The present research work deals with management of water resources which is very valuable for the survival of life. The management of any resource basically deals with the two aspects such as the availability and requirement of the same. Therefore, it is important to know the occurrence, quality and utilization of that resource. It is equally important to have a clear understanding of the factors which govern the availability and utilization of resource. As water is a finite resource, its overall management and the conservation are of utmost importance. It can be achieved by minimum utilization, recycling and rain water harvesting.

The declining availability of water resource is a serious problem faced in the several parts of the country. It is a difficult task to provide pure drinking water to the huge population of the country. Therefore, only positive way to safeguard the resource for future use is to undertake soil and water conservation activities for recharge augmentation. These activities involve a high degree of community acceptance and participation. It is, therefore, advisable to involve NGOs or Voluntary Agencies in the planning and execution of these activities and ensure popular support through them (Limaye, 1994).

The present study essentially deals with the role of geomorphologic factors related to the availability, potentials and utilization of water resources in the Dhule district of Maharashtra State. Within the study area, there is a moderate groundwater potential. The study region is well endowed with the drainage network of the river Tapi and its tributaries like river Panzara, Burai, Bori, Arunavati, Aner, Amravati and Kan. The district has no single major irrigation project. There are 12 medium irrigation projects with the total gross storage capacity of 480.61 M. Cu. M.

6.1 DISCUSSIONS AND CONCLUSIONS:

The major findings and observations of the present study are:

6.1.1 Dhule district is situated in the north-western corner of Maharashtra State. It extends between 20°38’ to 21°38’ north latitude and 74°52’ to 75°11’ east longitude. The total geographical area of the district is 8063.11 sq. km. The district is divided into four tehsils for the administrative purposes namely Shirpur, Sakri, Dhule and Shindkheda. There are six towns and 678 inhabited
villages. The population of the district was 17,079,477 while the rural and urban population of the district was 73.89% and 26.11% respectively (2001).

6.1.2 The territory of Dhule district exhibits four distinct physiographic divisions such as Satpura ranges, Dhanora and Galna hills, Deccan plateau and Alluvial Plain of Tapi river. The Tapi river is flows through the central part of the district and through rift valley. This alluvial plain forms good aquifer which is known as the largest aquifer in the state. The highest points within the district are spot height 1291 m. from msl. west of Mangi Tungi peaks and spot height 1290 m. from msl. in the south of village Shenvad in Sakri tehsil. While the lowest elevation is 109 m. from msl. along Tapi river near village Takarkheda in Shindkheda tehsil.

6.1.3 Two geological formations are found in the district, one is Deccan trap and other is Recent Alluvium. About 85% of the district is covered with basaltic terrain which is hard and massive. Some isolated pockets of deeply weathered basalt are located in the southern part of study area. The layers of red bole with varying thickness between few cm to 1.5 m. are observed near the villages Sangavi, Palasaner, Nimzari in Shirpur tehsil, Kudashi in Sakri tehsil and Songir in Dhule tehsil. A rare two tire layers of red bole are found near Bijasani Temple in Satpura ranges. Numerous dykes are found near Dhule, Sakri, Pimpalner, Lamkani, and Dondaicha. Several lineaments have been discovered in the southern part of the district and at foothills of Satpura ranges. The thickness of alluvium varies from few cm to 308 m.

6.1.4 Tapi is a major river of the study area with right bank tributaries such as Aner, Arunavati and left bank tributaries such as Panzara, Kan, Aru, Burai, Bori and Amaravati. The river Tapi is having its source from the sacred tank of Multai located Betul district of Madhya Pradesh. River Arunavati and Aner found their sources from southern slopes of Satpura ranges in Khargone district of Madhya Pradesh. The left bank tributaries such as Panzara, Burai, Bori and Amaravati take their sources from Dhanora and Galna Hills. The Tapi river is non-perennial in the study area. All other tributaries are seasonal. The Tapi river often experience floods.

6.1.5 Dhule district experiences monsoon type of climate. The minimum mean daily temperature during winter season is 12°C while the maximum temperature during summer season rises up to 47°C. Such high temperature is responsible
for increase in the rate of evaporation. The average annual rainfall within the
district is 592 mm because the district belongs to the rain shadow region. The
district comes under Drought Prone Zone of the state. Out of four tehsils
Dhule, Shindkheda and Sakri belong to the drought-prone area. The climate of
the study area is dry except in rainy season. Relative Humidity during winter
months is 40 to 45 %, 20 to 25 % in summer and above 70 % in rainy season.

