CHAPTER VI

DISCUSSIONS, CONCLUSION & SUGGESTIONS
6.1. Discussion:

The study area is situated in the semi arid regions of Maharashtra and is very much dependent upon seasonal rainfall. This rainfall is very much uncertain and uneven in nature. The present study mainly intends to ascertain the overall siltation rate in the Tavarja lake area and therefore to find major sources of sediments in the lake in order to know the reasons and contemporary geomorphic process operating in such an elongated mini basin.

It is revealed from the study of relief and soil characteristics of the study area that relief and soil characteristics play a significant role in siltation process of the Tavarja lake. Differences in elevation, resulting in variation of relief, other geomorphic attributes including absolute relief, relative relief, dissection index, slope etc. helped to classify the terrain and its erosional characteristics. In the present research work, it is also attempted to find out correlation between relief and various soil parameters. Correlation analysis of the same indicates that there is a positive correlation between relief and soil attributes.

The run off estimations have been carried out using NRCS (SCS) curve number method which certainly helped in understanding the problem of severe runoff in the study area. Based on the application of this method, following conclusions have been drawn and the sub basin wise priority levels for conservation planning have been expressed. All these estimations clearly indicated that there are certain physiographic changes taking place in the area, which are ultimately responsible for siltation of Tavarja lake.

Prioritization of each sub-watershed has been done on the basis of runoff, which shall make the basis for selection of area for treatment of the catchment. On the basis of runoff index, Bhoira, Savargaon, Kalmatha and Kavatakej etc sub watersheds lie in very high priority of conservation planning. While Chata nala, Andhora nala, Bopla nala and Bhada nalas sub watersheds lie in high priority of watershed conservation planning. Wadi nala part of Nagjhari nala lies in medium priority of conservation planning. Whereas Tavarjkheda nala, Kasar nala and Hatsan nalas etc. sub watershed
lie in low conservation priority class. While Utti (Bu.) nala, Ekurga nala etc lie in very low priority class for conservation planning.

Prioritization of each sub-watershed also has been done on the basis of Universal Soil Loss Equation (USLE) index, which shall make the basis for selection of area for treatment of the catchment. According to USLE index, Bhoira nala, Dhakni nala, Neoli nala, Gumphawadi nala, Tavarjkheda nala, Wadi nala, Kond nala, Utti (Bu.) nala etc sub watersheds require very high priority for conservation planning. While Chata nala, Ekurga nala, Kasar nala, Kahtkali nala, wadji nala and Bhada nala etc sub watersheds require high priority level for conservation planning, whereas rest of the sub watersheds requires low priority level for conservation planning.

An attempt has been made to estimate sub basin wise Sediment Yield Index (SYI), Soil loss and surface runoff to infer the sites contributing maximum silt load in the catchment.

SYI provides comparative erodibility criteria of watersheds in terms of high, medium, low and very low but does not provide absolute silt yield. Based on SYI value, very high priority to conservation is given to the sub watersheds- TLCW 8.8(Dhakni nala), TLCW 8.12 and TLCW 8.13(Neoli nala), TLCW 8.16 and TLCW 8.17 (Gumphawadi and Tavarjkheda sub watershed), TLCW 8.24 (Dhakni sub watershed), TLCW 9.2., TLCW 9.15. and TLCW 9.17 (Borgaon and Naholi sub watersheds) etc. While TLCW 8.11, TLCW 8.19 and TLCW 8.20 (Ekurga and Dhnakni sub watersheds), TLCW 9.10 and TLCW 9.11 (Kond and Kondwadi subwatersheds) lie in high priority of conservation planning and rest of the sub watersheds (Bhoira, Chata, Chabuksare nala , Hatsan nala, Andhora, Wadji and Bhada nala etc sub watersheds) lie in medium to low priority of conservation planning.

The highest average sediment yield index (SYI), soil loss and surface runoff of the study area is observed in sub basin TLCW.9.17 and TLCW 9.2. While lowest average SYI, soil loss and surface runoff of the study area is found in TLCW .9.4 and TLCW 9.5.

