



Digital Library & Portal for the Rejuvenating Watershed for Agriculture Resilience through Innovative Development (REWARD)

Technical Reference and User Manual

December 2025

Submitted by:

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Abbreviations Used

Abbreviations	Extended Forms
AHP	Analytic Hierarchy Process
AI/ML	Artificial Intelligence / Machine Learning
APIs	Application Programming Interfaces
ASM	Available Soil Moisture
AWS	Automatic Weather Stations
CRS	Coordinate Reference System
CWD	Crop Water Demand
DEM	Digital Elevation Model
DLT	Drainage Line Treatment
DPRs	Detailed Project Reports
DWD	Domestic Water Demand
DSC&WD	Directorate of Soil Conservation and Watershed Development
DSS	Decision Support System
ET	Evapotranspiration
FC	Field Capacity
GEPI	Ground Water Extraction Potential Indices
GEPZ	Groundwater Extraction Potential Zones
GIS	Geographic Information System
GPS	Global Positioning System
GRPI	Ground Water Recharge Potential Indices
GRPZ	Groundwater Recharge Potential Zones
GW	Ground Water
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HI	Horizontal Interval

Abbreviations	Extended Forms
ICT	Information and Communication Technology
IIT	Indian Institute of Technology
IMD	Indian Meteorological Department
IISWC	Indian Institute of Soil and Water Conservation
IWD	Irrigation Water Demand
LDA	Linear Discriminant Analysis
LRI	Land Resource Inventory
LSTM	Long Short-Term Memory networks
LULC	Land Use Land Cover
LUP	Land Use Planning
LWD	Livestock Water Demand
MAE	Mean Absolute Error
MARS	Multivariate Adaptive Regression Splines
MLP	Multi-Layer Perceptron
MSE	Mean Squared Error
MWS	Micro Watershed
NBSS	National Bureau of Soil Survey
NSE	Nash–Sutcliffe Efficiency
OUAT	Orissa University of Agriculture and Technology
PWP	Permanent Wilting Point
RAW	Readily Available Water
REWARD	Rejuvenating Watersheds for Agricultural Resilience through Innovative Development
RF	Random Forest
RS	Remote Sensing

Abbreviations	Extended Forms
RMSE	Root Mean Squared Error
SCS-CN	Soil Conservation Service Curve Number
SVM	Support Vector Machine
SWAT	Soil Water Assessment Tool
SWC	Soil and Water Conservation
ToR	Terms of Reference
VI	Vertical Interval
BCD	Brushwood Check Dam
LBCD	Loose Boulder Check Dam
MCDM	Multi Criteria Decision Making
nRPI	Normalized Recharge Potential Index
nGEPI	Normalized Groundwater Extraction Potential Index
CWR	Crop Water Requirement
ET _c	Crop Evapotranspiration
LPCD	Liters Per Capita Demand
T _{max}	Maximum Temperature
T _{min}	Minimum Temperature
T _{mean}	Mean Temperature

1 Background

The REWARD (Rejuvenating Watersheds for Agricultural Resilience through Innovative Development) program, implemented by the Directorate of Soil Conservation and Watershed Development (DSC&WD), Odisha, and supported by the World Bank, aims to enhance national and state capacities for improved watershed management to boost agricultural resilience. With a science-based, data-driven approach, the project will expand its reach across Odisha, focusing on shorter project cycles, strengthening institutional capacities, and addressing farmers' needs over five years (2021-2026).

The program aims to develop 17 greenfield sites to establish model watersheds in saturation mode. For this purpose, 169 micro watersheds have been identified in five pilot districts in Odisha which are:

- Sambalpur
- Dhenkanal
- Nayagada
- Deogarh
- Koraput

The REWARD program in Odisha, has several project objectives aimed at improving land and water conservation and climate resilience in selected watersheds, and strengthen capacities of national and state institutions to deliver more effective science-based watershed development programs. Below are the key indicators of the Project:

