Chapter –VI

CONCLUSION AND SUGGESTIONS

INTRODUCTION:

With the ever increasing demand of groundwater particular in Marathwada region, for different purposes more and more wells are being dug to tap it. As the amount of groundwater is not unlimited it is necessary to have an idea about how much of it is available. A consideration of water bearing characters of Deccan Trap rocks makes it clear that hydrogeological conditions on the whole are not very favorable for the formation of large storages of groundwater, and theses adverse conditions are responsible for acute shortage of groundwater in many parts of the Deccan Trap area. It has been noticed that even after the average or more than average groundwater scarcity does persist in some areas. This sanitation alone indicates that there must be some shortcomings or lapses in the management of surface water. However, in spite of actual experience of scarcity, the idea that groundwater is available in plenty is widespread. For these wrong ideas, misleading calculations of groundwater availability, based on unscientific estimation of the amount of rainwater that percolates into the rocks and becomes groundwater, are responsible.

Availability of groundwater will depend on the proportion of rain water that percolates into the rocks, and in the Deccan Trap area estimation of availability of groundwater depend on a number of geographical, geological and hydrogeological factors, groundwater availability cannot be taken for granted which affect the amount of percolation. It is patently unscientific to assume that in a vast area like the Deccan Trap region, having wide variations in all these factors. In the Deccan Trap area water can percolate only into jointed compact basalts, and will not percolate in fresh unrecompensed amygdaloidal basalt. Hence performance of a recharge structure will depend on what type of basalt is occurring in the area of submergence.
Watershed development programmes cannot succeed without undertaking geological studies of the area. Accomplishing surface storage and recharge of groundwater is the basis of water conservation schemes. Water will percolate only if stored at a proper place. If geological conditions are unfavorable, water will not percolate into the ground. As the programme is based on water conservation and artificial recharge to groundwater it must always be remembered that it will succeed only where rocks suitable for percolation exist. As such, the knowledge of geology is essential while implementing the water conservation programme.

But generally water conservation structures are constructed as per the convenience of the local people and also on the availability of the funds. Therefore most of the water conservation structures are constructed without considering geological studies in area.

Success of water conservation structures constructed from geological point of view in the area under investigation, two types of basalt flows are occurring, Compact basalt and Amygdaloidal basalt flows. As basalts are formed after cooling and solidification of hot lava, primary porosity hardly occur in the fresh, unweathered basalts. Therefore, the only avenue through which water percolates in the basalt is the contraction cracks like joints developed during the cooling of the lava. But it was observed that joints occur only in Compact basalt and fresh unweathered Amygdaloidal basalts is always free from joints and occurs as massive, homogenous rock. The absence of primary porosity in the basalts sets the limit for percolation of rainwater.

But on weathering, sheet jointing and secondary porosity are developed in Amygdaloidal basalt and spheroidal weathering is developed in compact basalt by percolation of water through the joints. Therefore, weathered basalts provide favorable condition for the percolation of water stored in the water conservation structures if they are located on such set up. By taking into consideration this aspect, utility of water conservation structures has to be determined by carrying out field characters of the basalt exposed in the region of the water conservation structure.

The wells located on Amygdaloidal basalt the quantity of water and rate of withdraw depend upon thickness and lateral extent of sheet jointed weathered zone. If the
thickness is more than 3 m, such well yield good quantity of water for a long period. But if the thickness is up to 1 to 1.5m, springs dwindle away after the rainy season. If the thickness of overlying weathered Amygdaloidal basalt is less, then water enter into the underlying Compact basalt through its joints. Due to continuous percolation and circulation of water along the joints spheroidal weathering is developed in underlying compact basalt and it becomes highly permeable.

Under such condition, springs are seems to have developed from both, overlying weathered Amygdaloidal basalt and underlying spheroidal weathered Compact basalt. Such wells yield good quantity of water. However water yielding capacity of the wells entirely depends upon stage of weathering of Amygdaloidal basalt and thickness of weathered shells around each spheroid of Compact basalt.

Wells located in top portion of the Compact basalt, fresh unweathered vesicular amygdaloidal upper part of the flow is always unjointed and occurs as massive, homogenous watertight mass. Only on intermediate stage of weathering, sheet jointing and secondary porosity are developed in it and it becomes highly permeable. Therefore water yielding capacity of the wells taken in vesicular amygdaloidal upper part of the flow depends upon whether Amygdaloidal portion is in weathered condition with development of sheet jointing and secondary porosity or is in fresh unweathered unjointed conditions.