Based on these estimations, composite land degradation index has been developed which confirms the sites of maximum runoff, soil loss and SYI together.
6.3. Conclusions:

The present study forms two major components in terms of its geomorphic evaluation. First, is the hydro-geomorphic evaluation of Tavarja lake catchment and second is the effect of all these contemporary geomorphic processes on the lake environment. Hydro-geomorphological characteristics of the basin clearly demonstrate that there is an intimate relationship between physical factors, land use/land cover and geomorphic processes. The north western and southern most parts of Tavarja lake catchment are highly characterized by barren land, devoid of vegetation and slope is a major influencing factor, subjected to severe runoff and soil loss as well as sediment yield from the sub watersheds.

Based on these field observations and the analysis carried out, the present study arrives at following conclusions:

1. In the runoff studies applying NRCS (SCS) curve number, it is observed that sub basins of western, northern and southern part of the catchment, runoff of which is ranging between 787 mm to 841 mm are the major areas contributing severe runoff in the sub basins of TLCW 8.8, TLCW 8.13, TLCW 8.14, TLCW 8.16, TLCW 8.17, TLCW 8.24.

2. In view of the geomorphic control, it is also observed that land use and land cover in the study area also have a prominent role in switching the geomorphic processes in terms of surface runoff and soil loss.

3. It is revealed from the LU/LC analysis that the area is characterized by low density of vegetation, undulating topography, and erodible nature of surface soil seems to be the major geo-environmental problem in the area.

4. On the basis of surface runoff, TLCW 3 (841 mm covering, 0.45 km² area), TLCW 4 (841 mm, 18.57 km²), TLCW 9.18 (840 mm, 5.86 km²), TLCW 9.19 (841 mm, 1.11 km²), TLCW 10 (841 mm, 0.62 km²) and TLCW 11 (841 mm, 0.56 km²) etc. minor sub basins of the study area lies in severe priority of conservation planning.

5. On the basis of Universal soil loss equation, TLCW 4 (1.05 kg/m²/year covering 18.57 km² area), TLCW 8.1 (13.60 kg/m²/year, 18.57 km²), TLCW 8.6 (12.15 kg/m²/year, 1.16 km²), TLCW 8.13 (15.67 kg/m²/year, 1.93 km²), TLCW 8.16 (15.60 kg/m²/year, 3.83 km²), TLCW 8.17 (15.75 kg/m²/year, 11.08 km²), TLCW 8.18 (12.98 kg/m²/year, 5.93 km²), TLCW 8.19 (13.93 kg/m²/year, 0.30 km²), TLCW 8.20
Chapter VI. Discussion, conclusion and suggestion

(14.87 kg/m²/year, 0.63 km²) and TLCW 26 and TLCW 27, TLCW 8.32 etc. sub basins lie in severe category of soil loss. Therefore it requires high priority of conservation planning.

6. The highest SYI in the Tavarja Lake Catchment is above 2100 Kg/m²/year. Very high SYI is found in the part of villages at Chata, upper part of Ekurga, Dhakni, Neoli and Gumphawadi, Tavarjkheda, Northern part of Wadji and Borgaon, Southern part of Waswadi etc. Moderate SYI i.e. 900 to 1500 Kg/m²/year is observed in northern part of Utti (Khu.), Bhoira, Chata, Neoli, Dhakni, Tavarjkheda, Kond Andhora, Waswadi, Bhada, and Wadji etc. villages. Bopla, part of Chata, Ekurga, Dhakni, Kavthakej, Utti (Khu.), Utti (Bu.), southern part of Andhora etc. villages falls under the category of low SYI <900 Kg/m²/year.

On the basis of SYI value, very high priority for conservation planning is required for sub basins TLCW 8.8 (2487.32 kg/ m²/year covered 10.5 km² area), TLCW 8.13 (2664.09kg/ m²/year, 1.92 km²), TLCW 8.14 (3167.60 kg/ m²/year, 4.81 km²), TLCW 8.16 (3075.48 kg/ m²/year, 3.833 km²), TLCW 8.17 (2216.35 kg/ m²/year, 11.08 km²), TLCW 8.24 (3984.54 kg/ m²/year, 2.45 km²) etc.

7. It is confirmed that the sites of erodible soils in the catchment is around 168.438 km² (67.23%) subjected to land degradation and is an area contributing the maximum silt load.