6.1.6 Black soil is the dominant soil type found in the study area. About 15 % area
of it is covered with black cotton soil and older alluvium. The part of Shirpur
and Shindkheda tehsils adjoining Tapi river is occupied by the deep black soil.
The soil is very fertile for agriculture and vegetative growth. Medium black
soil occupies admeasuring 25% area in Shindkheda, Sakri and Dhule tehsil in
the form of extensive patches. Shallow black soil occurs at the foot hills of
Satpura ranges, Dhanora and Galana hills. It is less fertile and occupies about
60% area of the district.

6.1.7 The land use / land cover of the district is divided in to eight sections. Near
about 5258.37 sq. km. of land means 65.22 % of the study area is under
agricultural use. It is observed in the river valleys, plains and foot hill zones of
Satpura, Dhanora and Galna Ranges. Forest scrub and Deciduous Forest
permeates 21.77 % area of the district. In fact, actual forest is standing on only
5.22 % area. The irrigated area is around 573.72 sq. km. and mostly from
groundwater resources. About 8.52 % and 1.03 % land is barren and rocky.
All the water bodies cover total 2.22 % land surface of study area. Settlements
pervades on 1.25 % area of the district.

6.1.8 Tropical Dry Deciduous forest is the natural vegetation type in the study area.
It ranges from grasses, thorny bushes, trees to deciduous trees. Satpura ranges
and Western Ghat sections are under the forest cover. About 2088.90 sq. km.
area of the study area is under forest, which accounts 25.90 % of the total
geographical area of the district. Large scale deforestation and grazing
practices have destructed the major part of the forest which is covered by
Satpura ranges as well as Western Ghat section. Now a days forest can be
observed in the form of small patches. In fact, only 6.59 % area is under forest
cover in Dhule district. Teak (Tectona grandis L.) is the predominant species
in the study area. In general, the dominating plants from Satpura ranges are
Anjan, Salai, Lal Khair, Black Khair, Sadada, Beheda, Arjun, Chinch, Shisam,
Palas, Nim, Bor, Mahu, Amla, Bel, Jamum etc. Scrub and grasses covers the vast area of south and central parts of the study area. Flood plain of Tapi and valley fills of her tributaries are principally occupied by the agriculture. Nim, Pimple, Mango, Vad, Chinch, Hivar, Bor, Acacia are distributed sparsely in the cultivated areas.

6.1.9 The district is facilitated with two national highways (NH-3 and NH-8), Surat – Bhusaval railway line and two aero drums near Shirpur and Dhule.

6.1.10 Dhule district is one of the important agricultural regions of Maharashtra. In the year 2008-09 total area available for cultivation was 4.59 lakh ha. It is 62.59% of total geographical area of the district but only 80% of cultivable area was under cultivation. The total net sown area in the district was 3.672 lakh ha. of which about 22984 ha. sown more than once. The area under summer crops was 8100 ha. According to kharip cropping pattern of the district, the cotton occupies the area of 84364 ha., which is 18.38% of total cropped area. Other major crops of the kharip season are jowar 21169 ha., bajara 26742 ha., maize 26211 ha., cereals 45296 ha., sugarcane 5747 ha., oil seeds 18766 ha. The cash crops of the district are cotton, banana, sugarcane and vegetables. The trend to grow cash crops like cotton, sugarcane and vegetables is noticeable in the study area.

6.1.11 There are twelve medium irrigation projects and 71530 wells. The net irrigable area is 57372 ha. out of which 4000 ha. (7%) is from surface water resources and 53372 ha. (93%) from groundwater resource. Hence Dhule district is mainly irrigated by groundwater.

6.1.12 There is no single major project available in the Dhule district. There are 12 medium irrigation projects in the district. About 525.383 sq. km. area of the district serves as catchment area for 12 medium irrigation projects. Total storage capacity of all medium irrigation projects is 480.61 M. Cu. M. The gross commanded area is 771.45 sq. km. and net irrigable area is 578.54 sq. km. Besides 12 medium irrigation projects, minor irrigation projects such as percolation tanks, K. T. weirs, storage tanks, village tanks have been proved to be useful for irrigation, percolation and augmenting groundwater. There are 384 percolation tanks, 22 K. T. weirs, 813 storage tanks and 302 village tanks constructed by the various departments. Total storage capacity of all the minor
irrigation projects is 47628.71 TCM and 21500.15 ha. of land has been brought under irrigation.