If well located in middle and lower parts of flows the compact basalt flow occur as jointed in nature. If this middle jointed portion of the flow is exposed at the surface, it provides for percolation of water. Jointed Compact basalt get opened out at the surface and become gradually close and watertight at the deeper levels, therefore in Compact basalt rain water percolates only up to shallow depth. The water bearing capacity of the well located in Compact basalt depends upon joint spacing and pattern of jointing.

Occurrence of Tachylytic basaltic band in dug well in confined conditions is always hard, watertight when exposed to atmospheric conditions form a loose friable material and at deeper levels it occurs as rather hard, watertight mass.
The river Girja is the main tributary of Purna which in turn drains into the river Godavari. Girja River Flows through the Aurangabad and Jalna district of Maharashtra. It is, in the region broadly demarcated by Longitude E 75° 10’ to 75° 48’ Latitude N 20° 5’ to 20° 9’ and the total areal distance is 89 Km, having elevation difference of 340m. The river flowing through the seven watersheds and suggestion as given below.

**Groundwater condition in compact basalt:**

The middle and lower parts of the compact basalt flow are jointed in nature. The middle jointed portion of the flow is exposed at the surface, it provides avenue for percolation of water. However, Joints in compact basalt observed at the surface are opened up and gradually close towards bottom they become watertight at the deeper level. Therefore in this case the rainwater percolates up to the shallow depths. Therefore, water bearing capacity of compact basalt depends upon spacing of the joints, pattern of jointing and degree of jointing.

**Groundwater condition in amygdaloidal basalt:**

The quantity of water and the rate of withdrawal depends on thickness of aquifer and lateral extent of sheet jointed weathered zone. If the thickness of weathered zone is more than in such case well yields higher volume of water for a long period of time. But the thickness is up to 1 to 1.5 m then in such case the water diminishes after the rainy season. The thickness of overlying weathered amygdaloidal basalt is less, then water enters in to the joints present in the underlying compact basalt. Due to continuous percolation and circulation of water along the joint planes spheroidal weathering is developed in the compact basalt and it becomes permeable. Under such conditions the springs are induced at the contact of both underlying compact basalt and overlying amygdaloidal basalt. Groundwater occurrence in such area entirely depends upon the degree of weathering of amygdaloidal basalt and underlying compact basalt as well. However, fresh amygdaloidal basalts are unjointed and therefore there is no availability of groundwater in such area.
Groundwater condition in top portion of compact basalt:

Top portion of the compact basalt flow is always hydrothermally altered and amygdaloidal in nature. Therefore upper part of this flow is unjointed in nature and acts as homogeneous, watertight mass. Only on intermediate stage of weathering, secondary porosity is developed in the form of sheet jointing and this rock becomes permeable. The groundwater occurrence depends on the condition of amygdaloidal portion of top compact basalt flow.

Red Tachylytic basaltic bands (RTB) are commonly occurring in the watershed area. In confined condition the rock is hard. However on exposure to the atmosphere it becomes friable and converted to red bole. This red Tachylytic band always acts as a barrier. Groundwater occurrence is restricted if the RTB bands occur in the wells. But at shallow levels, as the red Tachylytic basalt acts as barrier, it will hold groundwater above this layer for a long time, if the above lying rock is permeable. However, at deeper level, as the water does not percolate, there are few chances of groundwater occurrence at that level.

Volcanic breccia also occurs in the study area. It shows similar characters to that of amygdaloidal basalt if the volcanic breccia is grey. There are chances of availability of groundwater if the volcanic breccia with zeolitic basaltic matrix exists. In highly weathered condition sheet jointing is developed in rock and at shallow depth there are chances of occurrence of groundwater.

There are limitations in the vertical movement of the groundwater in horizontal flows of Deccan basalts. In sequence of horizontal flows if any single flow is impermeable, which is sandwiched between numbers of permeable flows, there is no chance of downward vertical movement of groundwater. Sometimes in jointed and permeable flows also top portion is hydrothermally altered and unjointed, and it acts as a barrier hence there is no downward movement. In Deccan Trap area of Maharashtra, shallow aquifers are high yielding and are the main sources of high potential groundwater water zones. In some cases the groundwater occurs at deeper aquifer also but once this groundwater is withdrawn then there is very less chance of recharge. Such conditions are
commonly observed at Pal village in GP-7 watershed. Phulambri in GP-8 watershed, Hasnabad villages in GP-20 watershed.

