CHAPTER VIII

WATERSHED DEVELOPMENT 
AND MANAGEMENT
8.1 INTRODUCTION

Water is an integral part of the environment, and its availability is indispensable to the efficient functioning of the biosphere. Water is also of vital importance to all socio-economic sectors-human and economic development simply is not possible without a safe, stable water supply.

A watershed is an area from which runoff resulting from precipitation, flows out through a single point into a stream, river or an ocean, is a natural geographical unit with a certain extent of homogeneity and uniformity. It is a convenient and clearly defined to topographic unit which can be taken as a basic erosional landscape element where land and water resources interact in a perceptible manner. Watershed approach is holistic, linking upstream and downstream areas and hydrologic processes relate the chain of cause and effect relationships. The inter-dependent nature of land and water resources thus necessitates the consideration of watershed as the basic unit in development planning.

Conflicts over water have become more common among competing water users. Misuse of water resources and poor water management practices has often resulted in depleted supplies, falling water tables, shrinking inland lakes, and stream flows diminished to ecologically unsafe levels. Water pollution, originating mostly from human activities, occurs even more frequently and in a wide spread manner, thus causing decreases for water suitable for many uses.

Under these circumstances, the need for improved, more efficient management of water resources is obvious. So far, water has been managed in a fragmented way. Groundwater and surface water are considered separately in development activities without due recognition of their interdependence. Water resources are not managed in conjunction with land resources. Quantity is generally managed separately from quality, as is water science and water policy.
This fragmentation of approach also impedes coherent hydrological analysis at regional, continental and global scales.

The interrelated nature of land and water resources calls for a holistic approach towards watershed management. Formulation of proper management programmes hence, requires reliable and up-to-date information about various factors, which affect the behavior of the watershed. Because of the ability to obtain synoptic view and repetitive coverage, remote sensing lends itself as a powerful input media representing the faithful, unbiased reproduction of the natural resources in a watershed for integrated development (Sebatian et al 1995).

Integrated water resources management (IWRM) is being actively promoted by the UN as a means of linking the development and protection of both natural and human resources within a basin under one overarching management structure. The basic idea of integrated management is to avoid developments in one field (Hufschmidt, 1993).

In Varada river basin, the following factors are responsible for the degradation of the watershed.

- Hills and pediments with rocky outcrops with poor soil formation and can support only sparse vegetation
- Steep slopes causing erosion of the top soil
- The existing sparse vegetation of land with scrubs or scrub forests provides very little protection against erosion
- Increase in human population leading to the degradation of forests
- Growing cattle population and rampant grazing has lead to depletion in vegetative cover
- Illegal felling of trees to meet fuel wood demands
- Lack of awareness among the local people
Therefore, for overall development, Varada river basin is taken up for integrated development and management study.

8.2 WATERSHED MANAGEMENT TECHNIQUES

Integrated approach is the one of the method by which both land and water resources in Varada river basin can be developed and managed. The techniques, which are normally used for management and development of land and water resources in a watershed, can be broadly classified into two as vegetative and structural measures (Sebastian et al, 1995).

Vegetative measures are those by which the conservation is attained with the help of a proper landuse system. It is a combination of woody perennials and herbaceous plants. The structural measure are of mechanical nature such as terraces, outlets and drop structures etc.,

These two measures should not be treated as two entirely different methods, but as two complementary items in an integrated approach. For effective watershed planning, there must be a close coordination of vegetative and structural control measures and the best combination is to be selected to tackle the problems of the watershed being planned.

For developing a comprehensive management plan, several factors are to be considered to arrive at the optimum combination of control measures that is effective, economical and less time consuming.

8.3 Land resources development

Land resources development depicts conservation measures with suitable change in land use and land cover. Priorities for development has been provided based on existing physical parameters within the watershed are
i. Staggered pits and afforestation of land with nongrazing variety of trees
ii. Contour trenching and afforestation with nongrazing variety of trees
iii. Contour trenching and silvipasture with non grazing variety of trees
iv. Pit and afforestation with non grazing variety of trees
v. Protective bunding and silvipasture in sheet erosion areas
vi. Gap filling with protection of forest
vii. Increasing Agro horticulture
viii. Increasing Argo-forestry
ix. Double cropping with groundwater exploitation.

8.3.1 Vegetative measures

Agro forestry as a collective name for land use system in which woody perennials (tree shrubs, etc.,) are grown in association with herbaceous plants (crops, pastures) and/or livestock in a spatial arrangement, a rotation or both and in which there are both ecological and economic interactions between the tree and non-tree components (Anthony young, 1990). Agro climatic or vegetative measures are employed as soil conservation practices because of their capability in increasing surface roughness, infiltration, interception, etc., and due to its control over runoff and other energy factors.

