Chapter 9. Environment Management Plan

EMP provides a delivery mechanism to address the adverse environmental impacts of a project during its execution, to enhance project benefits, and to introduce standards of good practice to be adopted for all project related work[55].

Integrated approach during project planning, design, construction and operation work acts as a better tool for implementation of Environmental Management Plan. The EMP measures include mitigation or enhancement measures as appropriate to the nature of impacts and are explained in the following sections. These include:

- Catchment area treatment plan
- Command area development
- Compensatory afforestation
- Biodiversity, Wildlife conservation and management plan
- Fisheries conservation and management plan
- Resettlement and Rehabilitation plan
- Green belt development
- Reservoir Rim treatment
- Muck disposal plan
- Restoration of quarry sites and landscaping
- Dam break analysis
- Water, Air and Noise management plan
- Groundwater management plan
- Labor management plan
- Sanitation and Solid Waste Management Plan in labour camps
- Local Area Development Plan
- Environmental Safeguards during construction activities
- Energy conservation
- Environmental monitoring programme

9.1 Catchment Area Treatment (CAT) plan

9.1.1 Strategy for cropping pattern

Cropping patterns and land use is governed by

- Topography
- Climate
- Soils
- Food habits of the people

[55] https://www.adb.org/sites/default/files/institutional-document/33739/files/environment-safeguards-goodpractices-sourcebook-draft.pdf

The annual rain fed crops, such as: Maize, tobacco, cotton and pulses constitute the major crops in the proposed command area. Important irrigated crop is paddy

The farmers are more enthused in the irrigated area to go for improved, high yielding and commercial crops. Generally the irrigated farmers take risks in using additional inputs and also management.

- Scope for Intensive Cropping

There is good scope for inter-cropping, which is now practiced. For eg., ginger, turmeric and chillies can be raised as an intercrop with areca nut and coconut etc. Seasonal leguminous crops, such as pulses, soybean etc., can also be raised as an intercrop with many horticultural trees/plants. The practice of relay cropping was in vogue in the past in some areas, It is, however, possible to cultivate lentil or pea etc., as relay cropping in the rice field. Various forms of multiple cropping can be practiced, depending on whether the land available is irrigated, rain fed, lowland, upland etc.

- Intensive Farming Systems

Since agricultural land is shrinking with growth of population and development, it has become essential to adopt intensive farming systems. Various forms of agro-forestry based farming systems are feasible in the study area. Such a farming system may include silvi-pastoral, horti-pastoral, agri-horti-pastoral-cum-fishery; land-livestock based farming systems, etc. An integrated approach to farming systems through scientific management of land and water on the principles of watershed management is also feasible.

- Multilayer Cropping

Various forms of multi-layer cropping, particularly in respect of horticulture and plantation crops, can be developed and practiced as a measure of intensive farming. A few examples of such feasible multi-layer cropping are:

1. Arecanut with betel vine/black pepper as a companion crop, and ginger, turmeric and chillies as intercrops.
2. Coconut-papaya./lime-pineapple/ginger
3. Banana-pineapple-cowpea.

Agriculture in the proposed command area is primarily rain fed; watershed wise activities are required for sustainable development land and water. Integrated development on watershed basis paves way for holistic improvement of entire area. Conservation of surface soil and erosion control measures paves scope for preserving the fertility and impounding run off in the form of farm ponds, Nala bund, check dam and other suitable structures are helpful in providing protective irrigations in times of long dry spells. Watershed management are important in this regard. It would be evident from the preceding discussions, that there is ample scope for diversification of cropping systems and patterns with immense potentialities to increase agricultural production. However, on farm research, effective extension activities and appropriate public policies which continuously back-up the agricultural production systems should be adopted. Similarly, certain infrastructural facilities will have to be catered following intensive cropping. These include rural storage structures, regulated market, effective institutional credit, timely supply of other inputs etc, In the case of horticultural crops, crop wise associations have to make and to link up with processing plants and markets etc., so that the community at large is benefitted.

9.1.2 Soil erosion

Soil erosion is the removal of surface material by wind or water. When raindrop falls on a soil surface, the soil particle are splashed and, higher is the velocity of impact, greater is the amount of soil splashed. Drop impact is more effective when a thin film of water covers the soil surface and the maximum dispersion of soil particles occur when the depth of water is about the same as diameter of raindrop. The detached soil particles are then carried further either by runoff or wind. This whole process is known as erosion. Soil conservation practices shall be on the basis of the following inventories,

i. Extent of the soil and nutrient losses and sediment transports in various environments.
ii. Land use/Land Cover details, provides basis for implementation of different soil conservation measures on soil losses and sediment yields.
iii. A better understanding of the soil erosion processes the dynamic and relative importance of the single processes and their interactions.