Conditions favorable for the percolation are also examined critically as water percolate through shallow depth and drains along the downstream area within a very short period of time. Cut-off trenches also play important role in the percolation of water. Excessive cut-off trench may not allow percolation and there is water loss in the form of evaporation. It is estimated that the 50 percent evaporation occurs from major and medium sized tanks because of the fact that the depth of water column in the reservoir is shallow and the water spread is more as the valleys are flat. However, the success of the watershed development scheme mainly depend on two factors viz. the amount of rainfall and the Geohydrological set up at the site of water conservation structure.

1] Watershed GP-3

The watershed area is falling under maximum elevation of 903 and minimum of 650 where Girja River flows in a entrenched channel. Across this tributary K.T. Weirs and percolation tank have been constructed. Due to entrenched nature of the river basin the structure constructed on lower level as compared to the adjacent area. In addition to this fresh Compact Basalt is exposed in the bed of Girja river basin, as discussed under the chapter number Two and Three, along its bank and in the vertical cut due to which impounded water could not percolate into the area or through the banks. Therefore at present the area does not get much benefit from the present structure.

The fifteen observation well selected at Deolana BK., Miasmal, Wanegaon, Kanakshil, and Bazar Savangi village. Seven year (2004 to 2010) Pre-monsoon and Post monsoon watertable level is taken in well inventory survey (Table No. 3) and comparative Graph is prepare (Graph No. 1). In this watershed at Village Kanakshil (Pre-monsoon) show deepest water table and at Village Miasmal dugwell No.1 and 2 show very shallow water table only 2 to 3 m. depth (Postmonsoon) winter and in summer
water scarcity problem for irrigation and drinking also only near Bazar Savangi village hydrogeological character suitable for recharge. Some high yielding well’s are found in this area. Average water table depth in Gp-3 watershed in between 4 to 19 m. depth.

In the lower area of watershed GP-3 there is Girja dam constructed because of these dam water percolation in to the well but as compared to the top portion of these watershed having a problem of water scarcity in the lower area water table at high level. This variation of occurrence of groundwater is due to the variation in hydrological property of basaltic flows. Therefore the top area of watershed require to repairs of the K.T. weirs, small bunds in series may be constructed and the watershed fall in hill area there is need to nala band gully plugs to be constructed to improve the groundwater potential for irrigation and drinking purposes.

2] Watershed GP-7

This watershed GP-7 has an total area of 20529 Ha. total area It has minimum elevation at Pal 618 above m.s.l. and maximum elevation at Nidhona 685 above m.s.l. Nidhona village is surrounded by hillock. It is having an altitude of 685 m. which total basaltic flow are discussed in chapter number two and hydrology in chapter number Three.

The fifteen observation well selected in Khamgaon, Nidhona, Pal, Hiwra, and Bodhagaon village Seven year (2004 to 2010) Pre-monsoon and Post monsoon watertable level is taken in well inventory survey (Table No. 4) and comparative Graph is prepared (Graph No. 2). In this watershed at Village Nidhona (Pre-monsoon) show deepest water table and at Village Pal Khamgaon and Bodhagaon dugwell show very shallow water table only 2 to 4m. depth. Average water table depth in Gp-7 watershed in between 10 to 15 m. depth in winter and only in pal village groundwater condition in summer also show high yielding.

All the development works have been undertaken on the underlying Amygdaloidal and Compact Basalt having small thickness of weathered zone varying from 0.5 to 1 m.
Therefore water stored in K.T. Weirs and Earthen Bund, Gully plugs on hilly area percolates only up to some depth only and due to which very less benefit to the area.

Although a large number of water conservation structures have been constructed in the area along hill slopes and arrest maximum rain fall of the area, but the near the river basin there are water conservation structure can be constructed which improve the groundwater in some area of the watershed and large area can be face the water scarcity problem. There is need for watershed management to minimize water sacristy problem it can be discussed on the end of this chapter.

3] Watershed GP-8

GP-8 watershed has an area of 27825 Ha. Having minimum elevation at Pathri 615 above m.s.l. and maximum elevation at Chawka 693 above m.s.l. the geology is discussed in chapter number Two and Hydrology in chapter number Three. It shows high permeability due to developed of sheet jointing and secondary porosity. This condition is very much favorable for percolation of water as mentioned chapter number Three.