6.1.13 There are 71407 total irrigation wells in the district which play an important role in agriculture. Dhule tehsil comprises highest number of wells and well density. It is 23695 and 11.95 wells per sq. km. respectively. Sakri tehsil stood second with respect to total number of wells and third in density of wells. Shirpur tehsil has the lowest number of wells and density of wells. It is because of north and north eastern portion of the tehsil is occupied by Satpura hills.

6.1.14 Potential of groundwater resources in Dhule district has been evaluated using Survey of India toposheets, Land Sat 7 ETM+ Band 2, 3, 4 false color image, remote sensing and GIS techniques. The potential of groundwater is demonstrated in five categories. Near about 1430.77 sq. km. (17.74%) area of Dhule district has very high groundwater potential. Most portion of very high groundwater potential zone is discovered along the course of Tapi river and lower reaches of its tributaries High groundwater potential zone constitutes about 28.76 % area of the district. Leading part of this zone appears along with the Panzara river and its tributary Kan river in Dhule and Sakri tehsils. Shirpur tehsil is also covered by the extensive patches of High potential zones. Moderate groundwater potential zone comprehensively accounts for about 34.72% part of the study area. South eastern portion of Dhule tehsil, south western part of Shindkheda tehsil and north eastern as well as south western part of Sakri tehsil possesses moderate groundwater potential. Groundwater potential along the southern part of Sakri and Dhule tehsil is found to be low, which occupies 833.76 sq. km. area. Western ghat section in Sakri tehsil possesses very low groundwater potential. It is only 8.43% in areal extent of the district.

6.1.15 It has been observed that 642132 ha. area is suitable for recharge which allows 126147 ham water to recharge within the district. Natural discharge is only 7546 ham. Net availability of groundwater is 118601 ham and 57821 ham is utilized hence 60780 ham water is available as balance for the district as a whole. Overall stage of groundwater development is 47 % hence there is further scope for the development of groundwater. Trend of water table is falling in pre-monsoon season while rising in post-monsoon season all over
the district. Hence all the tehsils are safe with respect to groundwater availability. Net 57203 ham groundwater is available for agriculture.

6.1.16 Dhule district exhibits varied physiographical features ranging from mountain ranges, hills, valleys, flood plain, plateau etc. The area which is under focus can be divided into four divisions from physiographic point of view. The first physiographic division is Satpura, Dhanora and Galna hills in Dhule district. These hills are poor in groundwater because of steep slope, thin layer of weathered material, absence of soil cover and degraded vegetation. The second is Alluvial Plain of Tapi river which is suitable for percolation of water. Hence it possesses a good deal of groundwater resources. The third division is talus and scree. Thickness of this zones reaches up to 50 m. at many places. This formation comprises mainly boulders, pebbles, coarse and fine sand as well as clay, which is poorly sorted and unconsolidated. Hence it is highly porous and normally yields copious groundwater. At present the dug wells and shallow tube wells in this zone have dried up. Fourth physiographic unit is Deccan plateau or Upland region. It holds low to moderate groundwater depending upon depth of weathering.

6.1.17 About 85 % portion of the district is occupied by hard rock such as Deccan Basalt hence weathering processes have immense impact over water resources. The weathered and fractured zones form groundwater potential zones. The thickness of weathered material varies from 0.5 m. to 12.6 m. within study area. Weathered profile is almost absent in Tapi valley because of excessive alluvial deposition. A thin veneer of weathered material is learnt in hilly area, but as distance from the mountain crest increases the depth of weathering increases. The prominent examples of deep weathering are Hadakhed (10 m.), Songir (9 m.), Dhule (12m.), Chinchwar (10.25 m.), Deshshirvade (12.6 m.), Shivarimal (10.5 m.). Weathered profile of near about half of observation wells is less than 3 m.

6.1.18 Slope controls the infiltration of water into subsurface. In the gentle slope area, the surface runoff is slow allowing more time for rainwater to percolate whereas steep slope facilitates high runoff. The area under focus is grouped into five classes according to the degree of slope. The areas having slope less than $5^\circ$ are designated as very gentle slope. It accounts 86.86% surface of the district which favors groundwater infiltration. While 6.5% area lies in between
5° to 10° which is known as moderate slope. Moderate steep and steep slope are very small in areal extent in the study area. It is confined to the Satpura ranges, Dhanora and Galna hills. Hence, it is inferred that due to flat or rolling topography there are better chances of groundwater percolation in the study area.