9.1.3 Soil conservation practices

Soil and Water are the two most important Natural resources which have a direct bearing on agricultural production. These resources have to be used judiciously to obtain optimum of yield of crops. Therefore utmost care has to be exercised in management of these resources, not only to prevent soil degradation but also to improve the productivity of the soil for sustained agricultural development. Measures to conserve soil *in-situ,* allow more infiltrations opportunity time for rain water and safe disposal of runoff water from arable lands are of prime concern in rain fed areas, since they directly affect soil erosion rates and consequent crop productivity. The recommended soil and moisture conservation measures for Central dry zone Dry zone are as follows:

a. Reducing wind erosion of soil by growing wind breaks (vegetation cover).
b. Diversion Drains/Water ways
c. Contour bunds with waste weirs.
d. Graded bunds/Graded border strips.
e. Zing terraces with raised waste weirs.
f. Gully plugging.

g. In over-grazed land silvi pastoral systems, which in irrigated land yield enough green fodder to cattle population.
h. Grazing animals should be kept in stalls.
i. Agro forestry and Agro horticulture systems to meet various needs of farmers, crop residue of this adds to the soil and increases carbon content and biotic activity.
j. Harvesting of runoff and impounding through appropriate structures.
k. Drainage line treatments to improve the flow and avoid nala course clogging.

9.1.4 Soil conservation practices for CAT

All India Soil Survey & Land Use Planning (AISS&LUP) Ministry of Agriculture,Govt of India have made inventory of soil resources in the catchments of major Reservoirs and prepared priority fixation soil survey and categorized into severe,meadium and low priority areas for treatment and micro catchments contributing high sediments are included for soil conservation treatments which include treatment holistically to arrest the sediments flow into Nala,Rivulet and Rivers and onward deposition in the major Reservoirs. Adoption of appropriate soil and water conservation practices is considered to be the only way of conserving and improving land resources and environment. Large scale soil and water conservation activity in India began in 1934. Realizing the importance of soil conservation, the state government had formulated scheme as early as in 1942.As per the estimates of state government, about arable land in the state needs protection. Out of the 49.61 lakh hectares of cultivable area in the state, 27.06 lakh hectares (54.54%) needs soil conservation measures. Telangana State is a pioneer in implementing watershed programmes. Rain fed area accounts for about 63.6%. Various conservation measures were undertaken to combat soil erosion through model watersheds, district level macro watershed programs, DPAP, DDP, IWDP, WGDP, RVP, NWDPRA and more recently from April 2008 Integrated Watershed Development Programme (IWMP).A state level perspective and Strategic Plan (SPSP) is prepared for the state and entire area (62.88 lakh ha) is contemplated to be treated by the end of XIV th plan period, on 90:10 ratio between centre and state by implementing Prime Ministers Krishi Sinchayee Yojan (PMKSY) to provide twin benefits of " Har Khet Ko Pani and More crops per Drop" of rain water.

In the district of Jayashankar Bhupalapalle already good amount of area is being treated under soil conservation and the entire catchment has to be treated to protect the rain fed area by implementing appropriate catchment area protection works.

9.1.5 Soil and water conservation measures for Modikunta Vagu Catchment Area

Some of the methods suggested for soil conservation for Modikunta Vagu catchment area and other details are provided below.

9.1.5.1 Gully plugging

This prevents the eroding and down-cutting of gully beds headwords while they encourage the deposition of silt load and create a micro-environment for the establishment of vegetative covers. Gully plugs act as grade stabilization structures. The specifications for gully plug are as follows;

Table 9.1 Specifications for gully plugs

Slope of gully bed (off)	Width of gully bed (m)	Location	Type of gully plug	Vertical interval (m)
0-5%	Upto 4.5	Gully bed	Brush wood	Upto 3
	4.5 – 10.5	Gully bed & ride branch	Earthen	2.25 to 3.0
	7.5 to 15.0	At the confluence of two gullies	Sand bags	2.25 to 3.0
10-20%	Upto 4.5	Gully bed	Brush wood	Upto 3.0
	4.5 to 6.0	Gully bed	Earthen and side branch	Bet 1.5 to 3.0

The gullies would be treated with engineering/mechanical as well as vegetative methods. Check dams are recommended for some areas to promote growth of vegetation that will consequently lead to the stabilization of the slopes area and prevent further deepening of gullies and consequent erosion. For controlling the gullies, the erosive velocities are reduced by flattening out the steep gradient of the gully. This is achieved by constructing a series of check dam which transform the longitudinal gradient into a series of steps with low risers and long flat treads. Different types of check dams would be required for different conditions comprising different materials, depending upon the site conditions and by using the locally available materials. This is often the most acceptable soil conservation measures that can easily establish and should form a dense thicket near the ground level when planted in close vicinity. The following materials are recommended for the purpose.

