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# भारतीय मानक मसौदा

# जलग्रहण क्षेत्र उपचार योजना की तैयारी — दिशानिर्देश

***Draft Indian Standard***

# PREPARATION OF CATCHMENT AREA TREATMENT (CAT) PLAN — GUIDELINES

Environmental Assessment and Management of Water Resources Projects Sectional Committee, WRD 24

Last Date for Comments: **13 August 2024**

## FOREWORD

(*Formal clause of the foreword will be added later*)

Man-nature conflict, to meet the un-satiating demands of land and other natural resources like fuel wood, fodder, etc., has resulted in overexploitation of the limited natural resources. Encroachment of forests and pasture lands and faulty agricultural practices have further aggravated the problem of land degradation and soil erosion. Heavy soil erosion from the degraded patches of the catchment, results in sedimentation of the reservoir, thereby reducing its storage capacity and impeding the life span of a river valley project.

In order to address the menace of soil erosion, proper soil and water conservation measures are required to be implemented as a part of the catchment area treatment (CAT) strategy. An ideal CAT intervention should focus on checking the soil erosion at the source, addressing the landslide hazards in the direct impact zone of a project, checking the sediment load from the tributaries directly discharging into the reservoir, and protecting the directly draining catchment from scouring/sloughing and slips.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded-off value should be the same as that of the specified value in this standard.

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## 1 SCOPE

This standard provides guidance on the methodology and criteria for preparation of catchment area treatment plan for hydropower, irrigation, drainage, flood control and multipurpose water resources projects.

## 2 GENERAL

**2.1** The catchment area treatment (CAT) plan pertains to the preparation of a management plan for the treatment of erosion-prone areas of the catchment through biological and engineering measures. However, a comprehensive CAT plan should also include the social dimensions associated directly or indirectly with the catchment. A well-designed CAT plan should not only control the sedimentation of the reservoir but should also provide a life support system to the local population through their active involvement. An effective CAT plan for a water resources project is a key factor in making the project eco-friendly and sustainable.

**2.2** CAT plan is an essential document as it portrays the ecological health of the catchment area and various soil & moisture conservation and watershed management programmes are required to arrest soil erosion, to improve free drainage in the area and to rejuvenate the degraded ecosystem in the catchment. The catchment area plan should evaluate the appropriateness of present land use and aim at planning proper future land utilization. The infrastructure component like construction of buildings, vehicles, salaries of staff, etc. should constitute a very small percentage of the CAT plan, as the main emphasis is on soil & water conservation and ecological improvement of the area. Wherever development/procurement of infrastructure is required, it should be site-specific and should be supported by proper justification.

**2.3** Integrated watershed management aimed at minimizing the sedimentation of reservoir and ecosystem conservation of the catchment area is the prime objective of the catchment area treatment, which can be further elaborated as listed below:

a) Soil conservation through biological and engineering solutions to reduce sediment load in the reservoir;

b) Ecosystem conservation through improvement in water retaining properties of soil and increase in vegetative cover;

c) To fulfill the fuel and fodder requirements of the local people;

d) Integration of the CAT plan with socio-economic activities of the local population through employment generation and community participation.

## 3 IMPORTANT ASPECTS OF CATCHMENT AREA TREATMENT PLAN

### 3.1 Understanding the Catchment Area

It includes identifying the different land uses, soil types, and slopes in the catchment, as well as the main sources of erosion.

### 3.2 Prioritizing Areas for Treatment

It is usually done by identifying the areas that are most at risk of erosion or that have the greatest impact on water resources.

### 3.3 Selecting Appropriate Treatment Measures

There are a variety of CAT measures available, including biological measures (such as afforestation and grassland restoration) and engineering measures (such as check dams and contour terraces). The best treatment measures will vary depending on the specific characteristics of the catchment area.

### 3.4 Monitoring and Evaluation

It is important to monitor the effectiveness of the CAT plan and to make adjustments as needed.

