IDENTIFICATION OF GROUNDWATER RESOURCE AND ITS CONSERVATION IN PARTS OF AURANGABAD, INDIA

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ABSTRACT:
Various geological and geomorphological factors play a major role at different levels in the occurrence, movement and potential of ground water in hard rock terrain of study area. The problems associated with the ground water resource development can be appreciated with reference to the topographic characteristics. Rainwater or surface water entering into the porous part of rock passes through a zone of aeration and the zone of saturation below is affected by the kind of geologic framework available and the hydraulics of water movement in sub-surface through the soil veneer. Thus, groundwater resources that develop in nature depending upon terrain conditions and the geological composition of terrain material are dissimilar in many respects. This aspect has been given importance for an understanding of the concept of groundwater resource development in the study area. Identification of the ground water potential zone in the study area was done on the basis of different hydro-geomorphic units. Accordingly five categories of groundwater potential zones were delineated as (i) Very Good (ii) Good (iii) Moderate (iv) Poor and (v) Very poor. An integrated approach of Remote sensing and GIS techniques has been used in this study. Methods of conservation of groundwater resource have been further suggested.

INTRODUCTION

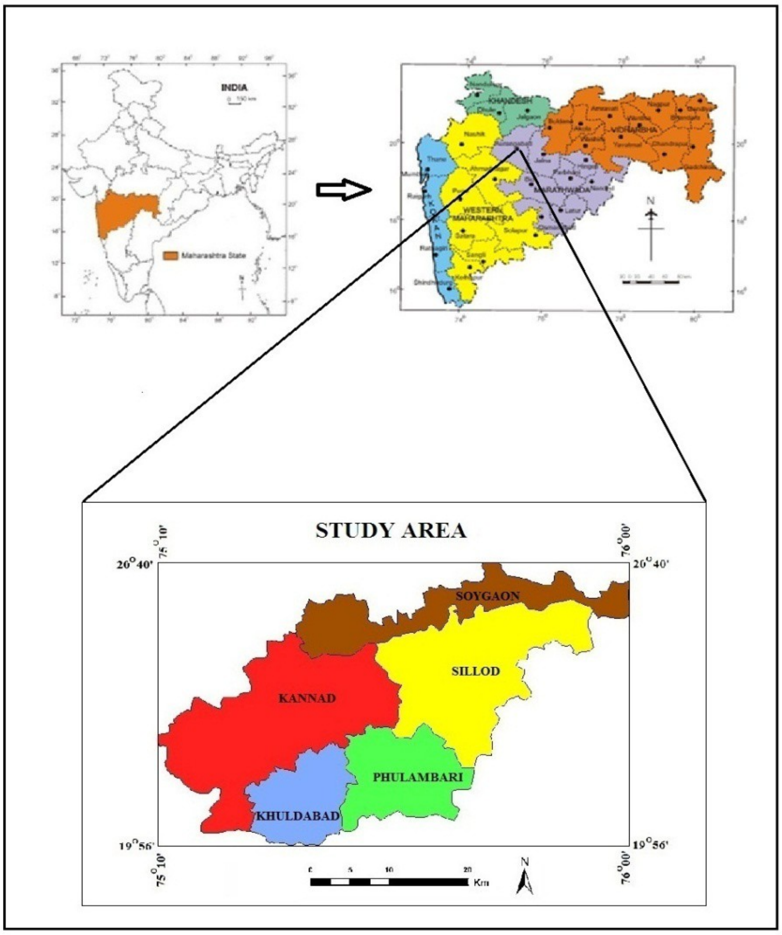
The main source of water on this Earth is rainfall. A portion of it percolates beneath the surface while some portion evaporates into the atmosphere and some of it makes run off. A portion which percolates through the surface forms groundwater. So Groundwater is that portion of water beneath the surface of earth which can be collected in wells, tunnels or drainage galleries or flow naturally to the earth's surface (Thornbury, 1976). Groundwater has been an important resource throughout the ages. Old dug wells can be found along the wadis of the Middle East. Some of the ancient tunnels or ghanate in Iran are still in use. Groundwater has thereby always played an important role in meeting the requirements of humans. Exploitation of groundwater reserves as a viable source of drinking water and for domestic use (or even for small scale industries) is safer and economical than that of surface water, as groundwater is not only found almost everywhere but also generally uncontaminated. As a result, groundwater investigation has assumed top priority in recent years. People all around the world face serious water shortage because of over exploitation of groundwater (for domestic, industrial and agricultural purposes). It is estimated that around seven billion people out of the projected 9.3 billion in the entire World will face water shortage, and out of these, 40% will suffer acute water crisis. Thus exploration, assessment and management of groundwater resource have become one of the key issues as groundwater forms an important component of the total water supply for drinking and irrigation purposes (Mahajan, 2008).