- Brushwood check dam
- Dry rubble stone masonry (DRSM)
- Check dams with stones available at the site
- Combination of DRSM and crate works – for moderate to deep gullies with locally available stones at sites

The advantage of brushwood check dams is that they are quick and easy to construct and are inexpensive as they are constructed by using readily available materials at the site. In addition to the vegetative measures used for stabilization of gullies, temporary or permanent mechanical measures are used as supplementary measures to prevent the washing away of young plantations by large volume of runoff. The gullies get stabilized over a period of time with the establishment of vegetative cover. With passage of time mechanical structures weaken and vegetative measures get strengthened.

The drainage basin of the river, usually referred to as catchment area needs some kind of treatment in the overall interest of the development of the area extending along the river with a view to improve land management through biological and engineering measures, with the objective of arresting soil erosion and improve its vegetation, and control over grazing by cattle.

The catchment area treatment involves intensive and highly technical measures, which require the expertise of technical skill. The watershed committees have to be constituted in the Mandals covered in the proposed catchment of Modikunta Vagu lift irrigation project area, spread over in the jurisdiction of Jayashankar Bhupalpally District, including meeting drinking water requirement in the parched district with the objective of an integrated approach involving multi disciplinary experts dealing with forest, agriculture, horticulture, watershed, sociologists, besides local Mandal members and community members. Local reputed Non Governmental Organization (NGO) to act as a facilitator in community mobilization and capacity building activities.

9.1.5.2 Soil Conservation Practices for Modikunta Vagu lift irrigation project Area

For the hilly regions, Watershed Development wing in Telangana, and CRIDA and ICRISAT has suggested the following soil conservation practices. The most important practice among those mentioned below, is contour Bunding and water impounding structures details are as follows;

Table 9.2 Soil conservation Measures and Practices

Sl. No.	Type of soil conservation	Practices recommended
1	Contour Bunding	Bund section of 0.48 and 0.52 sq mt
2	Bench terracing on steep slopes (12-15%)	Outward cross slope of 10% Longitudinal slope of 8% Length of terrace, 20-35 m Width of terrace, 3 to 5.5 m
3	Riser (earthen or stone)	Steep batters of, 0.25:1
4	Earthen shoulder bund	0.5 m base, 0.3 m height,01 m top
5	Stone bunding or fencing when stone is easily available.	0.3 m base, 0.2 m height, 0.1 m top Followed by earthen bund of 0.1 m top
6	Land leveling	Low (bottom) flat deep areas leveled. Bench terraces are also leveled by cut and fill.
7	Land slide control	Vegetative means

Sl. No.	Type of soil conservation	Practices recommended
8	Gools	Water channels conveying water from natural springs as well as rainwater. Same design delivers 5-50 liters/min in winter and 100-500 liters/min during rainy season. Need improvement in regulation.
9	Farm Pond/Seepage Pond	Earthen ponds collecting run off of water and seepage water.

The area under each watershed has been planned on the basis of Landuse / land cover and topographic conditions. The total area proposed for treatment is 5,500 ha, in the Modikunta Vagu project basin.

Table 9.3 Cost Estimates as per Soil conservation treatments suggested

Area to Treated (ha)	No. of Check dams (ha)	Cost (Rs. Lakhs)*	Contour bunding/Bench terracing (ha)	Cost (Rs. Lakhs)**
5500	30	90	3850	385
Total	475 Lakhs			

*Cost of each check dam being Rs.3.00 Lakhs
**Cost of bench terrace construction/Bunding is Rs. 10,000/ha
Total cost for catchment area treatment is = 475 Lakhs

Table 9.4 Area and Cost Estimate for Catchment Area Treatment

Year	Physical (ha)	Financial Outlay (Rs. In Lakhs)
2019-20	1100	95.00
2020-21	1100	95.00
2021-22	1100	95.00
2022-23	1100	95.00
2023-24	1100	95.00
Total	**5500**	**475.00**

9.1.5.3 Estimation of Soil Loss

A number of methods for assessing soil loss have been developed. They range from simple, qualitative models to elaborate watershed simulations. Qualitative models rely on subjective evaluation of a series of criteria. Watershed simulation models are often very theoretical. Several empirical models also are available and most models are best suited for estimating erosion from very large areas (more than 1 sq mile) and lack precision for use on small sites such as construction sites. The universal soil loss equation (USLE) is given by,

A = RKLSCP --------- Eqn (1)

Where,

A = is computed Soil loss per unit area expressed in the units selected fork and for the period selected for R. In practice, these are usually so selected that they compute A in m tons /ha/year, but other units can be selected.

R = the Rainfall erosivity, is the number of rainfall erosion index units for a particular location.