## 4 DELINEATION OF THE CATCHMENT AREA

**4.1** Silt yield index (SYI) model, as conceptualized by Soil and Land Use Survey of India (SLUSI) is used to identify the severely degraded units either in the free draining (catchment area falling between the dam/barrage of a project and the next upstream proposed or existing dam/barrage), or, in the directly draining catchment (catchment area draining directly into the reservoir) that are producing high silt yield/ load from the surface runoff. The prioritization of sub-watersheds (smaller hydrologic units) within the vast catchment is also based on the silt yield indices of the sub-watersheds which depend on several climatic, physiographic (including geology), slope, soil, land use/land cover characteristics. The hierarchical delineation system developed by the Soil and Land Use Survey of India (SLUSI) may be followed for the demarcation of sub-watersheds falling in the free draining or directly draining catchment area of a project.

**4.2** Satellite remote sensing-based methods may be adopted in combination with geographical information system (GIS) for spatial delineation and managing the various thematic layers. For characterization, the assessment of vegetation status, as well as spatial distribution, information on land use patterns, physiography, geomorphology, lithology, soil, drainage, slope (DEM) etc., are amenable through remote sensing. With multispectral capability, synoptic viewing and repetitive coverage, remote sensing techniques help in effective delineation of catchment area and they prove to be cost and time effective especially, in large catchments. However, limited ground checks should be resorted to validate the information.

## 5 IDENTIFICATION OF DEGRADED AREAS IN THE CATCHMENT

The determinants that ultimately define the erositivity of a particular land mass include several factors. The functional behaviour of each factor is summarized in **5.1** to **5.4**.

### 5.1 Physiography & Slope

The physiographic setting and relief of the land is of vital importance in determining the levels of erosion. Most important among the factors of relief is the slope category of a landform. As the slope becomes steeper, the runoff coefficient increases, the kinetic energy and carrying capacity of the surface flow becomes greater, soil stability as well as the slope stability decreases and splash erosion increases.

### 5.2 Land Use/Land Cover

Land use/land cover greatly modifies the effect of rainfall and thus affects soil erosion. The plant canopy intercepts raindrops and the water dripping off the leaves is less erosive than unhindered raindrops. Moreover, the detachment of sediments does not occur on the portion of the covered soil surface because the drops are intercepted and there is no fall distance for drops to regain energy. The surface cover also slows down the run-off thus increasing flow depth, which further decreases detachment by cushioning the impact of raindrops and reducing their hydrodynamic impact forces. Different land use/land cover categories also influence surface runoff. A land with dense forest cover, with substantial undergrowth, will have lesser or negligible soil erosion in comparison to land with open forests or degraded forests. Other landforms viz. agricultural land, scrubland, barren land, rocky area, settlement zones etc. will have their own surface runoff potential.

### 5.3 Soil Parameters

The soil properties influencing erodibility include soil type, organic matter content, its association with different morphological features and effective soil depth. Infiltration rate and soil permeability, which is a function of soil texture, coarse fragments, effective soil depth, etc., determine the quantity of surface flow. Soil structure or aggregate stability is another important factor offering resistance to soil detachment. Soil types of the catchment area could also be delineated based on the classification of mapping units of authorized agencies like the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) and Soil and Land Use Survey of India (SLUSI) which classify (taxonomic classification) soil mapping units based on the soil type, permeability, association with different physiographic forms including slope, etc., as well as the erosion potential.

### 5.4 Climatic Factors

The relationship of soil erositivity with various attributes (parameters) is very complex. Moreover, there are interrelationships among different parameters. Based on remote sensing studies and integration of the geographical information system (GIS) technique, various thematic maps on land use/land cover, soil, slope, drainage, aspect, etc. are generated. All these thematic maps are overlaid on the GIS platform and after assemblage of varying combinations and permutations of the attributes, the erosion intensity mapping units (EIMUs) are generated in the respective sub-watersheds of a catchment. Various erosion intensity mapping units are categorized as 'very severe', 'severe', 'moderate', 'slight' & 'very slight'.