The fifteen observation well selected at Pathri, Phulambri, Wadod Bazar, Sanjul and Babhulgaon village. Seven year from 2004 to 2010 Pre-monsoon and Post monsoon water table level is taken in well inventory survey (Table No. 5) and comparative Graph is prepared (Graph No. 3). In this watershed at Village Wadod Bazar (Pre-monsoon) show deepest water table upto 20m. and at Village Pathri dugwell No.1 and 2 show very shallow watertable only 2 to 3 m. depth postmonsoon. Average water table depth in Gp-8 watershed in between 5 to 10 m. depth in winter and in summer season dugwell show good recharge condition from present K.T. wear and percolation dam.

In this watershed number of K.T. Weirs constructed across the Girja river basin in series giving benefit to recharge the groundwater. Due to suitable Geohydrological condition all water conservation structure recharge water and rise water table. There is need for some repairing of K.T. weirs and small earthen structure.
4] Watershed GP-14

GP-14 watershed spans an area of 8284 Ha. It has minimum elevation at 550 above m.s.l. Borgaon Arj and maximum elevation at 630 above m.s.l. Aland. The area having a water scarcity problem due to unjointed basaltic flow generally in Deccan Trap basalts yield only limited quantity of water occurs in watershed. Although a large number of water conservation structures have been constructed in the area according to slopes maximum rain fall of the area, but due to inferable Geohydrological condition very less chance of stored water.

The fifteen observation well selected at Wadod Kh., Aland, Borgaon Arj and Nygoan village Seven year (2004 to 2010) Pre-monsoon and Post monsoon water table 20m. level is taken in well inventory survey (Table No. 6) and comparative Graph is prepare (Graph No. 4). In this watershed at Village Aland (Pre-monsoon) show deepest water table and at Village Nygaon Wadhod Kh. Borgaon Arj dugwell show very shallow water table only 2 to 3 m. depth. Average water table depth in Gp-14 watershed in between 10 to 15 m. depth in winter and in summer water table at very low level and groundwater yielding also very less.

There is need for contraction new water conservation structure for stream on tributaries of Girja river and some present structure can be need for repapering for large storage capacity.

5] Watershed GP-14B

Total area covered by these watersheds is 9764 Ha. It has minimum elevation of 525 above msl. Near Jodwalsa at the confluence of Purna and Girja rivers it’s maximum elevation 573 above msl. near Hasnabad. The geology and hydrology is described in chapter number Two and Three Compact basalt flow are occurring one above the other. Except in a small area, where Amygdaloidal basalt is exposed on the steep slopes developed flow number 1 and flow number 3 show small band of red bole which cant to
permit the percolation of water. Due to this formation the area having low groundwater potential.

The fifteen observation well selected at Gosegaon, Hasnabad, Wazerkhed, Kota and Javkheda Bk. village Seven year (2004 to 2010) Pre-monsoon and Post monsoon water table level is taken in well inventory survey (Table No. 7) and comparative Graph is prepared (Graph No. 5). In this watershed at Village Hasnabad, Wazerkheda and Kota (Pre-monsoon) show deepest water table upto 26 m. and at Village Gosegaon Hasnabad, Wazerkhed, Kota and Javkheda Bk dugwell show very shallow water table only 1 to 4 m. depth. Average water table depth in Gp-14B watershed in between 1 to 21 m. depth in winter and Feb. to May water scarcity for drinking purpose also.

There is need for construction of new structure. There is need for series of K.T. weirs and at some places earthen structure to be need. The some present structure are not well percolation of water there is need for hydrofrcturing or artificial opening upto permeable strata.


GP-15 watershed covers in area of 11050 Ha. It has minimum elevation at Padila 587m.s.l. and maximum elevation at Pirboda 641m.s.l. The area falls in the terrain of Deccan Trap basalt consisting of two major types of basaltic flows viz. compact basalt and amygdaloidal basalt, compact basalt is a thick and extensive flow. It may be aphanitic or porphyritic in nature. Jointing pattern in the compact basalt plays important role in the percolation of water. But jointing pattern shows variation even within short distances. Joints may be inconsistent, broadly spaced or closely spaced. Top of the compact basalt is almost always hydrothermally altered and becomes amygdaloidal.

The fifteen observation well selected at Georai Gungi, Girsavli, Ranjangaon, Ekghar Padali and Nandra Lowghad village Seven year (2004 to 2010) Pre-monsoon and Post monsoon water table level is taken in well inventory survey (Table No. 8) and
comparative Graph is prepare (Graph No. 6). In this watershed at Village Georai Gungi (Pre-monsoon) show deepest watertable and at Village Ekghar Padali dugwell show very shallow water table only 1 to 3 m. depth. Average water table depth in Gp-14 watershed in between 5 to 10 m. depth in winter season and summer groundwater yielding very flow in this watershed.