K = the Soil erodability is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot , which is defined as 21.13 m (72.6 ft) length of uniform 9 percent of slope continuously in cleaned tilled fallow.

L = The Slope Length factor, is the ratio of soil loss from the field slope length to that from 21.13 m (72,6 ft) under identical conditions.

S = the slope steepness factor, is the ratio of soil loss from field slope gradient to that from a 9 percent of slope under otherwise identical conditions.

C = the Cover and management factor is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow.

P = the support practice factor, is the ratio of soil loss with a support practice like contouring, strip cropping or terracing to that with straight row farming up and down the slope.

9.1.5.4 Erosion Index (EI30) Values on Storm Basis

The rainfall erosion index R is a measure of the erosive force and intensity of rain in a normal year. The two components of the factor are the total energy E and the maximum 30-minutes intensity (I_{30}) for all the storms in an area during an average year. Values of R have been computed for the various regions in India and abroad from rainfall records and probability statistics, and hence R should not be considered as a precise factor for any given year or location.

The energy of the rainstorm is a function of the amount of rain and all the storms component intensities. Median raindrop size increases with the rain intensity and terminal velocities of free falling water drops increases with increased drop size. Since the energy of the given mass in motion is proportional to velocity-squared, the rainfall energy is directly related to rain intensity. The relationship in metric units is expressed by the equation, where KE is the kinetic energy in meter tones / ha-cm and is the rainfall intensity in cm /hr.

The index values (EI_{30}), for each storm was determined. The product term EI was expressed as:

EI_{30} = (KE x I_{30}) / 100 ----------- Equation (1)

Where EI_{30} = Erosion Index

KE is Kinetic Energy of the storm

I30 = maximum 30 minutes Rainfall intensity of the storm

For computing Kinetic Energy of Rain storm the equation proposed by Wishmeier (1959) is

KE=916+331 log I -------------------Equation (2)

Where KE = Kinetic Energy of the storm in foot tons per acre inch and

I = Rainfall intensity in inch per hour

The Equation (2) has been modified into metric units by Wishmeier & Mannering (1965) and Ranganath, et al., (1970) the equation in metric units is:

KE = 210.3 + 89 log I ---------- Eqn (3)

Where,

EI_{30} is the erosion index

KE is the total storm kinetic energy in tonnes – m/ha

I_{30} is the maximum 30 minutes intensity of rainstorm.

The monthly, seasonal and yearly EI values will be determined by adding the storm EI values for that length of period.

9.1.5.5 Soil Erodibility Factor (K)

The soil erodability factor K is a measure of the susceptibility of soil particle detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute to K values ranging from 0.45 to 0.59.

9.1.5.6 Nomograph Method

The United States Department of Agriculture (1978) has suggested a Nomograph and the following equation for the determination of soil erodability for soils containing less than 70% silt and very fine sand:

100K = $2.1M^{1.14} \times 10^{-4}$ (12-a) +3.25 (b-2) +2.5(c-3) -------- Eqn (4)

Where, K is the soil erodability factor,

M is the particle size parameter which is equal to: (percent silt + very fine sand) / (100% clay),

'a' is the percentage of organic matter content,

'b' is the soil structure and

'c' is the profile permeability class.

The preferred method for determining K values is the nomograph method. Use of the nomograph requires a particle size. The Soil sample code collected from the field were characterizes carefully for estimating, the K values.

9.1.5.7 Determination of LS

Since the LS factor has a considerable effect on predicted erosion, care in figuring values for the factor is warranted. In particular, results of the soil loss calculation will be more accurate if the USLE is individually applied to portions of a site with similar slopes (similar gradient and length) and summing the individual soil loss estimates. Slope gradient is the field or segment slopes, usually expressed as percentage. The topographic component, LS, was evaluated by using the contour length method for large watersheds.

LS was calculated base on the following equation

$LS = (L)^m / 22.1(0.065 + 0.0454S + 0.0065 S^2)$ --------- Eqn (5)

Where,

LS = Average length slope component

L = Slope length in meters

S = Average watershed slope in percent and

m = Exponent (m= 0.2 if slope < 1%)

9.1.5.8 Evaluation of Cropping Management Factor (C)

The cover factor C is defined as the ratio of soil loss from land under specified crop or mulch conditions to the corresponding loss from tilled, bare soil. In the USLE, the C factor reduces the soil loss estimate according to the effectiveness of vegetation and mulch at preventing detachment and transport of soil particles. On activity sites, recommended control practices include the seeding of grasses and the use of mulches. These measures are often considered "temporary" -they are designed to control erosion primarily during the activity period. Permanent landscaping may be added later, or temporary erosion control plants may be left as a permanent cover. Any product that reduces the amount of soil exposed to raindrop impact will reduce erosion.