8. Annual rate of siltation is computed using volumetric analysis in GIS environment. The total volume of ASTER elevation grid is 1837378 m³ and that of depth measurement data with GPS is 304586.4 m³. This has given a difference of 1532792 m³ (1.532792 mm³). Thus annual rate is computed considering 6 years time span is 1.532792 m³ / 6 years = 0.255465 mm³ per year. However it is to be noted that siltation rates designed at the time of construction of dam is computed to be 0.149160 mm³. This is about 58.39 % high than the designed one. This picture is applicable to almost all irrigation project areas in Maharashtra i.e. actual siltation rate is far higher than the design rate.

9. The lack of proper soil and water conservation measures in Tavarja lake catchment has certainly triggered the problem of soil loss and there by the siltation.

10. The application that is judged to have significant and substantial merit is to assign a priority score. The scale of 1.0 (very highest score) to 5.0 (lowest score) is used to
score the Sediment Yield Index (SYI), Universal Soil Loss Equation (USLE) and Runoff estimation of Tavarja lake catchment. To determine the priority score, SYI, USLE and Runoff estimation each was assigned by numerical rating that reflects the weightage of the overall impact of each category. This is based on consideration of the following criteria (Very high, high, medium, low and very low) depending on the nature and its relative strengths.

6.4. Suggestions:

The lack of proper soil and water conservation measures in Tavarja lake catchment, the increased runoff from the denuded hill slopes, with the accelerated soil erosion through a network of gullies and streams carrying sediments with its flow are the major problems in the study area. Another important factor that adds to the sediment load, which contributes to soil degradation is extensive grazing pressure. A large number of cattle sheep and goats graze the hill slope pastures during monsoon and winter season continuously for about more than six months. The Catchment Area Treatment plans (CAT Plan) envisage controlling the soil erosion process such as gully and sheet erosion and subsequent sediment transfer to lake.

The present CAT Plan comprises details of field investigations, identification of biological and engineering control measures for sediment arrest. Considering the topographic factors, soil type, climate, land use/land cover in the catchment area, the following engineering and biological measures have been proposed to be undertaken with the aim to check the soil erosion and to prevent siltation of lake water body to maintain its storage capacity in a long run.

6. 4. 1. Sub basin prioritization based on SYI, Runoff and USLE

Prioritization of each sub-watershed also has been done on the basis of SYI, Runoff, USLE index, which shall make the basis for selection of area for treatment of the catchment. (Table 5.8) presents the subwatershed details such as area, runoff value and the priority assigned for treatment. Location of these sub-watersheds is given on a plan (Figure 5.15). On the basis SYI, runoff and USLE, Very High priority level for conservation is required for TLCW 9.2 and TLCW 9.17. While Bhoira watershed, Chata nala, Dhakni nala, Neoli nala, Gumphawadi nala, Tavarjkheda nala, Kond nala, Wadi nala, Kahtkali nala, Wadji nala, and Bhada nala
etc subwatersheds require high priority for conservation planning. Whereas remaining subwatersheds require low priority for conservation planning.

6.5. **Engineering measures**

For planning engineering structures, data on geological, hydrological, and seismological features along with land characteristics is required. It is therefore, suggested that, “Planning Cell’ at Directorate level be created. This cell should be headed by a Civil/ Agricultural Engineer of class- I grade supported by requisite technical staff. This is particularly important for a project like Tavarja lake where landscapes are very common and the engineering structures so constructed are damaged frequently. (Fig. No. 6.1 and 6.2)

6.5.1 **Gully Erosion control measures:**

Gullies are mainly formed on account of physiography, soil type and heavy biotic interference in an area. The scouring of streams at their peak flows and sediment laden runoff cause gullies. The gullies would be required to be treated with engineering/mechanical as well vegetative methods. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilization of slopes/ area and prevention of further deepening of gullies and erosion. 5.75% area of the total Tavarja lake catchment shall be provided with this type of treatment, where the entire area is characterized by plateau fringe area with sleep slopes and gullies.

6.5.1.1 **Gully Plugs**

Gully plugs can be defined as stones placed across gullies, so as to capture nutrients, silt and moisture. Stones are often embedded into the upper surface of spillway aprons and wells to provide support for the next layer. The principle is to capture runoff from a broad catchment area, thus transferring low rainfall into utilizable soil moisture, and to prevent soil erosion. Slowing of the flow of water helps in settling down organically rich soil. A well maintained gully plug creates a flat, fertile and moist field, where high value crops and trees can be grown. Gully Plug is creating obstruction by placing bags filled with sand. Gully Plug is the effective method to slow down the speed of flowing water of the stream in any area.
6.5.1.2. Earthen Gully Plug (EGP)

Second order stream junction has been considered for EGP, which will reduce high peak flow of water in rainy season. EGP construction requires more than 100m diameter of boulders. Here, farmers’ view shall be also taken into consideration. Generally first order channel junction is suitable for this type of construction.