Various geological and geomorphological factors play a major role at different levels in the occurrence, movement and potential of groundwater in hard rock terrain. The present work was based on a concept that groundwater is not only controlled by the geology but their occurrences are also influenced by geomorphology. Geomorphological analysis of groundwater provides with the information on accumulation, occurrence and circulation of groundwater as it is directly connected with relief, associated rocks and sediments. Like the landforms, groundwater depends on one hand on the geology and geological processes in depth and on the other hand on physiographic environment, especially climate. As water becomes increasingly commercially valuable, geomorphological mapping becomes important and inevitable. Considering all these aspects, through the present study an attempt was made to identify and delineate potential zones for groundwater in a semi-arid drought prone and water scarce ecosystem like Aurangabad. Groundwater favourable zones have been delineated and depicted based on the geomorphological map of study area(Roy Burman, 2016).

The Study Area:

Aurangabad district is famous for historical and archaeological importance owing to the presence of Ajanta and Ellora caves, in Maharashtra. The district lies in the north-west corner of Maharashtra in India and is situated between the parallels of 19° 18' and 20° 40' North latitude, and between the meridians of 74° 34' and 76° 04' East longitude (Fig.1.1) covering an area of 10,107 km^2. It accounts for 3.28 % of the total area of Maharashtra state and 2.99 % of the total population of the state (CGWB, 2010). The district is bounded by Jalgaon district in the north, Nashik district in the west, Ahmednagar and Beed districts in the south and Parbhani and Buldhana districts in the east. There are 1300 inhabited villages, 44 desserted villages and 9 talukas which comprises of Aurangabad, Paithan, Sillod, Soygaon, Vaijapur, Gangapur, Kannad, Phulambari and Khuldabad. The district headquarter is located at Aurangabad City. The present study focuses on the northern talukas viz., Soygaon, Sillod, Phulambari, Kannad and Khuldabad. They are situated between the parallels of 19º 56' and 20º 40' North latitude and between meridians of 75º 10' and 76º East longitude as shown in Figure 1.

FIG.1 : LOCATION MAP OF STUDY AREA



GEOGRAPHICAL PERSONALITY OF THE STUDY AREA

The study area lies in the North East of the Aurangabad district where the Ajanta plateau begins with elevations of over 900 metres and slopes gently eastwards drained by the River Purna and its tributaries. The northern part of the study area is covered by shallow soil which is not good for irrigation. The soils generally increase in depth and fertility eastwards. The climate is semi-arid so it is generally dry except for the monsoon season. It receives an average annual rainfall ranging from 500 mm to 800 mm from the southwest monsoon during June to September. The maximum day temperature ranges between 39ºc and 42ºc during summer. December is the coldest month of the year and May is the hottest month. The vegetation is peculiar to Western India, and marked by a prevalence of long grass and a paucity of large trees like teak. The jungles are open-mixed composed of shrubs and bushes that are more or less deciduous in the cold season. The valley fill areas are utilised for agriculture and the larger spontaneous vegetation mainly confined to the outer slopes of the hills, and to the deep ravines that form the sources of the streams issuing from the highlands. Dendritic and sub-dendritic patterns were found in central parts of study area. They develop upon rocks of uniform resistance. The development of stream segments was found to be affected by slope and local relief. These produced differences in drainage density from place to place in the study area.