Although a large number of water conservation structures have been constructed in the area according to slopes and the arrest maximum rain fall of the area, but the near the river bank are water structure can be constructed they recharge the groundwater upto certain limit in the watershed GP-15 and large area can be face the water scarcity problem. There are need for watershed management it can be discussed on the end of this chapter.

There is need of contraction of conservation structure tributaries of Girja River and some existing structure can be need for repapering for large storage capacity. This stored water will allow percolating throughout the area, after watershed management program implemented.

7] Watershed GP-20

GP-20 watershed has an area of 27637 Ha. having minimum elevation at Latifpur 574 above msl. and maximum elevation at Dhabadi 596 above msl. The Dhabadi area falls in the terrain of Deccan Trap basalt consisting of two major types of basaltic flows viz. compact basalt and amygdaloidal basalt, compact basalt is a thick and extensive flow. It may be aphanitic or porphyritic in nature. Jointing pattern in the compact basalt plays important role in the percolation of water. But jointing pattern shows variation even within short distances. Joints may be inconsistent, broadly spaced or closely spaced.

The top portion of every flow is hydrothermally altered, weathered amygdaloidal basalt with varying thickness as described in chapter no Two where middle and lower portion of every flow are closely spaced with open joints. Due to weathering, sheet jointing is developed in the top portion of every flow and spheroidal withering is
developed in the middle portion. Both these permeable portion of every flow are exposed in well section.

The fifteen observation well selected at Janefal Dhabadi, Latifpur, Pimpri, Dhabadi and Vita village Seven year (2004 to 2010) Pre-monsoon and Post monsoon watertable level is taken in well inventory survey (Table No. 9) and comparative Graph is prepare (Graph No. 7). In these watershed at Village Dhabadi (Pre-monsoon) show deepest watertable upto 19m. and in Village Pimpri Vita Janefal Dhabadi dugwell show very shallow water table only 1 to 3 m. depth. Average water table depth in Gp-14 watershed in between 4 to 8 m. depth in winter season and water table at very low level in summer season.

Due to favorable permeable nature of the rock occurring in the region of water conservation structures, impounded water percolate in them their by increasing groundwater potential.

**Suggestions:**

1. Development of groundwater by means of dug wells may be considered in safe and semi-critical watersheds GP-15.
2. Nearly 1/2km area, that bank all narrow valley portions may also be considered for groundwater development in watershed GP-7.
3. A large number of irrigation wells in the trappean area can be made more productive by deepening to allow full penetration of the weathered and fracture zone GP-14B and the under lying vesicular or zeolitic units,
4. Instead of dug wells, it would be more economical to put radial boreholes of 4 to 8m length from near the bottom of well below average summer static water level to allow increase the yield of dug well considerably.
5. Construction of new dug wells may be taken up according to balance groundwater available for future groundwater development watershed wise.
6. Dug wells tapping shallow aquifer and yielding insufficient quantity of groundwater, may be converted in Dug-cum-bore well wherever semi confined aquifer underlying shallow unconfined aquifer are potential in watershed GP-7.

7. The measures for augmentation of groundwater potential to be considered are.
   - Incomplete watershed treatment to be completed.
   - New water conservation structures depending upon scope.
   - Revival or bringing effectiveness in the existing water conservation structure.
   - Identification of underground storage space e.g. depleted aquifers and aquifer not getting sufficiently recharged.

8. Practice conjunctive use in canal command and areas close to river banks/ reservoirs.

9. In view of heterogeneity of Deccan Traps, micro level data base may be created for better planning, development and management of groundwater resources in watershed GP-20.

10. A comprehensive survey has to be undertaken for selection of pump sets. Farmers should be educated on proper selection of pump sets to optimize yield of wells and also to reduce the expenses on agriculture in watershed GP-8.

11. The soil conservation and water spreading techniques will have the necessary in watershed GP-3 impact on the groundwater recharge.

12. The new structure can take according to geological formation in total watershed across the river basin.
Recommendations:

- Before deciding to develop groundwater potential of Girja River basin it is prime importance to consider the stage of ground water development so that the system is not damaged and no side effects like over development, deterioration of water quality etc. are encountered.

- Watershed such as GP-8, are success stories of watershed development in the sub basin. These needs to be replicated on large scale in the sub basin.

- So as to make watershed development programme more effective, it is high time to make input of groundwater survey as an integral and mandatory part of project planning.