## 6 Prioritization of Sub-Watersheds Falling in a Catchment

Prioritization of the sub-watersheds falling in the free/directly draining catchment is done in the following manner:

a) Preparation of a framework of sub-watersheds through systematic delineation and codification;

b) Rapid reconnaissance survey leading to the generation of a map indicating erosion-intensity mapping units (EIMUs);

c) Assignment of weightage values to various mapping units based on relative silt yield;

d) Assignment of maximum delivery ratios to various erosion intensity mapping units and assessment of adjusted delivery ratios for different sub-watersheds;

e) Computing silt yield index for individual sub-watersheds;

f) Grading of sub-watersheds into very high, high, medium, low and very low priority categories.

NOTE — Satellite-derived layers such as the generation of erosion intensity units, soil maps along with the delivery ratio and corresponding weightage of the units, and spatial analysis of SYI can also be accomplished using GIS as well as other modeling techniques.

### 6.1 Assignment of Erosion Weightage Values

The composite erosion intensity mapping units are assigned relative erositivity values based on the combined effect of erositivity determinants like physiography & slope, soil characters, land use/land cover pattern etc., as has been explained in the preceding paragraphs. A factor $k$ is rated as an equilibrium state between erosion and sedimentation. Any addition to this factor is indicative of erosion, roughly in proportion to the added factors, whereas, the subtraction is suggestive of the deposition possibilities. The erositivity values may be assigned in the range of $8(k-2)$ to $30(k+20)$.

### 6.2 Assignment of Delivery Ratios (DR)

**6.2.1** Delivery ratio (DR) refers to the percent of soil material detached from the source area reaching the sink area or a reservoir through surface flow or traveling through drainage courses. The values of delivery ratios employed as a measure of transportability of the detached soil material to the site of catchment reservoir are adjudged for individual mapping units based on the factors influencing the suspension and mobility of the suspended material. The maximum DR values, assigned to mapping units, range from 0.40 to 0.95.

**6.2.2** The maximum DRs are further adjusted for individual sub-watersheds to account for the deposition of the detached material en route the reservoir. The distance of the sub-watershed from the active stream or from the reservoir site is the major factor for affecting the requisite adjustment. In general, no adjustment is initially carried out for the sub-watersheds located within the periphery of 40 km from the reservoir site and the further reductions are made by values of 0.05 and its multiples for every additional 10 km distance.

### 6.3 Computation of Silt Yield Index (SYI)

The silt yield index of a particular sub-watershed is calculated based on the following equation:

$$\mathrm{SYI} = \left(\frac{\mathrm{A_i} \times \mathrm{W_i} \times \mathrm{D_i}}{\mathrm{A_w}}\right) \times 100; \qquad \mathrm{i} = 1 \text{ to } n$$

where,

| | | |
|---|---|---|
| *SYI* | = | Silt yield index; |
| $A_i$ | = | Area of $i^{th}$ mapping unit; |
| $W_i$ | = | Weightage value of $i^{th}$ mapping unit; |
| $D_i$ | = | Adjusted delivery ratio assigned to $i^{th}$ mapping unit; |
| *N* | = | No. of mapping units; and |
| $A_w$ | = | Total area of sub-watershed. |

NOTE — The area of each of the mapping units as well as the sub-watersheds is computed on a GIS platform.

### 6.4 Categorization of Sub-Watersheds into Various Priority Categories

The values of silt yield index as given in Table 1 may be used to categorize the sub-watersheds into various priority categories:

**Table 1 Values of SYI Used for Categorization of Sub-Watersheds into Various Priority Categories**
(*Clause* 5.4 *and* 6)

| Sl. No. | Priority Category | SYI values |
|---|---|---|
| 1 | Very high | > 1300 |
| 2 | High | 1200 - 1299 |

| | | |
|---|---|---|
| 3 | Medium | 1100 - 1199 |
| 4 | Low | 1000 - 1099 |
| 5 | Very low | < 1000 |

## 7 AREAS TO BE TREATED UNDER CAT PLAN

For the CAT, areas falling under very severe and severe erosion intensity categories are prioritized. Works needed to mitigate the immediate and direct adverse impacts of the project during the construction phase and to improve the carrying capacity of degraded/highly degraded lands along the reservoir should be addressed concurrently with the construction program. These efforts should be included in cost estimates of the project. The sub-watersheds should be addressed first, followed by subsequent areas according to the priority category given in Table 1.