Geological setting:

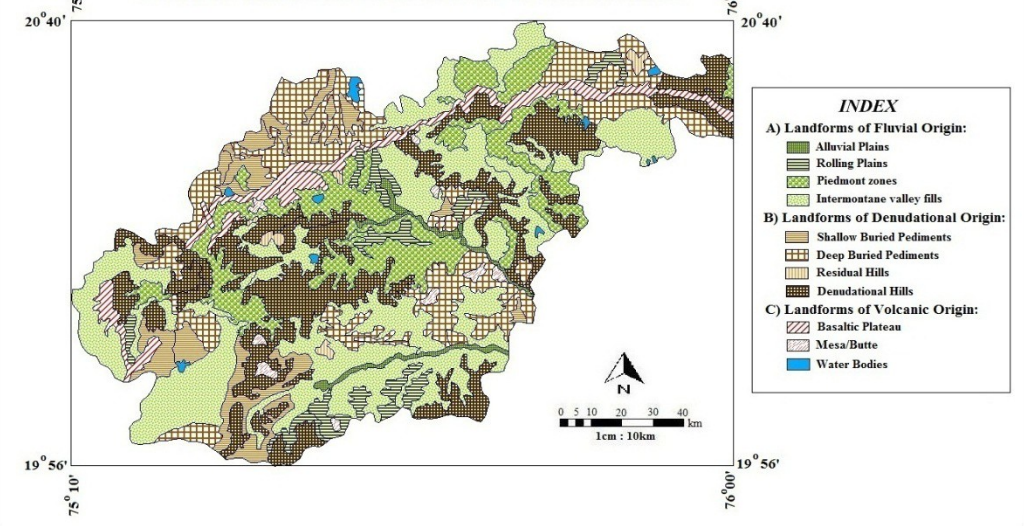
The geomorphology of the study area has been continuously evolving for a long period since rocks and materials from the tertiary and Mesozoic to Quaternary era occurs in this region. The different litho units and a number of lineaments which are fracture zones had been identified on the satellite imagery due to linear pattern, exhibited by darker tone and straight drainage course. These lineaments are favourable for occurrence of groundwater. The field traverses helped to observe in detail the characteristics of different rock types. The prominent geological units observed in the study area are the horizontally disposed basaltic lava flows and each flow has distinct two units. The upper layers consist of vesicular and amygdule zeolitic basalt whiles the bottom layer consists of massive basalt. This basaltic lava flows are the only water bearing formations in the area. The weathered and fractured mantles of the traps are forming aquifers in the area where groundwater occurs under phreatic conditions. The study area has been underlined by series of basaltic lava flow that range in age from late cretaceous to Eocene and whose accumulated thickness is from a few meters to thousands of meters. The flows are generally flat lying or gently warped but in few places they are folded or faulted. The study area also consists of new or recent alluvium which consists of clay, silt and sand. They were coarse to medium textured, neutral fairly to high fertile soils and were found mainly near the streams and rivers (Athavale, 1992).

Geomorphological landforms:

Based on the Endogenic and Exogenic processes the geomorphic landforms were identified and described. An observation and investigation of remotely sensed images and topographical maps supplimented with fieldwork led to identification of the land forms considering geotechnical elements (vegetation cover, drainage pattern, erosion pattern, structure and landuse) and photographic image recognition elements (tone, texture, pattern, shadow, shape size and convergence of evidences). The major geomorphological landforms identified, delineated as shown in Figure.2 and mapped in the study area are basaltic plateau, messa and butte, denudational hills, residual hills, rolling plains, deep buried pediment, shallow buried pediment, intermontane valley fills, piedmont zone and alluvial plains (Roy Burman, 2016).

In preparing the groundwater maps full potential of remote sensing and GIS was utilized by adopting an integrated approach. This was prepared based on specific tone, texture, size, shape and association characteristics of remotely sensed data. Significant geomorphic units were identified and analysed through Google earth satellite image and verification with topographical map of the study area.