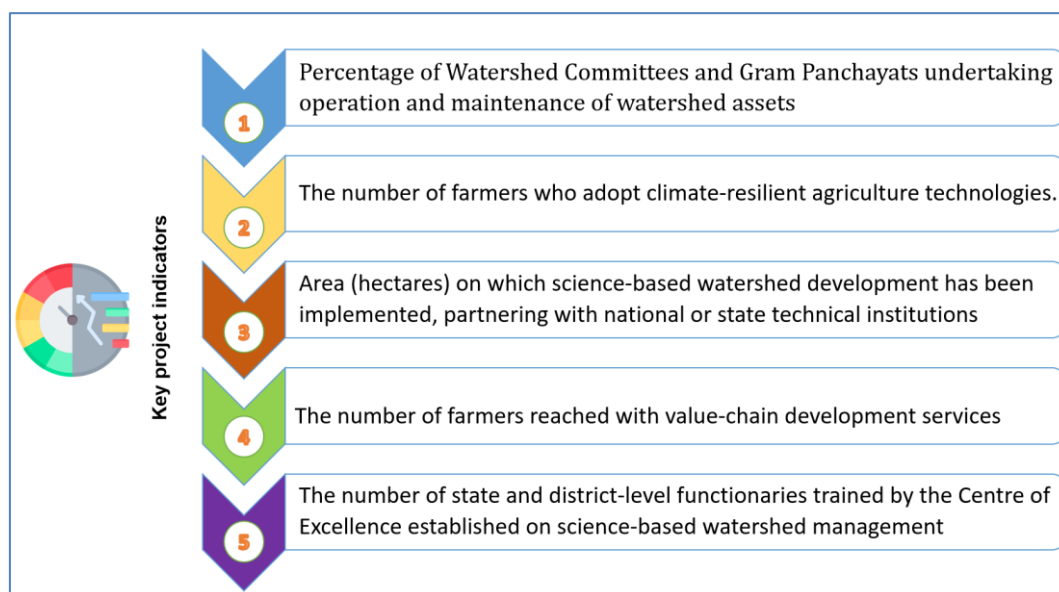


Figure 1-1: Key indicators of the project

1.1 Project Objectives:

The primary objective of this project is to design, develop, and deploy a comprehensive ICT solution to support science-based watershed development and land resource management under the REWARD-Odisha Programme. The specific objectives include:

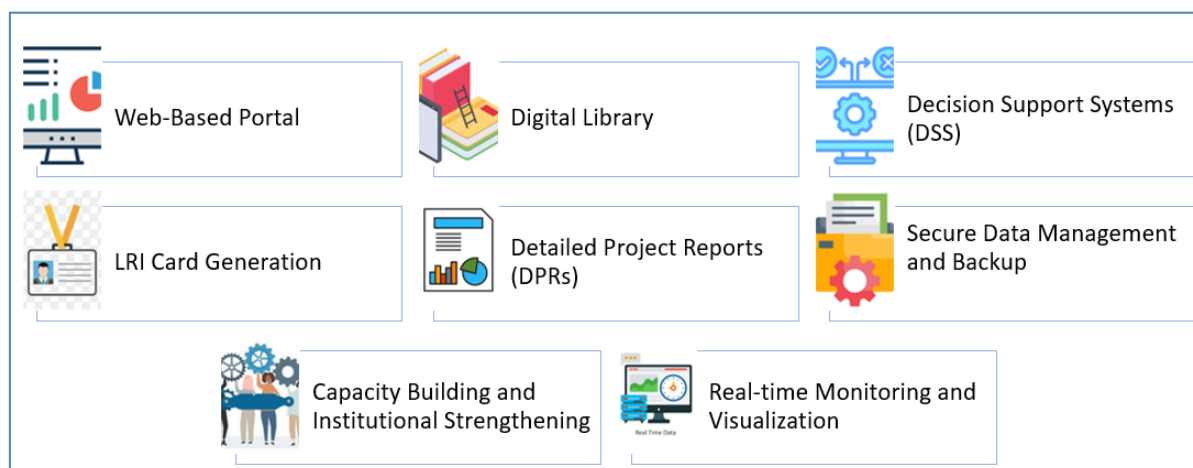


Figure 1-2: Project objectives under REWARD-Odisha programme

1. **Establishment of a Digital Library:** To develop a centralized, GIS-enabled repository that houses all spatial and non-spatial datasets related to land resources, hydrology, weather, agro-advisories, and socio-economic indicators for selected micro-watersheds in selected districts in Odisha as a pilot project.
 2. **Development of a Web-based Portal:** To provide user-friendly, bilingual (English & Odia) interface that enables users—such as technical partners, administrators, farmers, and other stakeholders—to access, visualize, and analyze integrated datasets for informed decision-making.
 3. **Integration of Decision Support Systems (DSS):** To develop and integrate a set of functional DSS tools (8 for hydrology and 2 for LRI) to assist in crop suitability analysis, nutrient management, water budgeting, siting of conservation structures, and agro-advisory generation at various administrative levels (district, taluk, gram-panchayat, watershed, village, plot, etc.).
 4. **LRI Card Generation:** To enable retrieval of site-specific soil and hydrology information for automated generation of LRI cards providing actionable crop and input recommendations for farmers.
 5. **DPR Generation:** To develop a feature for generation of Detailed Project Reports (DPRs) for micro-watersheds, integrating inputs from the DSS and available resource inventories.
 6. **Secure Data Management and Backup:** To implement robust security and backup systems to ensure secure storage, retrieval, and management of sensitive project data.
- Note -: The deployment environment will be provided by DSC&WD.
7. **Capacity Building and Training:** To train DSC&WD staff, partnering with agencies for effective use and management of the Digital Library, Portal, and DSS tools for long-term sustainability.
 8. **Real-time Monitoring and Visualization:** To incorporate real-time and near real-time monitoring capabilities (e.g., soil moisture, rainfall, etc.) using data from automatic weather stations (AWS) and other integrated sources.