8.3.1.1 Forestlands

Forestlands and grassland have an effective role in watershed management. Forest generally occupy a strategic position in a watershed usually at higher elevation and can cause high erosion unless properly protected. Forestlands are the major sources of water that sustain stream flow to a certain extent during non-storm periods.

The important component of forest from hydrological point of view is canopy, leaf litter and humus with dense roots. Leaf litter and humus act as a cushion against
the impact of raindrops and provide temporary pondage as the rich organic content of dense leaf litter helps in high infiltration and soil moisture storage. Forest with more tiers of canopy has greater influence on soil erosion and catchments hydrology. Infiltration capacity of forest soil is greatly affected by changes in forest cover and forest floor. Heavy grazing and soil compaction as well as reduction in humus by repeated burning reduces infiltration capacity.

Thus, dense vegetative cover, deep root system, abundant litter and humus obtain maximum protection and erosion will vary with the degree of protective covering. To rehabilitate deteriorated lands and thereby decrease flood runoff and erosion, the area should be protected from fire and grazing and it is necessary to plant openings and bare areas with suitable fast growing species. Sometimes, it may be necessary to supplement these measures with contour furrows or terraces to break up small gully systems that tend to concentrate storm runoff. Using the forest for timber production or grazing, every attempt should be made to control such uses so as to keep disturbances to the soil and vegetation within safe limits. Roads constructed for logging purposes should be carefully located to avoid impairment of streams, unstable slopes should be avoided, gradients should be kept to a minimum, and provision should be made for drainage of storm runoff to avoid concentration of flow and to discharge such water into natural channels or non-erodable surfaces.

8.3.1.2 Grass Lands

Natural grasslands are similar to forests to a certain extent and occur widely in zones of lower precipitation than forest areas. As these are frequently located below forest areas, clear water flowing from the forestland may be seriously impaired in quality by silt eroded from the grasslands, unless the latter area is well managed and in good condition.

However, interception of precipitation by grass is considered comparatively insignificant; it has a significant effect in maintaining infiltration rates. Litter and
growing plants not only protect the soil surface from raindrop impact, but also act as barriers to prevent water movement and increase percolation rates and storage capacity. Besides, where soils are deeper than 1 m and precipitation is sufficient to penetrate the soil mantle, transpiration losses will generally be significantly less with a grass cover than in the case of trees or shrubs.

8.3.2 Structural measures

Vegetative measures alone may not be effective in attaining the required level of conservation and in many cases, structural measures are to be employed to supplement them. Erosion control, sediment control, flood prevention, drainage, water supply and ground water recharge are the primary purposes for which structural measures can be utilized.

8.3.2.1 Erosion control

Erosion control is the most important purpose of any watershed management activity. The detachment of surface soil can be controlled by reducing the velocity of surface runoff, protective covering, storage, and controlled discharge, and diverting the surface runoff.

Runoff velocity is reduced to the point where present or constructed channels can safely carry anticipated flows without bottom or bank erosion. The channel conditions can be altered either by controlling the grade of the channel or by controlling the cross-section of the channel. While drop spillways, chutes or drop inlets are used for the former purpose, channel improvement measures such as earth moving and bank sloping are employed to attain the latter.

The effect of energy factors can be reduced by improving the efficiency of protective factors. Typical protective coverings are riprap, revetments, cribs, etc. To reduce the rate of surface flow, temporary storage facilities such as impounding dams are constructed which will temporarily retain peak flows and discharge them.
at a safe velocity into the existing channels. Runoff from gulleyed or badly eroded areas should be diverted by constructing large graded terraces or diversion ditches above official areas and is carried at safe velocity to a suitable disposal area.

8.4 Water resource management

Techniques for holding of water collected from the watershed area can be separated into three general groups.

i. Soil profile storage
ii. Storage through ponds and tanks (surface reservoirs)
iii. Storage through well (sub-surface)

8.4.1 Soil profile storage

Depends upon factors such as depth of soil profile, water holding capacity, infiltration rate, etc., the soil profile should be filled up to field capacity for the efficient utilization. Over filling may result in water-logging situation.

8.4.2 Storage on the surface

This storage could be utilized for dry crops, water supply to rural community and livestock. In many water-harvesting systems, the storage facility is the most expensive component and may represent about 50% of the total of the project.