FIG. 2 : GEOMORPHOLOGICAL MAP OF STUDY AREA



GROUNDWATER POTENTIAL ZONES

These geomorphological features of the study area provide a simple and efficient way to identify the groundwater potential zones and to contribute to the decision-making process. The geomorphological map of study area has been depicted in Figure.2. On the basis of different geomorphic units, five categories of groundwater potential were delineated as (i) very good (ii) good (iii) moderate (iv) poor and (v) very poor as depicted in Table 1:

TABLE 1
GROUNDWATER POTENTIAL ZONES IN STUDY AREA

Geomorphological Units	Ground Water Potential
Alluvial Plains	Very Good
Piedmont zone, Intermontane valley fill	Good
Rolling plains, Buried pediments and Shallow buried pediments	Moderate
Denudational Hills, Residual hills	Poor
Basaltic Plateau, Messa and Buttes	Very Poor

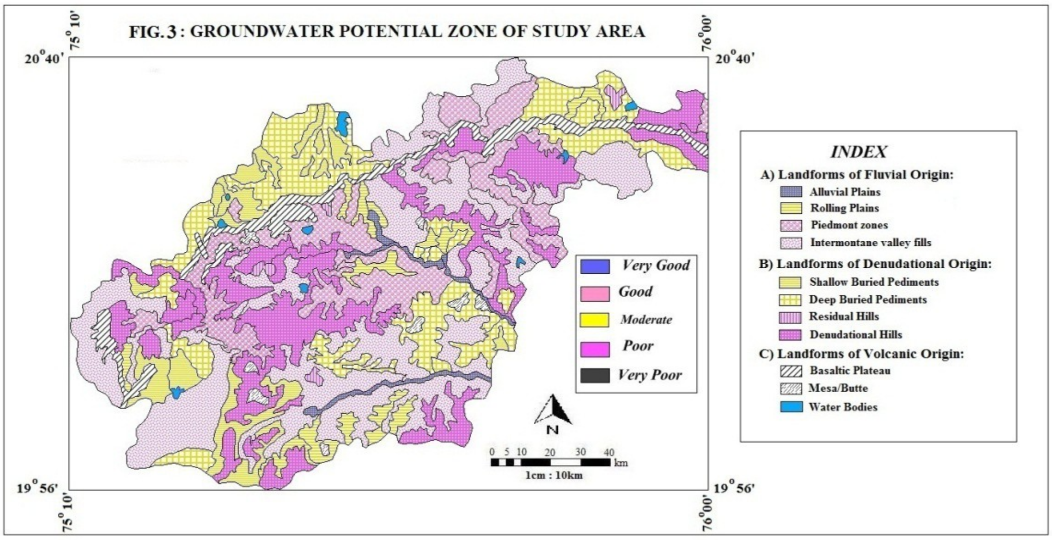


FIG. 3 : GROUNDWATER POTENTIAL ZONE OF STUDY AREA

Very Good Groundwater Zones:

1) Alluvial Plains:
This is the youngest geological unit including various landforms formed by fluvial action. They are formed due to periodic flooding by river Purna, Girja, Shivna and Anjan. This consists of sand, silt and clay and facilitates channel bed infiltration. It is highly permeable zone helping the partial bank recharge and subsurface flow of groundwater occurs under semi-confined to perched water table conditions with shallow water levels. The depth of groundwater level was found ranging between 5.5 m bgl and 11.5 m bgl in pre-monsoon while during post-monsoon period depth to water level was found between 1.5 m bgl and 3.5 m bgl. Groundwater prospects in alluvial plains are therefore invariably found to be very good and this unit exist all along the river courses of study area (Roy Burman, 2016).