The cropping management factor, C is computed as follows:

$C= \Sigma^n Ci\ Ai / A$ ------- Eqn (6)

Where,

C is the cropping management factor for the watershed

Ci is the cropping management factor for crop i,

Ai is the drainage basin area growing crop i with a particular management level,

n is the number of land use areas in the watershed, and

A is total watershed area.

9.1.5.9 Evaluation of Support Practice Factor (P)

The erosion control practice factor P is defined as the ratio of soil loss with a given surface condition to soil loss with up and down hill plowing. Practices that reduce the velocity of runoff and the tendency of runoff to flow directly down slope reduce the P factor. In agricultural uses of the USLE, P is used to describe plowing and tillage practices. In activity site applications, P reflects the roughening of the soil surface by tractor treads or by rough grading. In computing the P factor, land cover conditions are considered depending upon the cultivated and uncultivated area of the watershed. In addition, slope is also considered as a key factor in assigning the value. For the study area, a P factor considered is 0.6 for terraced agricultural land having slope less than 2% and for the rest of the land having a slope more than 2%, a value of 0.5 is assigned.

Table 9.5 Sub catchment/Watershed and codification of MVIP project

Region	Basin	Catchment	Sub-catchment	Watershed Name	Sub-Watershed Code	Micro watershed Code
Bay of Bengal (4)	Godavari (4E)	Godavari delta with confluence of Indravati	4E1G	4E1G8	4E1G8a	4E1G8a1
						4E1G8a2
					4E1G8b	4E1G8b1
						4E1G8b2
					4E1G8c	4E1G8c1
					4E1G8f	4E1G8f1
						4E1G8f2
						4E1G8f3
					4E1G8g	4E1G8g1
						4E1G8g2
						4E1G8g3
						4E1G8g4
					4E1G8h	4E1G8h1
						4E1G8h2
						4E1G8h3
						4E1G8h4
						4E1G8h5
					4E1G8j	4E1G8j1
						4E1G8j2
						4E1G8j3
					4E1G8k	4E1G8k1
						4E1G8k2
					4E1G8m	4E1G8m1
						4E1G8m2
						4E1G8m3
						4E1G8m4
					4E1G8n	4E1G8n1

Region	Basin	Catchment	Sub-catchment	Watershed Name	Sub-Watershed Code	Micro watershed Code
				4E1G7	4E1G7k	4E1G7k2