6.1.19 Lineaments with considerable length are observed in south and south-eastern part of the study area which extends for 80 to 100 km. They are parallel to the Dhanora and Galna Hills. Few north south trending lineaments are marked in the same region. Some of the lineaments present in north are varied in directions. High lineament density of 0.8 to 1.36 km/sq. km. is discovered in east and central Shirpur tehsil, central part of Sakri tehsil from north to south and central part of Dhule tehsil from east to west. Areas of medium lineament density take up more space in Sakri and Dhule tehsil along Panzara river. A large part of the Panzara basin is occupied by low density indicating a poor groundwater potential. Shirpur tehsil has the lowest density of lineaments. Based on the lineament density it is inferred that the groundwater prospects are poor in a large part of the study area.

6.1.20 Two types of aquifers have been noticed in Dhule district, namely Basaltic and Alluvial aquifers. About 85% part of the district is suffused by Deccan Basalt. It is less permeable because the primary porosity is much less and the vesicles are filled with secondary minerals. Secondary porosity is developed due to joints and weathering. Highly weathered rock and zones contact between two flows embedded with gravel, pebbles, boulder and gravel is the most favorable area for huge storage of groundwater. Groundwater occurs in semi-confined and confined conditions in most of the Deccan trap areas. Alluvial aquifer is formed due to the accumulation of sediments in Tapi rift valley. It is composed of unconsolidated material like pebbles, gravel, sand and silt, hence, it is highly porous. Alluvial aquifer possesses ample quantity of water. Groundwater in Tapi and Purna alluvial area occurs under water table and unconfined conditions. Alluvium acts as natural store of water.

6.1.21 Porosity of deep black soil is 0.60 %. Permeability is $10^{-10}$ cm/sec. Free Swelling Index of this soil is > 50 %. It is poorly permeable because of high clay content in study area. Due to high clay content and agricultural machinery it has low infiltration rate which is prone to runoff generation. In
compact and ploughed conditions constant infiltration rate of deep black soil is 1.2 cm/hr. and 1.6 cm/hr.

6.1.22 Hydrogeomorphological map of the study area has been prepared using visual interpretation of satellite image and hydrogeomorphological map provided by GSDA, Dhule. The area under the study is classified in different hydrogeomorphological zones such as alluvial plain, valley fills, eroded land, un-dissected plateau, medium dissected plateau, highly dissected plateau and Western ghat section. First is Alluvial plain that occurs along both banks of Tapi river and its tributaries in Shirpur and Shindkheda tehsils. This formation accounts 384.47 sq. km. area means 4.77% territory of the district. The study reveals that paleo-channels and alluvial plain are the geomorphological features with excellent potential for groundwater occurrence. Second zone is valley fill. It is deposition of unconsolidated materials in the narrow fluvial valley. They have covered an area of 506.8 sq. km. which is about 6.28 % of the district. Valley fills are located along the Panzara river in Sakri and Dhule tehsil and along Burai river in Sakri and Shindkheda tehsil. Valley fill captures very limited area in Shirpur tehsil. They possesses high quantity of groundwater due to coarser material and high permeability. Third unit is Eroded land occurred mainly along Tapi river in Shirpur and Shindkheda tehsils. It covers 692.41 sq. km. area. Un-dissected plateau is the fourth hydrogeomorphological unit. Un-dissected plateau has good weathered profile and hence high potential of groundwater is found. Un-dissected plateau is spread over 2609.7 sq. km. It is 32.37 % of the study area. It occurs almost in all tehsils of the study area. Fifth unit is Medium dissected plateau that occurs over 3061.1 sq. km. area of the district. Groundwater prospectus of this zone is moderate. Sakri and Shindkheda tehsils constitute medium dissected plateau. Sixth unit is Highly dissected plateau which covers an area of 535.4 sq. km. It is located in southern portion of Sakri tehsils and middle-east part of Shirpur tehsil. It has low potential of groundwater. Western Ghat section occupies 273.59 sq. km. with poor groundwater potential.

6.1.23 According to morphological classification study area has been classified in to three categories namely, Runoff zone, Recharge zone and Storage zone. Runoff zone is situated in the upland area near water divide with steep slopes and undulating topography. It is characterized by barren hills, rocky outcrops,
poorly weathered mantle and absence of vegetation. Hence it leads to poor infiltration and rapid runoff of rainfall. Hydrological conditions of this area indicate poor or absence of aquifer. It accounts about 1397.91 sq. km. Recharge zone is located in the middle course of the basin. It is moderately dissected with moderate relief, shallow soil cover. These conditions are favorable for moderate infiltration and recharge of groundwater. Hence it is suitable for groundwater development. Well yield of recharge zone is seasonal and it can support only kharip and rabbi crops. Recharge zone occupies 3665.62 sq. km. of the study area. It is distributed all over the study area except alluvial plain of Tapi river. Low lying areas and lower reaches of the river basins fall in the Storage zone. Thick soil cover of storage zone is either derived by deep weathering or by alluvial deposition. It holds substantial quantity of water. This zone is benefited by good recharge conditions and getting recharge by groundwater inflow from upland areas after rainy season. Hydrologically storage zone is highly suitable for groundwater exploration. Storage zone is discovered in the alluvial plain and eroded land of the Tapi valley. Storage zone is admeasured 2999.58 sq. km. in the study area.