Good Groundwater Zones:

2) Piedmont zone:
Piedmont, in geology, is a landform created at the foot of a mountain or mountains by debris deposited by debouching and shifting streams. Such an alluvial region in a humid climate is known as a piedmont and in arid climates such a feature is called a bajada. A series of adjacent alluvial fans and alluvial cones coalesce to form a piedmont zone. It consists of talus and scree material, which are derived from the hilly areas. This material of coarse pebbles and finer material favours ground water recharge. Considering the adverse conditions like slope and unconsolidated material, this zone is unsuitable for landfill site. Piedmont are formed at the foothill and spread over a few sq km of area in the study area. The ground water potential zones were checked against the bore well yield data which reflects the actual groundwater potential and it is found that groundwater potential zones identified from the multilayered formation are in good agreement with yield data. The depth of ground water level varied during pre-monsoon (8.7 m bgl and 15 m bgl) and post monsoon (3.5 m bgl to 6.5 m bgl) periods in the study area (Roy Burman, 2016).

3) Intermontane Valley Fill:
Intermontane valley fills are linear depressions present in between the hill ranges and occupy the lowest reaches in topography, commonly filled with pebbles, cobbles, gravels, sand, silt and other detritus materials. Depending upon the parent rock, the valley fill deposits vary in composition and texture. They have been demarcated on the basis of their reddish tone on satellite images which indicates high moisture content due to intensive cultivation. In the present study, the valley fills are recognised between the denudational hills on northern part of the study area. The drainage pattern over the valley fill is parallel to sub parallel indicating that the drainage is largely controlled by the lineaments. Groundwater prospects in valley fills are good because of the topographical location at the

bottom of the hill and geological composition consisting of highly porous materials. Subsurface water potential is also good in the intermontane valley fills. These valleys are developed along the fractures and such places can be exploited for groundwater through deep bores. In general, it is observed that adequate recharge source of groundwater is met within valley fillings. The depth to groundwater level was found ranging between 8 m bgl and 12.5 m bgl during pre-monsoon period while in post-monsoon it was found between 3.5 m bgl and 7.6 bgl. Hence, in such places, the groundwater is considered to be good with adequate source of water. This has very good porosity and permeability but sometimes presence of clay may make it impermeable.

Moderate Groundwater Zones:

4) Deep Buried Pediments:
The term "pediment" is defined, as an eroded rock surface of considerable extent at the foot of a mountain slope or a face formed under arid to semi-arid climate erosion. Deep buried pediments are formed when the sloping surface of pediment gets gradually covered with a thick mantle of soil and colluvial material. The deep buried pediments have greater moisture retention capability than the pediments. The water-table fluctuation is relatively less and recharge area is large. Hence they form potential zones for groundwater development by dugwells and borewells. Deep buried pediment falls between gentle slopes in study area and is considered as suitable hydro-geomorphic unit because it checks the velocity of surface runoff and thus provides moderate chance of water accumulation. Deep buried pediment zone with thick soil cover has deep water table ranging from 5.45 m bgl to 16 m bgl (pre-monsoon) and 2 m bgl to 8.5 m bgl (post-monsoon) below ground level. However, at times the depth of groundwater level has fallen up to 33 m bgl during pre-monsoon due to anthropogenic influence and landform control over groundwater percolation.

5) Shallow buried pediments:
This unit consists of very low weathered zone. A flat and smooth surface of buried pediments consists of shallow overburden of weathered derivative materials (photo 3a and 3b). Shallow buried pediment zones have thin soil cover and depth to water table ranging from 9.7 m bgl to 13.5 m bgl (pre-monsoon) and 5.25 m bgl to 9.3 m bgl (post-monsoon). Groundwater prospects are moderate, but open well yields good amount of potable water after monsoon.

6) Rolling Plains:
The geomorphological map shows that rolling plains are ubiquitous all over the study area. The material brought down from denudational hills result into reduction in capacity of stream to transport the coarse material which gets deposited on rolling plains. The depth of groundwater levels are found ranging between 8 mbgl and 13 m bgl during pre-monsoon and 5.1 m bgl and 8.08 m bgl in post-monsoon period. They are not capable of supporting intensive cultivation thereby suggesting moderate prospect of groundwater.