## 8 TREATMENT MEASURES

**8.1** To effectively address erosion and degradation in catchment areas, a variety of engineering and bioengineering solutions are recommended. The treatment measures include afforestation, grassland restoration, check dams, contour terraces, agroforestry, improved agricultural practices, etc.

a) Planting trees and shrubs can help to stabilize soil and reduce erosion;

b) Restoring native grasslands can help to improve soil health and reduce runoff;

c) Check dams can slow down water flow and reduce erosion;

d) Contour terraces can help to trap sediment and rainwater;

e) Agroforestry practices, such as planting trees and shrubs on farmland, can help to improve soil fertility and reduce erosion;

f) Improved agricultural practices, such as conservation tillage and cover cropping, reduce soil erosion and enhance soil health, thereby contributing to the effective management and conservation of water resources within catchment areas.

**8.2** In regions with very severe and severe erosion intensity, options like brushwood check dams, contour bunding, gabion structures, loose boulder check dams, and silt retention dams can be implemented. For instance,

a) in the upper catchment, brushwood check dams can be installed to manage erosion in first-order basins;

b) in the lower reaches of first-order streams, where discharge is higher, loose boulder check dams at appropriate intervals are suitable;

c) in areas with even higher discharge, gabion structures are preferred;

d) contour bunding can be utilized to counter land degradation caused by surface runoff;

e) further downstream, particularly in third-order drainage areas, silt retention dams are effective.

**8.3** While formulating the CAT, the following forest-focused measures should be considered:

a) In the dense forest area, a focus on soil and water conservation, including the implementation of water harvesting structures like check-dams, gully plugging, gabion dams, contour trenches and vegetative structures is necessary;

b) Open forest areas require a combination of soil and water conservation measures alongside the plantation of indigenous and water-conserving plant species. In higher altitudes, *Deodar* can be planted, while *Chir* plantation should be avoided;

c) Due to significant cattle pressure on revenue lands/civil soyam forests, which are integral to the catchment, the CAT plan should incorporate fodder development on these lands/forests. This is essential to fulfill the need for fodder, small timber, and firewood, thereby mitigating pressure on reserve forests;

d) Plantation of rare/medicinal species may be taken up in a defined area.

**8.4** When proposing treatment measures, a thorough assessment is essential, especially for engineering measures (such as check-dams, gabion structures, gully plugs, contour trenches, etc.) and bioengineering interventions (such as plantation, turfing, etc.). This includes justifying the number of measures per unit area and estimating the anticipated treated area. A proper layout/section of each engineering and bioengineering measure is also required to be given in the plan.

## 9 MONITORING

**9.1** It is very essential that proper and regular monitoring is carried out for the effective implementation of the CAT plan. The multidisciplinary Environmental Monitoring Committee constituted for the monitoring of other environmental management plans, should also monitor the progress of CAT works. The Committee should have representatives from project authority, forest, wildlife, horticulture, soil and water conservation departments of the concerned state government, the local area representatives, etc. as required.

**9.2** Evaluation of changes in landscape during pre and post-treatment phases should be done by satellite and remote sensing-based methods in combination with GIS-based methods.

## 10 PERIOD AND SCHEDULE OF IMPLEMENTATION

The plan needs to be implemented in a phased manner so as to attain the goals set, successfully. The CAT plan should be implemented well before the stage of reservoir filling. While preparing the schedule, it may be kept in mind that the treatment measures (engineering, bio-engineering and biological) are proposed year-wise and sub-watershed-wise, along with the break-up of physical and financial targets being proposed year-wise.

## 11 COST ESTIMATE

Unit cost estimate of each engineering, bioengineering and biological measures should be given under the head. The provision of overhead/administrative/contingency costs may also be kept in the cost estimate.