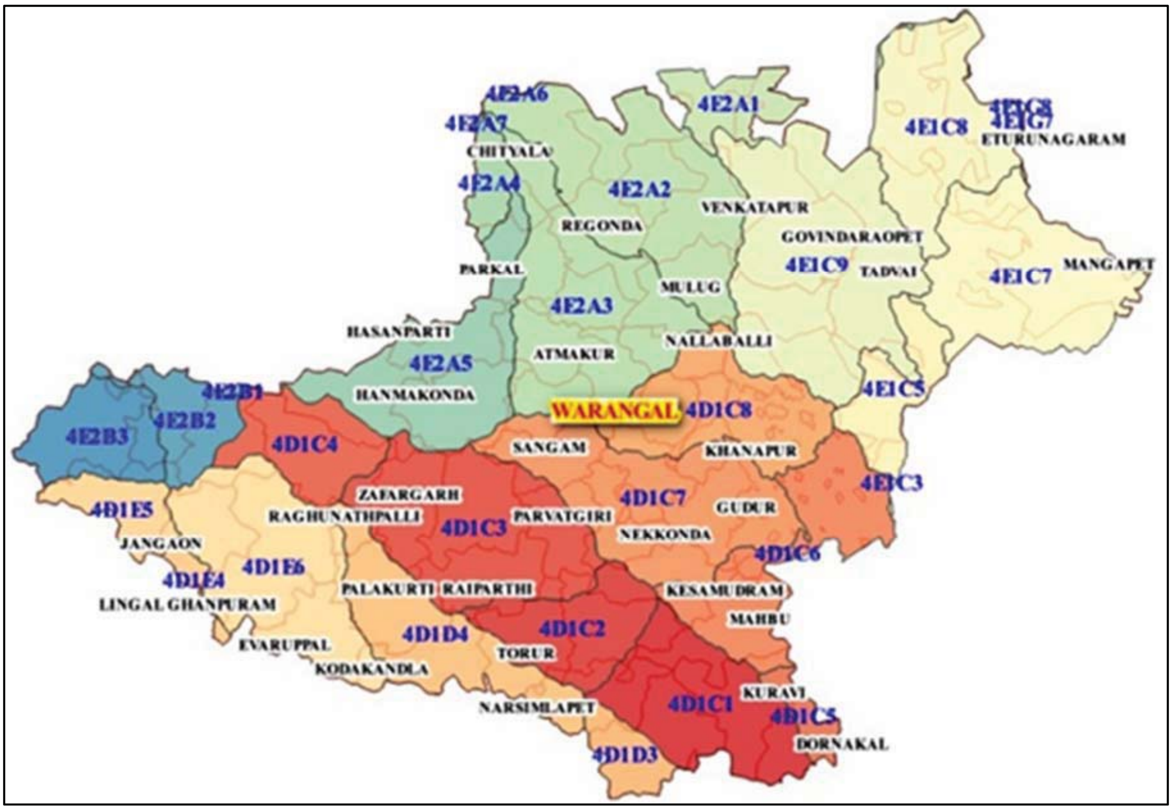

Fig 9.1 Watersheds delineated in Warangal district

Table 9.6 Estimation of soil loss in Watersheds in the Command Area

Watershed	R	K	LS	C	P	A(Tons/ha)
4E1G8a1	2.65	0.49	0.536	0.278	0.5	0.096
4E1G8a2	2.68	0.42	0.851	0.28	0.555	0.148
4E1G8b1	2.58	0.52	0.862	0.292	0.5	0.168
4E1G8b2	2.64	0.54	0.702	0.286	0.5	0.143
4E1G8c1	2.56	0.52	1.221	0.258	0.5	0.209
4E1G8f1	2.62	0.53	0.732	0.282	0.55	0.157
4E1G8f2	2.74	0.45	1.483	0.27	0.55	0.271
4E1G8f3	2.12	0.46	1.411	0.28	0.52	0.200
4E1G8g1	1.94	0.45	1.428	0.311	0.55	0.213
4E1G8g2	2.39	0.59	1.323	0.276	0.6	0.308
4E1G8g3	2.32	0.56	1.123	0.281	0.51	0.209

Watershed	R	K	LS	C	P	A(Tons/ha)
4E1G8g4	2.26	0.45	1.423	0.283	0.52	0.212
4E1G8h1	2.38	0.5	0.781	0.272	0.51	0.128
4E1G8h2	2.55	0.56	0.702	0.266	0.53	0.141
4E1G8h3	2.6	0.53	1.211	0.274	0.52	0.237
4E1G8h4	2.68	0.52	0.792	0.262	0.55	0.159
4E1G8h5	2.56	0.48	1.33	0.28	0.55	0.251
4E1G8j1	2.48	0.51	0.892	0.29	0.5	0.163
4E1G8j2	1.82	0.47	1.478	0.322	0.55	0.223
4E1G8j3	2.48	0.51	0.882	0.29	0.5	0.161
4E1G8k1	2.45	0.51	0.732	0.282	0.55	0.141
4E1G8k2	2.31	0.45	1.43	0.283	0.52	0.218
4E1G8m1	2.41	0.53	0.732	0.282	0.55	0.145
4E1G8m2	2.11	0.51	0.892	0.29	0.5	0.139
4E1G8m3	2.26	0.45	1.42	0.283	0.52	0.212
4E1G8m4	2.12	0.53	0.732	0.282	0.55	0.127
4E1G8n1	2.48	0.51	0.89	0.29	0.5	0.163
4E1G7k2	2.26	0.48	1.43	0.283	0.52	0.228

Table 9.7 Erodability index

Watershed	R	K	LS	Erodability Index (R x K x LS) / T
4E1G8a1	2.65	0.49	0.536	7.19
4E1G8a2	2.68	0.42	0.851	6.44
4E1G8b1	2.58	0.52	0.862	6.85
4E1G8b2	2.64	0.54	0.702	6.99
4E1G8c1	2.56	0.52	1.221	7.75
4E1G8f1	2.62	0.53	0.732	6.45
4E1G8f2	2.74	0.45	1.483	6.73
4E1G8f3	2.12	0.46	1.411	6.87
4E1G8g1	1.94	0.45	1.428	5.85
4E1G8g2	2.39	0.59	1.323	6.04
4E1G8g3	2.32	0.56	1.123	6.98
4E1G8g4	2.26	0.45	1.423	6.80

Watershed	R	K	LS	Erodability Index (R x K x LS) / T
4E1G8h1	2.38	0.5	0.781	7.21
4E1G8h2	2.55	0.56	0.702	7.09
4E1G8h3	2.6	0.53	1.211	7.02
4E1G8h4	2.68	0.52	0.792	6.94
4E1G8h5	2.56	0.48	1.33	6.49
4E1G8j1	2.48	0.51	0.892	6.90
4E1G8j2	1.82	0.47	1.478	5.65
4E1G8j3	2.48	0.51	0.882	6.90
4E1G8k1	2.45	0.51	0.732	6.45
4E1G8k2	2.31	0.45	1.43	6.80
4E1G8m1	2.41	0.53	0.732	6.45
4E1G8m2	2.11	0.51	0.892	6.90
4E1G8m3	2.26	0.45	1.42	6.80
4E1G8m4	2.12	0.53	0.732	6.45
4E1G8n1	2.48	0.51	0.89	6.90
4E1G7k2	2.26	0.48	1.43	6.80
			Total	6.74

Average soil loss=6.74 Tonnes per Hectare

Estimated potential soil erodability is 6.74, which is less than 8 and therefore it is inferred that this is a moderately erodable land.