Poor Groundwater Zones:

7) Denudational Hills:Denudational hills are the remnants of the natural dynamic process of denudation and weathering. The geomorphic forms of denudational hills occur as exfoliation domes, linear ridges, messa and buttes, low mounds with partial scree or debris accumulated at the foot slopes. The geomorphic expression and shape of the denudational hills are controlled by lithology, and spacing of structural features like joints and fractures occurring in them. Denudational hills with an average height of 700 m above mean sea level occupy the north western and central part of the study area encompassing Soygaon, Sillod, Kannad and Phulambari. They are exposed as a group of massive hills with resistant rock bodies and rounded summits and are formed due to differential erosion and weathering. These hills are covered with big boulders and sparse vegetation in contrast to structural hills. Denudational hills in Sillod and Soygaon are marked by sharp to blunt crest lines with rugged tops indicating that the surface runoff at the upper reaches of the hills has caused rill erosion. This landform acts as a high runoff zone due to its deep slope so groundwater potential is poor. The depth to groundwater level ranges between 12 m bgl and 21 m bgl in pre-monsoon while during post-monsoon it is found within 7 m bgl and 17 m bgl. On account of its hilly terrain these landforms in the study area except for a few sources, faces shortage of drinking water.

8) Residual Hills:
Residual hills are generally resulted from the end product of pediplanation, which reduces the original mountains into a series of scattered knolls standing on the pediplains. These hills are having more resistant formations standing out prominently to differential erosion and weathering. Their occurrences as isolated patches are found at lower altitudes. Inspite of their isolated occurrence, their continuity in a linear or curvilinear fashion indicates that they are structurally controlled. The shape of the residual hill are controlled by the different lithological composition, distribution and spacing of joints and fractures. In the present study (Fig.2) these types of residual hills features have been noticed in small pockets all around the denudational hills but the cluster is more on the north-eastern part of the study area. In pre-monsoon depth of groundwater level ranges between 8 m bgl and 19 m bgl while in post-monsoon 5.1 m bgl and 12 m bgl. These units are considered as poor groundwater potential zones, as they have unfractured rock material, low infiltration and behave largely as runoff zone.

Very Poor Groundwater Zones:

9) Basaltic plateau:
The study area is covered by the Deccan traps and trappean landforms which pre-dominate the geomorphology of the area. The plateau areas along the northern boundary forming part of Ajanta, Satmala and Antur hills run in NW-SE direction. The processes of differential erosion and weathering formed massive hills with resistant rocks. The elevated parts of the plateau e.g. Mahismal in Khuldabad, are largely dissected by streams. The groundwater prospects in the basaltic plateau zones are very poor. The escarpment zones are registered as the marked runoff zones, so very little or no recharge possibility may be observed. Very limited recharge in basaltic plateau zone can be observed along lineaments, valleys and slopes of low angles having veneer of soils. As a result, on the plateaus with high relief and steep slopes shows high runoff zone and very poor recharge. The depth of groundwater level varies within 21 m bgl (pre-monsoon) to 15 m bgl (post-monsoon). However, on the way to Daulatabad perennial small springs in the fracture zone were noticed as seen in photo 19a and 19b. The groundwater in this landform is mostly developed in these rocks due to fractures, joints and weathering so they have small perennial springs found within the fault lines.

10) Mesa and Buttes:
Buttes and mesas, for example, are formed when the surface material of a hill or a mountain called the cap rock resists physical weathering but underlying materials (usually softer rock) do not. Over a time, the underlying materials break down through a process called weathering and erosion, leaving an isolated, flat-topped hill called a butte (or a mesa if it is really large). Buttes and mesas are usually found in fairly dry areas. When plants and ground cover are scarce, the softer rock layers of buttes and mesas are left exposed to running water. Over a time, softer rock is eroded, leaving steep, vertical sides and gently-sloping bases where the eroded rocks get collected. In the study area these landforms are found in small patches over the denudational hills located in northeast of Phulambari and west of Khuldabad (Fig.1). The ground water prospect is very poor in these areas due to fast runoffs over steep slopes so they fall under the category of very poor groundwater potential zone (Fig.3). The depth to groundwater level varies between 12 m bgl and 20.17 m bgl during pre-monsoon while it is found within 7.1 m bgl and 17 m bgl during post-monsoon period.