6.1.24 The wells are significant tool which gives an important information regarding occurrence of water, nature of aquifers, properties of material, water table levels and water quality aspects. Dhule district is divided into six Hydrogeomorphic sections from Satpura ranges in north to Dhanora and Galna hills in the south across physiographic divisions and major rivers at an interval of near about 5 km. 114 dug and tube wells are selected as a sample for present study. The field survey was conducted using questionnaire for the Hydrogeomorphic sections. These sections of the study area give an idea about depth, width of alluvial deposition at various places, subsurface geological formation, depth of weathering, occurrence of red bole etc. From this study it is revealed that the major deposition of alluvium occurs along Tapi river with the width of about 12 to 16 km. The thickness of the alluvium reaches up to 68 m., 70 m. and 91.5 m. at village Taradi, Shirpur and village Wadi respectively. Here the fluctuation of water table is less as compare to plateau region. It has been discovered that the thickness of weathered profile is maximum in between hill tops and valley floors such as Chinchkheda – 10.25 m, Kalkheda – 6.2 m, Dhule – 12 m, Hadakhed – 10 m, Hisale – 16 m,
Dhavade – 7.4 m, Nardana – 8 m, Deshshirwade – 12.6 m and Shvarimal – 10.5 m. The fluctuation of water table is high where the thickness of weathered profile is more. The hill tops and steep slopes show absence of weathered rock layer. Both are characterized by shallow wells and low potentials of groundwater. These wells dry in summer season.

6.1.25 From the chemical analysis of water sample of the study area it is observed that the water quality in general is good for agricultural and domestic purposes except in the northern part of Shindkheda tehsil adjoining Tapi river. Groundwater of this pocket is saline and not suitable for drinking as well as for irrigation purposes. The pH, EC, TH, TDS, Ca, Cl, Mg and SO$_4$ values of the several samples from Shindkheda tehsil crosses the permissible limits. Nitrate and Fluoride values are within permissible limits.

6.1.26 Groundwater of Sakri and Shirpur tehsils is highly suitable for irrigation because mean of SAR in these tehsils are 1.07 and 1.50 respectively. On other hand, Dhule and Shindkheda tehsils bespeaks moderate to high SAR e.g. five villages of Shindkheda have very high SAR namely Bamhane – 10.78, Chilane – 9.48, Darane-II – 10.27, Hol – 19.76 and Melane-I – 13.23, while several villages show moderate values of SAR. Groundwater of Shindkheda tehsil possesses high SAR particularly the villages which are located along southern bank of Tapi river. In this area groundwater cannot be used for irrigation purpose.

6.1.27 Eleven physicochemical parameters, namely pH, total dissolved solids, total hardness, chloride, sulfate, nitrate, fluoride, sodium, magnesium, calcium and alkalinity were used to calculate the WQI. Weighted Arithmetic Index Method was used to calculate WQI. Water quality index shows that groundwater out of 166 sample villages only 37 belong to excellent class. Out of 37 sample villages 28 villages are located in Sakri tehsil. Groundwater of good class has been observed in 59 sample villages of the study area. About 48 villages have been using groundwater of poor class. Shindkheda and Sakri tehsils comprise 16 and 24 sample villages of poor class respectively. Very poor quality of water is discovered in 19 villages and 11 of them are included in the boundaries of Sakri tehsil. Groundwater of only two villages of Shindkheda tehsil is unfit for drinking purpose. It can be inferred that groundwater quality
in general is good for agricultural and domestic purposes except in the northern part of Shindkheda tehsil along the Tapi river.

**6.1.28** According to C. C. Ingliss (1930) non-ghat formula (Tapi and Narmada Basin) for Bombay Catchment runoff of Dhule, Sakri, Shindkheda and Shirpur tehsils are 3.631”, 2.921”, 2.812” and 4.820” respectively. The yield of rainfall is 182.645 M. Cu. M., 179.101 M. Cu. M., 92.811 M. Cu. M. and 289.269 for Dhule, Sakri, Shindkheda and Shirpur tehsils respectively. Total yield of rainfall of Dhule district is 743.826 M. Cu. M.

