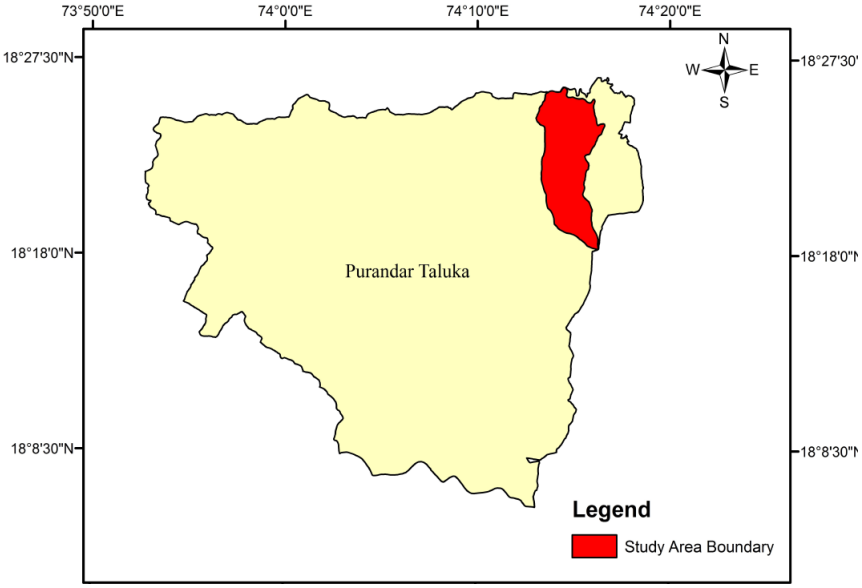
From the study undertaken by us, the proposed watershed treatment structures / remedial measures to be implemented in the area are as follows---

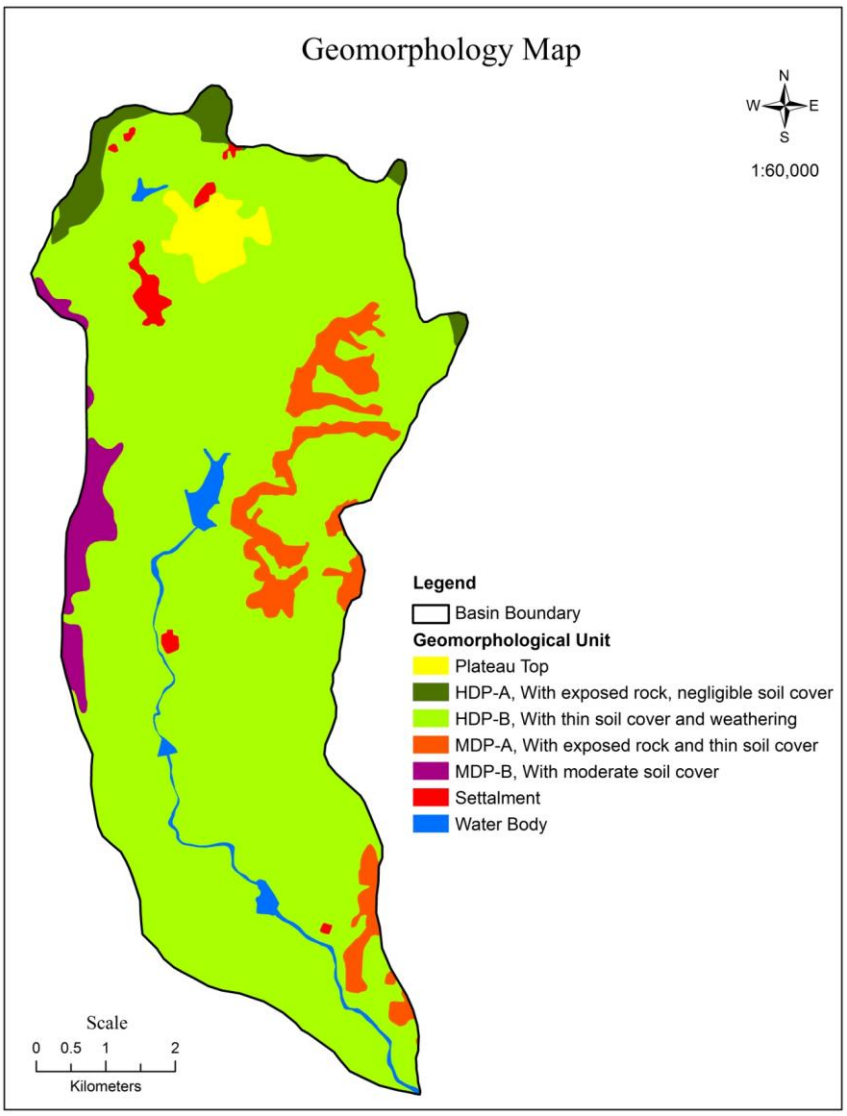
- Six percolation tank is proposed in study area as shown in Fig 16.
- It is also proposed to have five Gabion structures; from which four are suggested at the higher elevation , one near Romanwadi on downstream of the basin.
- Five check dams are proposed on fifth order stream. In between these four check dams, 'Nala' widening is proposed to accommodate sufficient backwater and use them for agricultural purposes.
- There are few existing wells in the study area and gully plugs
- Underground bandhara are suggested in between main stream of the odha.