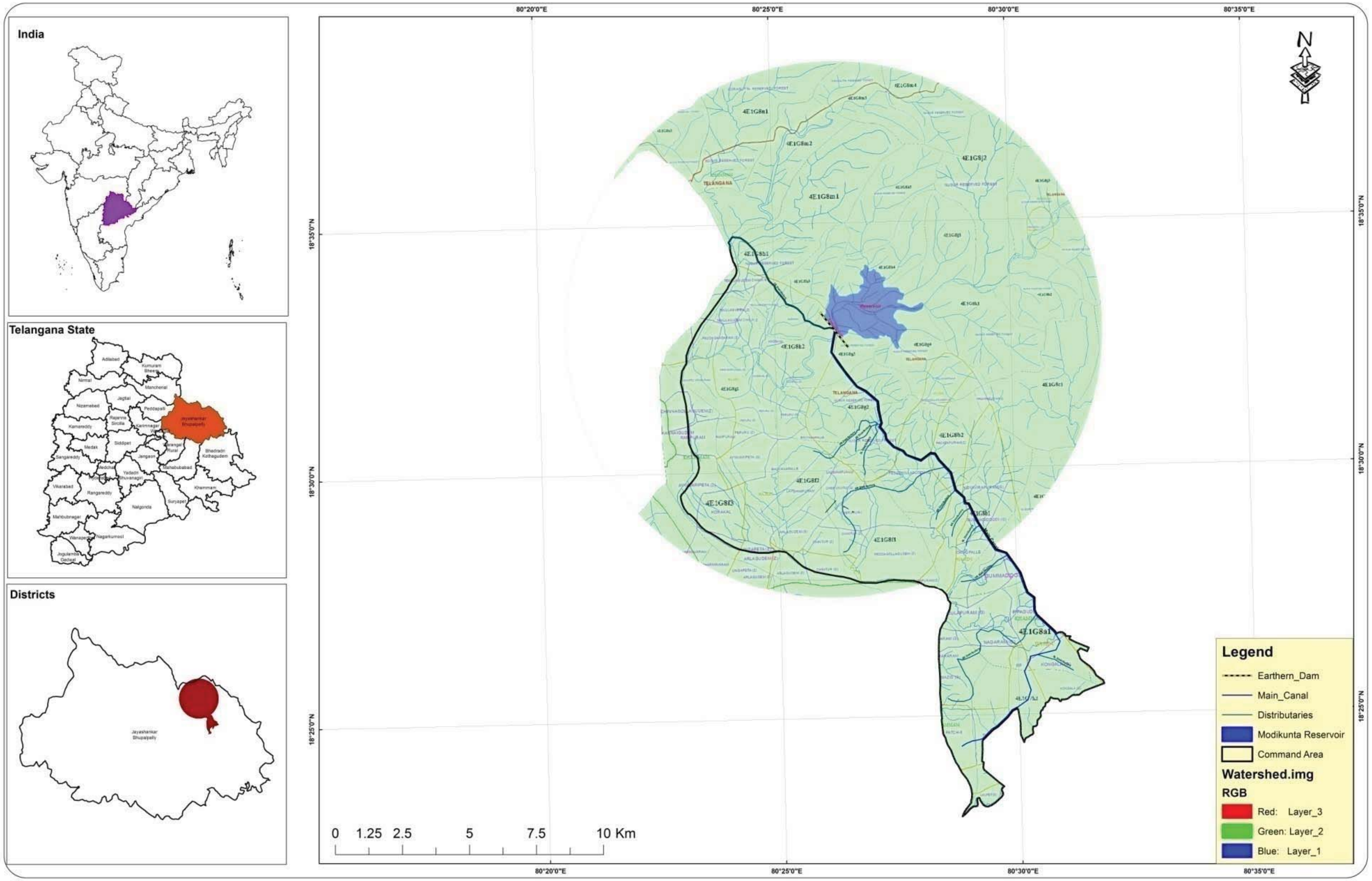

Fig 9.2 Watersheds delineated in MVIP

9.1.5.10 Sedimentation Studies

Erosion, transportation and deposition of sediments are natural processes controlled by geological, climatic, physical, vegetative and other related conditions all through the geological times. However, during the present century, because of deforestation and urbanization the rate of transport of sediments from the watersheds and siltation pose substantial environmental problems and before equilibrium conditions are reached, additional problems are likely to arise.