Farm ponds: Farm ponds are small storage structures used for collecting and storing runoff water. They are of three type’s viz., excavated farm ponds suited for flat topography, embankment ponds for hilly and rugged terrain, and excavated and embankment type.

Nallah bunds: They are of required dimensions, with a provision for surplusing, to hold maximum runoff water for creating flooding situations of the upstream area of the watershed. These bunds arrest the silt and allow the water in a
controlled manner. The impounding of water facilities percolation into deeper layers of soil profile which otherwise will flow with high velocity, causing silting of natural drainage courses. In addition, the bunds help in recharging of the aquifers, which in turn increases the availability of groundwater for irrigation purposes, and increasing the command area of wells.

Check dams: Check dams are barrages for masonry structural built across nallah watercourses to impound runoff water and slow down the velocity of flow to enable large volumes of water to infiltrate into the soil. Benefits of the system include availability of water for irrigation, retention of silt for spreading on fields, fewer losses due to evaporation and cheaper construction as the peak flows are not intercepted but are allowed to flow over the check dams.

Contour trenching: Trenching of suitable dimensions at regular interval on contours is excavated and placing the spoil on the downstream side of the trenches mainly to create favorable moisture conditions and thus accelerates the growth of the vegetation. Contour trenches break the velocity of runoff. Rainwater percolates and helps in replenishing of groundwater storages.

Dugouts: A dugout is a deep pit excavated to provide storage below the ground surface. The depth and diameter of a dugout must be adjusted to fit the local physical conditions. They should be located in vegetated area not subjected to high silt loads during floods. These dugouts are especially suitable in flat terrains where water can be collected and impounded below the ground surface. The capacity of an ordinary dugout varies from 100-200 cubic meters. A series of dugouts help in recharging of groundwater as well water is made available for irrigating lands in the neighbourhood.

Contour cropping: it has been shown that by many scientists that contour cultivation reduces runoff and prevents soil erosion when compared to up and down cultivation (Tejwani et al., 1975). Contour farming is easy, simple and
economical. In low rainfall area, contour cultivation not only conserves soil and moisture contributes to increased crop production. Experiments have shown that by adopting contour farming for potato, cultivated of 25 percent slope, runoff was reduced from 52 to 29 mm and soil loss from 39 to 14.9 t/ha (Raghunath et al., 1967). Apart from conserving the water and soil, counter cultivation conserves soil fertility and increases crop yield.

8.5 Action plan (Suggestions and Recommendations)

Use of GIS techniques helps in integration of various thematic maps in a more efficient fashion. Based on the integration of slope, soil, drainage, hydrogeomorphology, land use and land cover suitable sites are demarcated for the following.

- Construction of rain water harvesting structures
- Implementation of soil conservation measures
- Identification of area suitable for afforestation, agro-forestry, agro-horticulture and fuel wood as well as fodder development.

Construction of rainwater harvesting structures: Based on the hydrogeomorphological maps prepared using Remote sensing data along with collateral data a number of rainwater harvesting structures such as percolation tanks, farm ponds, check dams, subsurface dykes etc., are proposed at suitable sites within the basin.

Percolation tanks and check dams have been proposed across streams in developed areas to facilitate raise of groundwater table.

Farm ponds have been proposed in area where dry land agriculture is prominent to provide one assured irrigation crop and a substantial economic return.
Subsurface dykes are proposed in area where the topography is flat, shallow soil cover, and the depth to basement rock is within 5 m.

In addition to these structural measures, desilting of tanks and ponds in the basin area has to undertaken.

In Varada river basin about 24 rainwater harvesting structures are proposed, of which, 7 check dams, 4 farm ponds, 5 percolation tanks and 8 subsurface dykes are proposed. Apart from these rainwater-harvesting structures, 640 tanks (minor irrigation structures) need modernization and rejuvenation (Fig. 8.1 and 8.2).

Design features of the rainwater harvesting structures are not discussed here. Standard designs are recommended to store water so that soil moisture is preserved and the aquifer will be recharged.

Implementation of soil conservation structures: Integration of thematic maps like land use and land cover, soil and slope maps, Composite Land Development Unit (CLDU) maps are prepared and the following recommendations are suggested.

Wastelands, which are relatively on gentle slope with better soil conditions, have been suggested for agriculture, plantations and grassland development. Wastelands, which are within the notified forests area has to be taken up for afforesation.
Figure 8.1 Tanks and ponds in Varada river basin
Figure 8.2 Water harvesting structures in Varada river basin