Overall it has been observed that in study area a large portion of geomorphic unit comprises of intermontane valley fill and piedmont zones which have good groundwater potential. Therefore, these groundwater reserves can be considered as sustainable yields which can be safely utilized to meet the water demands of different sectors in the study area. The poor and moderate prospective zones fall under in areas where more withdrawal of water takes place for domestic and industrial purposes along with resistance from landforms.

CONSERVATION OF GROUNDWATER RESOURCES

Groundwater resources occur under dynamic system in which there is unending relationship between recharge to the sub-surface depth level and discharge to the surface (Dhokarikar, 1995). As a matter of fact, the hazards and problems experienced in the study area are interlinked and cannot be separated from each other and studied in isoloation. It is very obvious that the change in one factor affects another causing change in other areas. It is a delicate system consisting of physical and human interactions which need comprehensive understanding of the system for sustainable use of groundwater. The problems of the study area in utilizing the groundwater are manifold. It was found that most of the problems are due to climatic, geomorphic processes and human interventions. The problems of the study area which could be identified on the basis of hydro-geomorphological investigation are as under:

1. Rill Erosion
2. Gully Erosion
3. Aridity
4. Low water table
5. Deforestation

Rill erosion and Gully erosion occur when run off is concentrated and channelized sufficiently. As it is noticed, rills get slowly enlarged into gullies and ravines resulting into bad land topography. The study area receives torrential rainfall during short spells, the water collected over basaltic terrain and highland rushes down and removes unconsolidated materials. The gullies encroach upon the fertile cultivable lands on buried pediments, active flood plains, intermontane valley fills and along river banks. It is noticed that over grazing and human intervention have caused damage to natural vegetal cover and accelerated gully erosion. It is recommended that the gully erosion should be checked by plugging gullies and bringing the land under protected forest and grass with controlled grazing. Over the denudational hills, residual hills and basaltic plateaus the slope is very steep which gives rise to uncontrolled and unchecked run off descending down the slope. It has resulted in serious rill and gully erosions. The problem of steep slopes cannot be overcome but at least these slopes can be put under forest, grasses and grazing may be regulated to avoid further erosion (Roy Burman, 2016).

From the data regarding climatic parameters it has been observed that the study area faces the problem of aridity. It is needless to explain the causes of aridity as the area experiences semi-arid climate. The aridity is the major cause of water deficiency and poses problem to crops. It is observed that most of the streams in the area are non-perennial owing to aridity and low rainfall concentrated in short period and high temperatures in summer. The water from the rivers cannot be utilized for irrigating crops during rainfall deficiency period thereby increasing the dependency over groundwater. This leads to over abstraction of groundwater and reduction of water table in piedmont zone, buried pediments and alluvial plains. Thus, the potential social and economic consequences of continued weak or non-existent groundwater management are serious, as aquifer depletion is concentrated in many of the most populated and economically productive area of the study. The implications are disturbing for sustaining economic growth and local livelihoods, and for environmental and fiscal sustainability. The consequences will be most severe for the poor. Furthermore, climate change will put additional stress on groundwater resources while at the same time will have an unpredictable impact on groundwater recharge and availability. Recharge ponds and check dams like structures such as Kolhapur weirs and vasant bandharas have provided good measure of artificial recharge in the hard rock terrain of the study area by collecting the surface runoff and increasing the surface area of infiltration (Roy Burman, 2016).

Suitability of these structures depends on various factors which can be further identified using GIS techniques. The remotely sensed satellite and airborne images spatial coverage helps in mapping and monitoring the earth surface at local and/or regional scales (Jadhav,1986). The advantages offered by remotely sensed satellite image data include:
- It provide a synoptic/regional view compared to both aerial photographs and ground sampling
-It is cost effective
- It is has high spatial resolution and coverage compared to ground sampling, and
- It provides relatively high temporal coverage on a long term basis.