**6.1.29** Agriculture sector is the major consumer of the water resource for irrigation purpose. It utilizes 2326.155 M. Cu. M. to irrigate land in the study area. Rural and urban population requires 34.923 M. Cu. M. of water for drinking and domestic purposes per year. All the domestic animals such as cows, bullocks, buffaloes, sheeps, goats, horses, donkeys, poultry etc. requires 11.240 M. Cu. M. of water per year. Water requirement of the industries is considered 5% of the total yield of the district. It is 37.191 M. Cu. M. Total calculated water requirement of the study area per year is 2409.509 M. Cu. M. while total yield of the rainfall is 743.826 M. Cu. M. hence there is deficit of 1665.687 M. Cu. M. of water per year. This deficit of water may be fulfilled by groundwater abstraction and the water coming from upper or and other minor catchments.

**6.1.30** The district experience considerable deficit in yield of rainfall and utilization of water under major headings. So it is pressing need to conserve and manage water resources to fulfill the ever increasing needs of population, agriculture, livestock and industry. Roof top rain water harvesting, well recharge, watershed management, irrigation projects are the prominent approaches towards the management of water resources.

**6.1.31** There is a rich tradition of community based water harvesting in India. In order to adopt various means of water conservation it is prime importance to know whether the geology, geomorphology, slope, soil, lineaments, land use/land cover etc. are favorable or not. Artificial recharge zones are delineated by integration of various thematic maps using GIS technique. As per artificial recharge zones about 1783.1 sq. km. is highly favorable zone in the district. Eastern and south-eastern part of the Shirpur tehsil and a narrow strip along Panzara river is the most favorable for recharge. Moderate favorable zone is spread all over district and occupies an area admeasuring 5068.75 sq. km.
Upper course of Panzara and Kan rivers in Sakri tehsil, eastern portion of Dhule tehsil, northern and southern part of Sakri tehsil, western Shindkheda tehsil are the least favorable for recharge of groundwater which covers 1209.15 sq. km. area.

6.1.32 The study area experiences dry spells, fluctuation in seasonal and annual rainfall, frequent droughts possesses serious problem of scarcity of water while Girna river of adjoining Nasik district and Panzara river carries excess water during floods. The river linking project was initiated in Dhule district by Mr. Bhaskar Mundhe, District Collector, in August 2005 when the district was under drought situation. Girana – Bori – Kanoli river link, Haranbari - Mosam – Girna – Kanoli rivre link, Panzara – Iras nala – Waghada nala - Nakane Reservior Link and Panzara – Bhat nala – Sonvad Project Link are completed and working successfully. Fifteen more river link projects are suggested by the Irrigation Department, Zilla Parishd, Dhule. It may cost Rs. 20075 lakh and transfer 4300 M. C. Ft. River linking has numerous benefits. Moreover river linking on small scale is more beneficial than on large scale. In case of river linking on small scale water is diverted due to gravity while electricity is required to lift water at various stages on grand scale.

6.1.33 Few NGOs have done noteworthy work of water conservation through watershed management activities in Dhule district. Huge project of water conservation in Shirpur and Shindkheda tehsils is undertaken by Priydarshini Co-operative Cotton Mill, Shirpur, under the supervision and guidance of Mr. Suresh Khanapurkar (retired Senior Geologist). Widening and deepening of 14 streams for 30 km., construction of 91 cement bunds, 59 well recharge and three field ponds were carried out under this project. Main distinctive feature of this project is that it is implemented in non-command and rain fed portion of Dhule district. This work is being acknowledged at national and international level. As a result water table in Deccan basalt and alluvial plain increased considerably. Streams are flowing up to summer. About 1950 ha. area has brought under irrigation and farmers cultivating two to three crops.

6.1.34 Baripada represents a unique example of community participation in rural development through soil, water and forest conservation. Mr. Chaitram Pawar along with two NGOs initiated Rural development activities in the village Baripada. He mobilized the village community and urged them to act. The
local ‘Forest Protection Committee’ was formed in 1993. The villagers have undertaken watershed programme. Gradually village Baripada became self-sufficient in terms of water, fuel wood, vegetables, food grains etc. The village Baripada participated in a competition on "Local Knowledge and Innovation of the Rural Poor" in the Asian region, organized by the International Fund for Agricultural Development, Rome, and SRISTI in 2003 and won 2nd prize.