6.5.1.3. Boulder Gully Plug (BGP)

BGP is proposed at the EGP section and it is drawn on treatment map of watershed. Farmer’s agreement should be considered for this intervention. The maximum numbers of BGP in drain area is suggested on the basis of availability of construction material.

6.5.1.4. Slope modification by stepping or terracing:

The slope stability increases considerably by grading it. The construction of steps or terraces to reduce the slope gradient is one of the measures.

6.5.1.5. Bench terracing

The area under gentle to moderate slopes would be subjected to bench terracing. The local people would be convinced to follow this type of terracing for comparatively better yield and with minimum threat of erosion. While making bench terraces, care will have to be taken not to disturb the topsoil by spreading earth from the lower terraces to higher terraces. The vertical intervals between terraces will not be more than 0.2 m and cutting depth may be kept at 15 cm.

6.5.1.6. Continuous Contour Trench (CCT)

The CCTs are useful in arresting further erosion of depression, channels and gullies. In addition, retaining walls would be constructed to provide support at the base of slopes. The main purpose of CCT is to break the slope and reduce velocity of runoff. This type of conservation measures have been suggested mainly in the upper reaches of watershed.

- where there is sloppy land/hill slopes.
- degraded/waste lands

Without treating the upper regions of watershed with other treatment options, CCTs alone should not be constructed.
6.5.1.7 Farm Ponds

There is very little qualitative difference between a pond and tank, which usually serves the population of a village, and farm pond, which serves an individual agricultural field. Farms ponds greatly vary in size depending upon the rainfall. Surplus water from one pond spills over to a lower pond. In some cases a series of farm ponds are built on one single stream. Each pond caters to the irrigation needs of one farm and also augments ground water recharge.

6.5.1.8 Cement Bund

A cement bund is an embankment or wall of brick, stone, concrete or other impervious material, which forms the perimeter and floor of a compound and provides a barrier to retain the flow of water. These bunds control the volume and velocity of runoff in each slope unit. The cement bunds are proposed at the end points of EGP and BGP in the study area.

6.5.3.7 Farm Bund (FB)

This is the most popular soil conservation structure in the country and it is practiced at large scale all over India. Farm bunds are constructed on agricultural land with the aim of arresting soil erosion and improving the soil moisture profile. Ideally, bunds on farms should be made on the contour line. It would lie along the boundary of the field. The farm bunds are suggested on the basis of the slope of the land and size of field. It would help to conserve the water in the field and maintain in situ moisture in the field. The erosion of the field is reduced. Farm bund structure of study area treatment plan is recommended for the lower slope i.e. agricultural area.

6.5.1.9 Stream Bank Protection

Eroding stream banks not only damage adjoining agricultural lands but also contribute large quantities of sediment load to the river systems. Under the watershed management programme, bank protections of only small/ minor streams are included. However, works of this nature should only be taken up if the benefits justify the cost of construction. The works usually involved are in the nature of boulder pitching on banks of about 20-30 cm thickness after dressing the bank to a stable slope. Where the flow velocity of the stream is high (1.5 m/sec or more) gabion structures should be built at the toe of the bank with foundation firmly embedded in the streambed and bank.
6.6. Biological Measures:

6.6.1. Restoration of Degraded Areas:

In critically degraded areas, plantation of locally useful diverse and indigenous plant species such as timber species, fodder species, teak, fuel wood species, grasses, shrubs, legumes, medicinal and aromatic plants, would be undertaken. In the present study area, it is proposed to be taken up for various biological measures under this component during the project construction period. For raising plantation, nurseries would be developed along with irrigated organic agriculture.

6.6.3 Afforestation:

This will include rising of multi timer mixed vegetation of suitable local species in the steep and sensitive catchment areas of rivers/streams with the objective of keeping such areas under permanent vegetation cover. It is proposed to bring out an area of 5.00% under such plantation. Furthermore degraded areas would also be brought under some vegetation cover by way of timber plantation. An area of 5.00% would be covered under this plan.