Deforestation is also a very serious problem giving rise to erosion, accentuation of aridity, depletion of groundwater, lowering down of water table and mass movements in the study area. Afforestation programes must be initiated in large scale to control the hazards resulting due to deforestation. Public awareness and people’s participation must be encouraged.

Surface water resources are visibly exposed to our direct observations. The quantity and quality of surface water supplies directly depend upon the rainfall precipitation. The problems associated with the surface water resource development can be appreciated with reference to the topographic characteristics alone rather than wholly on geologic considerations. Rainwater or surface water entering into the porous part of rock pass through a zone of aeration and the zone of saturation below is affected by the kind of geologic framework available and the hydraulics of water movement in sub-surface through the soil veneer. The same reason of geologic elements, controlling the sub-surface behaviour of groundwater is predominant thereafter. Thus, surface water and groundwater resources that develop in nature depending upon terrain conditions and the geological composition of terrain material are dissimilar in many respects. However both of them have exchangeable inter-dependence. This aspect is important for an understanding of the concept of groundwater resource development in the study area.

Groundwater resources occur under dynamic system in which there is unending relationship between recharge to the sub-surface depth level and discharge to the surface (Dhokarikar, 1995). As a matter of fact, the hazards and problems experienced in the study area are interlinked and cannot be separated from each other and studied in isolation. It is very obvious that the change in one factor affects another causing change in other areas. It is a delicate system consisting of physical and human interactions which need comprehensive understanding of the system for sustainable use of groundwater.

Recommendations:

Based on the geomorphological analysis of units, processes operating in the study area, the following recommendations can be made for sustainable development of groundwater resources.

1. Remote sensing data are powerful tools to improve our understanding of groundwater systems. Despite unable to measure hydrogeological properties directly, they provide continuous detailed terrain information and allow the mapping of features significant to groundwater development therefore it is important to incorporate them in the data collection stage of groundwater exploration works.

2. Despite various satellite data with different spectral and spatial resolutions coupled with digital image processing techniques help to produce detailed maps, ground verification is crucial to increase the accuracy of the interpretation results. The result obtained from this study should be supported by subsurface data obtained from geophysical study.

3. Dug wells are recommended in the weathered amygdaloidal basalt and highly jointed compact basalt. Most of the dug wells in the amygdaloidal basalt and compact basalt with non-interconnected joints dry up during pre-monsoon period hence bore wells and dug-cum bore wells are recommended for these areas. The sites for borewells need to be selected only after proper scientific investigation. Borewells generally tap deeper fractures, which may not be sustainable. Besides, the borewells should only be used for drinking water supply and not for irrigation.The groundwater in the area of weak protective capacity is often vulnerable to pollution if, for example, there is leakage of buried underground storage tanks it can become a source of serious environmental hazard.

4. It is very important to promote more informative public discussion with due appreciation of the complexity of the water problem. An essential condition for this is to force the government to place all relevant information relating to water resources, their utilisation and allocation and the rationale of decisions freely accessible in the public domain. Civil society has to be proactive in pointing out gaps and inconsistencies in the data, and contribute actively to improving the database (Joy, 2008).

5. It is also important to develop the capacity to analyse the information and come up with technically sound alternative solutions; institutional mechanisms for democratic management by representatives of all stakeholders and for settlement of disputes based on clearly defined principles; and economic incentives combined with transparent but strict governance to induce efficient, equitable and sustainable use of available groundwater (Joy, 2008).

To conclude, the concept of groundwater management centers on equal demand for groundwater with supply. It means fulfilling the needs of users without unnecessary depleting or causing damage to groundwater resource regime. It is hoped that this geomorphological analysis of groundwater resource may help to provide valuable information to the authorities in planning and development of groundwater resource in the study area through optional and rational utilization of available resources.

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