6.1.35 Dr. Dhananjay Newadkar, a social activist, along with villagers formed ‘Joint Forest Management Committee’ and undertook eco-development activities. Now the land which is treated with CCT is covered by dense grass. Livestock and milk production has been substantially increased in surrounding 20 to 25 villages. These activities minimized the intensity of drought in 2008. Main results of all water conservation activities are increased water table, vegetation, fodder and more wild animals. Now farmers are cultivating two to three crops in a year. Government of Maharashtra declared 1st prize under the ‘Mahatma Phule Jal Abhiyan’ to Lamkani village in Dhule district. The village also received ‘Sant Tukaram Vangram’ Prize in the year 2007.

6.1.36 Major part of Dhule, Sakri and Shindkheda tehsils experiences severe scarcity of drinking water. About 36 villages of Shindkheda tehsil, 35 villages of Sakri tehsil and 9 villages of Dhule tehsil are facing acute shortage of drinking water. Therefore several villages of Shindkheda, Sakri and Dhule tehsils depended on tankers for drinking water.

6.1.37 Amount of chlorides, sodium and calcium in groundwater crosses the upper limit in several villages. Hence a tract of 10 to 12 km. to the south of the Tapi river in Shindkheda tehsil is found to be Saline. This part of the study area does not produce irrigated crops because of saline groundwater.

6.1.38 River Tapi experiences devastating floods submerging settlements and agricultural land. There are several records of severe floods in the study area in historical and current past. Most of the villages located on the banks of Tapi river in Shirpur and Shindkheda tehsil are prone to the floods.

6.1.39 Alluvial part of Tapi basin in Shindkheda and Shirpur tehsil has been experiencing depletion of aquifer. The water table has dropped between 10 to 50 m. Around 1980s the water table which was about 30 m. b.g.l. has dropped to 60 m. b.g.l. Water table is sinking due to both human consumption as well as irrigation purpose. Lined dug wells of 1980s of this area have been dried up
and hence abandoned. Severe problem may arise due to depletion of aquifer in future.

6.1.40 Average annual rainfall of the study area is 592 mm. The district suffers from uncertain and poor distribution of rainfall, dry spells of 2 to 10 weeks, delayed onset and early withdrawal of monsoon. Dhule district historically has been known for the droughts. Long-term rainfall data (1901-2006) for 4 tehsil analyzed using Gamma distribution. Frequency distribution of annual average rainfall indicates that drought and severe droughts will hit Shirpur tehsil in only 15 out of 106 coming years. While Sakri tehsil has to go through maximum years of droughts i.e. 37 out of 106 years. Likewise Shindkheda and Dhule tehsils will experience 29 and 25 years of drought condition in forthcoming 106 years.

6.2 CONTRIBUTION TO THE SUBJECT:

Civil engineers, geographer, geologists are engaged in research related to the water resources. Geologist rather than geographer have contributed more in the field of Water Resources such as delineate groundwater potential areas, potential artificial recharge zones, conservation of water, artificial recharge, demarcation of watersheds, monitoring water table, chemical analysis of water etc. Geologists were using mainly geophysical methods to delineate groundwater potential areas. Nowadays recent techniques like Remote Sensing, GIS, GPS are being used by geologists, geographers and civil engineers. A geographer can play a crucial role in the study of water resources because geographic elements such as geomorphology, weathering, drainage network, slope, sedimentation etc. have been proved crucial in delineation of ground resources. Geographer can understand the role of these elements thoroughly while dealing with various aspects of water resources. In the present research impact of geomorphology, weathering, drainage network, slope, sedimentation has been examined to delineate groundwater potential zones and potential areas of artificial and it is proved successful.

6.3 CONTRIBUTION TO THE SOCIETY:

Study of water resources consist of various aspects which are directly related to the various human activities. Such as WQI, SAR, groundwater potential zones, potential artificial recharge zones, calculating runoff, calculation of yield, probability
of analysis of rainfall. Such studies of water resources within the study area are directly beneficial to the various elements of the society.

Nowadays, the government of Maharashtra has decided to test water sources of each village. It is a welcome step towards availability of safe drinking water. But chemical analysis of water comprises several parameters and their standard values prescribed by BSI, ICMR, and WHO. By using only test results and standard values, it is very difficult to decide whether the water is safe or fit for drinking or not, but the technique of WQI provides us a decision. If we use WQI, it is possible to take a decision regarding drinking water at village level. If the source of drinking water is not suitable, administrators or policy makers can decide policy for it. Part of Shindkheda tehsil to the south of Tapi river has been experiencing a problem of salinity. SAR is a measure of salinity of water. It helps to guide farmers SAR of their own village, area, and to cultivate the crops which tolerate salinity such as cotton. Tehsil wise probability analysis of annual rainfall has been calculated. It gives us probability of droughts, normal rainfall, excess rainfall, etc. It may guide farmers in the farm management practices. It is also helpful for local administrative officers and disaster management cell.