- The watershed programmes are implemented by Govt. and non Govt. agencies. There is need to establish watershed authority at sub basin level/ district level to avoid the duplication, and will also assist in prioritization and integration with line departments.

- In case of small and marginal farmers the community wells are recommended instead of individual wells according to geological formation.

- Micro-irrigation is recommended from all groundwater dependent sources for increasing productivity and irrigation potential.

- While the micro-irrigation is being advocated strongly for increasing the productivity and irrigation potential, this recharge component will cease, therefore the thrust will have to be given to complete watershed development.

- Rainfall is the main source of recharge to groundwater. Therefore, it is recommended that surplus monsoon that flows out of the sub basin has to be changed to groundwater reservoir.

- Plantation drives in runoff zone and watershed boundary regions and along hill slope. Tree species that are better for soil and water conservation and provide more and better fodder, to be planted, conserve existing forest cover and other vegetation.
For sustainable yield and to maintain quality of groundwater, both supply and demand management options and their integration are necessary.

Future selection of sites for water harvesting artificial groundwater recharge structures should be based upon thorough investigations of the geology and hydrogeological conditions. Groundwater potential created due to water harvesting/ artificial groundwater recharge structures should be retained in the aquifer for use during scarcity period.

Over exploited and critical watershed may be given priority for artificial recharge.

Selection of methodology for artificial groundwater recharge and citing of location may be done based on geological profile and aquifer geometry worked out through L and cross sections.

The farm ponds (in command and non-command) mostly in heavy soils will achieve twin objective of water harvesting and drainage improvement and hence in command area also this activity needs to be promoted.

The design of groundwater structures depends upon geological formation, and bore wells of 50-60 meters depth are recommended while in alluvial area, the dugwells 2-4 meter diameter and 7-20 meter depth and shallow tube well of 20-30 meters depth are recommended to be constructed.

Major part of the basin is underlain by Deccan Trap Basalt, where only dugwells are the most feasible structures for ground water development.

The sites for bore wells need to be selected only after proper scientific investigation. Bore wells generally tap deeper fractures, which may not be sustainable besides, the bore wells should only be used for drinking water supply and not for irrigation.

Contour bunds and gully plugs are important and low cost treatments for soil and water conservation. With little economic assistance, even very poor farmers can treat their fields. If proper maintenance is done, they are very effective for improvement of land fertility. Better results can be achieved through ridge to valley treatment. This process can be adopted only if more time is spent with those farmers whose fields are located in the same watershed. They have to be
convinced about the benefits of SWC (Structure of Water Conservation) work and ultimately watershed development. Village institutions can be a common platform to discuss these aspects where people are given an equal chance to participate in developmental issues.

- As mentioned in the beginning, the SWC programme is a part of the watershed development approach. SWC programme cannot achieve the expected results independently. The programme has to be linked with other programmes including forestry, agriculture extension, animal husbandry and biogas. Linkages with other programmes can help in achieving multiple results, and also lead villages towards socioeconomic and environmental sustainability.

- In case of small and marginal farmers the community wells are recommended according to the geological formations, instead of individual wells.

- Micro-irrigation systems are recommended from all groundwater dependent sources for increasing productivity and irrigation potential.

- While the micro-irrigation is being supported strongly for increasing the productivity and irrigation potential, the recharge component will come to an end. Therefore the trust will have to be kept on the watershed development programme.

- In low-lying areas due to good precipitation in monsoon there is availability of surface water. But, this surface water cannot percolate through the thin compact basalt flow having inconsistent jointing. But, there is availability of permeable rock below it. Such conditions are prevalent in the Bazarsawing, Phulambri, Pal Khonir etc. In such areas hydro-fracturing is suggested to percolate water up to rechargeable zone.

- Rainfall is the major source of recharging groundwater. Therefore, it is recommended that monsoon which run-off has to be intercepted by means of various watershed management tools.

- Plantation drives are recommended in run-off zones and watershed boundary regions on war path.
- Tree species suitable for this region for soil and water conservation are to be planted and conserved.
- Conservation and protection of the existing forest cover and vegetation is recommended.
- For sustainable yield and maintain the quantity of groundwater, both demand and supply options of the management are to be evaluated and their integration is necessary at micro level.
- Contour bunds and gully plugs are important for low cost treatments for soil and water conservation. Better results can be achieved through ridge to valley development along Miasmal, Nidhona hills.
- Recommended for fixing of observation wells and establishment of rain gauge in each village of study area.
- Recommended for groundwater audit of the village as well as for watershed
- Maximum farm ponds must be constructed in every watershed wherever recharge conditions are suitable.