6.6.4. Fodder Plantation:

To overcome the problem of scarce availability of fodder, it is proposed to bring a sustainable area under fodder plantation with suitable fast growing species. (area of 1%). This would be initiated along bunds of agricultural fields.

6.6.5. Plantation of horticultural and medicinal Crops:

Under this treatment plan, suitable horticultural crop species like mango, custard apple, and walnut shall be planted in selected area adjacent to the villages. These plantations would be distributed to families with the objectives of supplementing their income. An area mainly in the slope category of 0 to 2% (about 15%) has been earmarked to be undertaken for this treatment measure. This means that there should be proper crop rotations in the irrigated areas.

6.6.6. Forest land expansion Programme

Comprehensive programme of afforestation in the area should be taken, Tree plantation, Social forestry, agroforestry, Nursery rising, Horticultural, medicinal plant, rural fuel wood plant should be included in afforestation programme. Plantation can be used for wasteland, which will be helpful in regeneration of wasteland and decreasing in soil loss of the study area. Implementation of social forestry will
provide fuel wood, small timber and employment opportunities to the local people; hence social forestry is also suggested.

6.6.7. Treatment measures for individual sub watersheds:

The present study confirms the following observations in terms of anti-erosion measures to be undertaken for each and every sub basins as deduced from the prioritization of sub basins for conservation planning. In all three priority levels have been determined.

The details of sub watershed wise treatment measures are described as below:

6.6.7.1. Priority level I- Sub watershed Savargaon Nala (TLCW 4)

The predominant land use is under barren land / pastures constituting about 30% of the total area followed by shrub, riverine forest etc. The treatment measures suggested for this sub watershed are fodder plantation, horticulture, agriculture (irrigated) necessarily for the area below 5% slope. The area is characterized by rolling, gullied and ravenous topography and seems to be very sensitive for erosional runoff processes. Therefore gully control and plugging structure should be erected according to levels of the contours.

6.6.7.2. Priority level I- sub watershed Tavarja river (TLCW 8.20)

Maximum area is characterized by high proportion of waste land. Slope of the basin is noted to be below 5%. This sub basin also contributes maximum runoff as well as soil erodibility and denudation, inferior quality soil is a dominant characteristic of the area. Therefore, fodder plantation, horticulture, and non-irrigated agriculture is required. This basin also requires anti-erosion measures like CCT and construction of bunds.

6.6.7.3. Priority level II- Nagjhari nala sub watershed (TLCW 9)

This sub basin is characterized by considerable slope variation from 0 to 10 % in the category of gentle sloping area. Two clear zonations can be made as follows: Below 5% slope in which entire sub basin should be occupied for fodder and horticulture. 5% to 10% slope area can be covered by bench terracing. Very sensitive zone to the extreme south part should be treated with gully plugging and CCTs.

6.6.7.4. Priority level II sub-basin Bhada nala (TLCW 13)

This basin lies to the extreme southern end and can be called as major source of sediments in the Tavarja lake. This is extremely characterized by gullied and ravenous
topography and moderate-to-moderate gentle sloping ground. The area should be assigned to fodder plantation, horticulture and timber plantation. The area above 6% of slope should be treated with gully control structures and bench terracing.

6.6.7.5. Priority level II- sub basin Wadji nala (TLCW 9.13)

The total sub basin area can be treated with fodder plantation, horticulture, and irrigated agriculture.

6.6.7.6. Priority level III- sub basin Kasar nala and Khatkali Nala (TLCW 9.5)

There are two sub basins in the vicinity of Tavarja lake and should be practiced with fodder plantation, horticulture and agriculture. The area of both the catchments requires CCT and bench terracing.

6.6.8. Sustainable Development of Tavarja lake Watershed:

Sustainable development is a process of change in which exploitation of resources, the direction of investments, the orientation of technological development and institutional changes are made consistent with future as well as present day needs. It is a means of growth which respects the limits of environmental resources such as clean air, water, forest, soil etc, growth which maintains genetic diversity, which uses energy and raw material efficiency (Brundtland, 1987). Thus sustainable development is concerned with the present as well as the future requirements of mankind. There is evidence, that sustainable development is not realizable unless emphasis is placed at a very early stage on the relationship between human society and its ecology (Spare, 1987).

Development planning that recognized the harmony between man and nature is possible only if based on comprehensive environmental appraisal planning process, which is most concerned about human welfare as a matter of priority than material advancement.