Present study of water resources deals with calculation of surface runoff using Ingliss formula and yield of rainfall. It provides total availability of water in the study area while crop water requirement, water need of population and livestock has also been calculated. Above measurement reveals the total availability of water resources and utilization through various ways for all purposes. If such calculations are performed at local, village, and water shed level, people may be made aware of the availability and utilization of water resources. These activities also disclose not only the crops consuming high quantity of water but also over or miss-use of water. Finally, people’s participation in the water management and conservation may be increased.

6.4 SUGGESTIONS:

The researcher has drawn the conclusions from the research work and suggests the following suggestions:

6.4.1 Rejuvenation of traditional methods of artificial recharge instead of implementing new projects. It would be the first step towards water conservation because traditional methods of artificial recharge are cost effective as they do not require electricity and special staff for their management.
6.4.2 To adopt scientific methods for targeting groundwater potential zones and suitable areas for artificial recharge such as Remote Sensing, GIS, GPS etc. to ensures the success.

6.4.3 It is advisable create awareness among women, children and people regarding importance of water, scarcity of water, methods of water conservation, optimum use of water which will be beneficial for the society.

6.4.4 A massive programme of a forestation should be undertaken on fallow land, waste land, deforested areas, mountain slopes with involvement of various elements of the society such as students, youths, workers, farmers, women, retired persons and so on. It would be a key to forest, water and soil conservation.

6.4.5 Rooftop Rainwater harvesting should be made compulsory for each household in urban as well as rural areas. It will certainly minimize the intensity of droughts and scarcity of drinking water.

6.4.6 In order to avoid continues cultivation of water intensive cash crops like cotton and sugarcane, instead of the suitable crops for drought prone area should be cultivated.

6.4.7 Agriculture sector is the largest consumer of water all over the world. Instead of traditional flood irrigation method drip, sprinkler, rain-gun method should be used. It may reduce consumption of water considerably.

6.4.8 Pavements like roads, use of pavement blocks, unnecessary surface covering concrete should be avoided because it reduces percolation and promotes surface runoff which results in flush floods.

6.4.9 By means of interlinking of rivers and streams it is possible to transfer the surplus water during peak runoff to ensure water supply in arid and semi-arid areas or to store excess runoff in dams or recharge aquifers for later use.

6.4.10 In order to avoid the problems like water logging, salinity, submergence of valuable land and forest, displacement of indigenous people instead of large projects small measures of artificial recharge should be employed. So that water conservation will take place in decentralized manner and more people will be benefited of it.

6.4.11 The problem of groundwater salinity can be minimized by means of well recharge using surface runoff every year. This is simple, cheap and the best remedy for saline tract of Shindkheda tehsil of the study area.
6.4.12 The ‘Mantra’ of 3 - R i.e. **Reduce** the use of water, **Reuse** water and **Recycle**
water is necessary for houses, industries and so many sectors.

6.4.13 In order to avoid damage of life and property, the flood affected settlements
should be rehabilitated at sufficient height and safe distance from river
courses.

6.4.14 Disaster Management Cell should be provided with appropriate equipments to
cope up with floods and droughts.

6.4.15 Flood Alarming System should be installed for flood affected villages.

6.4.16 Dug and tube wells which are dried up and abounded can be utilized for
groundwater recharging.

6.4.17 The district is underlined by hard rock, hence, percolation is small. Therefore
Farm Pond shall prove the best measure to catch surface runoff in situ.

6.4.18 Horticultural is advised for drought prone areas instead of water intensive cash
crops.

6.4.19 Regular de-silting of percolation tank, K. T. weir, storage tank, village tank
must be undertaken.

6.4.20 Alluvial aquifer in Shirpur tehsil is overexploited hence restrictions should be
imposed on new tube wells.

6.4.21 Recharge structures like percolation tanks should be constructed exactly along
lineaments.

6.4.22 Restrictions should be imposed on new tube wells in overexploited ares and
preference should be given to recharge groundwater.

6.4.23 Alluvial plain in Shirpur and Shindkheda tehsils is favorable for groundwater
augmentation. A massive program for groundwater recharge should be
undertaken.

6.4.24 Moderate water potential zone is deeply weathered. It is also suitable for
recharge purpose.