One of the major problems noticed in agricultural watersheds is that the crop productivity reduces to zero or becomes uneconomical, because of soil erosion (Walling, 1988). There are many theories which can be used to evaluate sediment movements in rivers. It is essential that functional relationship between various physical, geomorphic and sediment related parameters are developed, such that the magnitude of sediment eroded from watershed can be estimated. The increase in sediment yield from the watershed will have an impact on the watershed itself and on the river system and associated reservoirs. The impact of eroded soil on natural system is varied and widespread. The sediment particulates eroded from the watershed move in the downstream directly and in the process influence the drainage channels, flood plains, river beds, wetlands and lakes.

The key factors which affect the sediment yield from drainage basin are:

- Hydrology: Rainfall and runoff
- Catchment characteristics: Size of the catchment, slope of the catchment and length of the overland flow.
- Soil characteristics: Soil erodability, soil transportability, soil texture and structure.
- Nature of drainage network and drainage density.
- Landuse cover: Plant canopy, mulches and plant residues.
- Management practices: Tillage, soil conservation structures, terraces, diversions and bunds. .
- Of all the factors listed above rainfall and runoff provide the basic energy input to drive the erosion process. Steepness of slope plays an important role in the process of erosion. Soil properties such as soil texture, structure and the land cover, i.e., plant residue, mulches etc have a major role in erosion process.
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At the outset, it is clear that, the process of sedimentation is a matter of serious concern in irrigation projects, because it reduces the storage capacity, water supply capability, power generation, discharge control etc of reservoirs, rivers/catchments. The erosion of the catchments changes the ground water regime and results in lowering of water table in some places and rise at the formation of arid zone and marshes respectively. The fertility of the soil, its chemical composition also changes due to catchment erosion.

9.1.5.11 Sedimentation index

An estimate of sediment index must be developed to provide a basis for comparison with management induced sediment yield predictions. The best source of this information is actual long term real data of sediment yield. Another possible source is data from similar or related watersheds.

9.1.5.12 Stream Flow and Suspended Sediment Load

Although there is a definite variation in sediment transport rate in a natural stream at a particular location, still there exists a good relationship between the sediment load of the stream and certain hydro- morphological factors. The factors which are considered important in estimating sediment yield of a catchment are drainage area, annual water discharge, relief ratio, mean stream length and total stream length etc.

Regression analysis was carried out to know the relation between discharges and sediment load in Modikunta Vagu irrigation Project area. The relationship has been found to be,

$Y=7.47*10^{-6}\ x+3401.28$, with $r=0.97$

Where, Y= suspended sediment load in tones/year

X=stream flow in m^3/year (post-monsoon flow only).

Sediment Types	Total load in percent (by weight)
Coarse (Sand)	40.2
Medium (silt)	35.0
Fine (Clay)	24.8

It is observed a fairly relationship exists between annual discharge and annual sediment load and hence the problems of sedimentation is not much encountered in the proposed Modikunta Vagu lift irrigation project.

9.1.5.13 Reclamation of salt affected soils and management of saline and sodic soils

- The land should be level or contour farmed so that the surface of the soil will be soaked uniformly by water
- Selection of crops or crop varieties that have higher tolerances for salt or sodium
- Use of special planting procedure that minimizes salt accumulation around the seed otherwise lowers Germination percentage.
- Use of the appropriate irrigation method for the root characteristics of the crop
- Use of sloping beds and other special land preparation procedures and tillage methods to provide a low salt environment

- Use of canal or surface irrigation water to dilute the salts and to leach out the salts from the root zone for good germination.
- Application of amendments such as manure, compost, etc. for improving soil structure and tilt. Conservation tillage to incorporate crop residues will help create drainage.
- Deep ploughing of soil to break up sodic and other hardpans or other impervious layers to provide internal drainage.
- Use of chemical amendments as described.
- Good, sound agronomic farming practices and careful need based fertilizer management.

Table 9.8 Cost Estimate for Catchment Area Treatment

<table>
<tr><th>Sl. No.</th><th>Item</th><th>Time period</th><th>Cost in Rs.</th><th>Implementing agency</th></tr>
<tr><td>1</td><td>Soil conservation measures and implementation of CAT plan for 3 years</td><td rowspan="2">During operation phase</td><td>4,75,00,000/-</td><td rowspan="2">I&CAD Dept., & Forest Dept., and Agriculture Dept., GoT</td></tr>
<tr><td>2</td><td>Reclamation of affected soil for 15% of total CA (825 Ha)</td><td>4,12,50,000/-</td></tr>
<tr><td colspan="3" align="right">Total</td><td>8,87,50,000/-</td><td></td></tr>
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