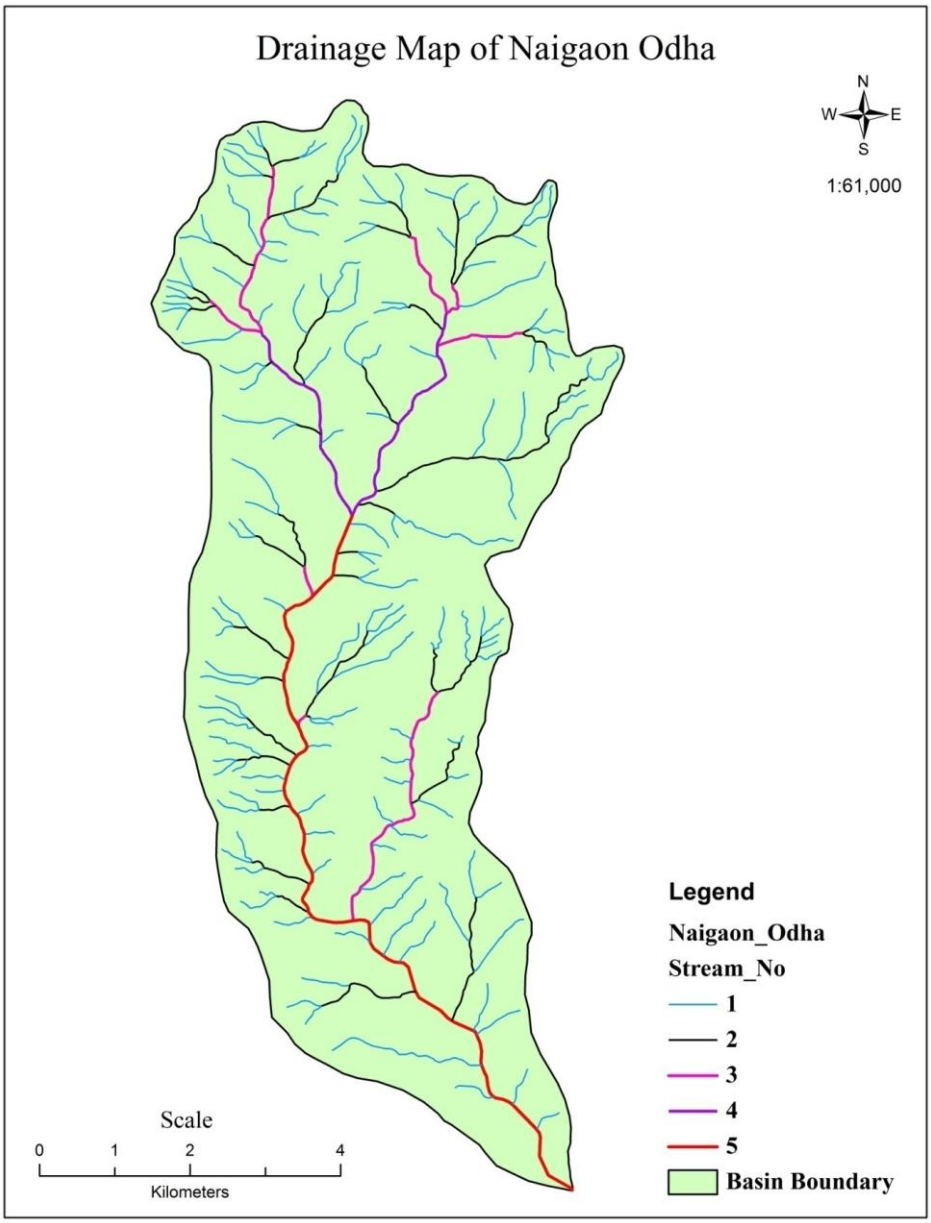


Location of Study Area (Toposheet No. 47 J/7 and 47 J/3)





Geomorphology map of Study Area



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