Note-: APIs will be provided by DSC&WD or Data Partners.

1.2 Project Scope

The objective of this project is to design, develop, and deploy a robust, scalable, and user-centric **Digital Library, Web Portal, and Decision Support System (DSS)** to enable optimal use of the REWARD-Odisha spatial and non-spatial database. The system will support science-based watershed development through improved planning, monitoring, and decision-making tools, leveraging ICT and geospatial technologies.

This platform will serve as a comprehensive knowledge and service delivery system for DSC&WD, technical partners, line departments, and other stakeholders engaged in land resource and watershed management.

Major Components of the Scope:

- Digital Library
- Web Portal
- Decision Support System (DSS)

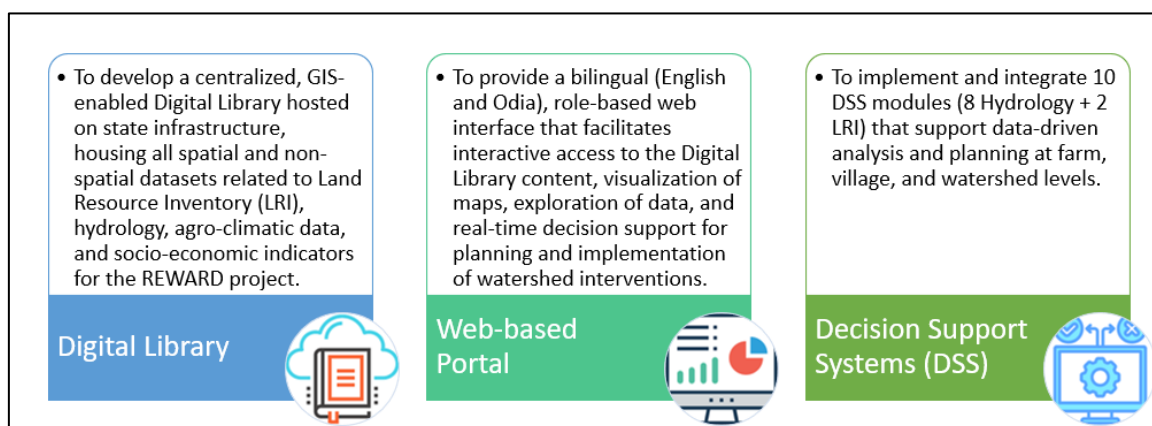


Figure 1-3: Major Components of the Scope

2 Introduction

A Key component of REWARD Project is the development of Decision Support System (DSS) along with LRI Digital Library, LRI Portal and Mobile Application for real time dissemination of LRI information and advisories to the farmers, line departments, research institutions and other stakeholders in the state. A DSS is a computerized expert interactive information system developed and integrated in a Geographic Information System environment (GIS) to support decision-making in a particular field or domain. The development of DSS for watershed development/natural resource management depends on the availability of spatial and non-spatial information, like data on soil, water, land use, hydrology, demography, climate, base maps, remote sensing data, and other resource information and models, algorithms and rules that can help to infer the outcome.

The Digital Library under the REWARD-Odisha Project is envisaged as a centralized, geo-spatially enabled, ICT-based repository of all spatial and non-spatial datasets related to Land Resource Inventory (LRI), Hydrology, and associated watershed management components. It will facilitate evidence-based decision-making, knowledge dissemination, and delivery of real-time agro-advisories to stakeholders at multiple levels including government officials, researchers, FPOs, and farmers.

The Decision Support System is developed primarily to serve the needs of planning, implementation and monitoring of watershed development programs in the state by the Watershed Development Department, Departments of Horticulture, Agriculture, Animal Husbandry, and other line departments, LRI project partners, and other stakeholders. The DSS development is based on the integration of data generated by LRI partners and compiled from other sources with criteria, models and algorithms already available or developed under this project. It is critical for the successful implementation of various watershed programs, other line department schemes and for empowering farmers and other stakeholders in the state. As a part of REWARD Project, 10 Decision Support Systems are developed in the first phase to facilitate the departments to take up key interventions and to provide advisories to the farmers and other stakeholders at the grassroots level as indicated below.

2.1 DSS (Decision Support System)

The Decision Support System (DSS) is an integrated system that combines different components for watershed and land resource management. The system will consist of:

- Data management and visualization tools for watershed characteristics.
- Functionality for water balance, Surface water groundwater behavior, conservation structure design and siting, water demand and water allocation.
- Tools for crop suitability and nutrient management for farming.

The list of 10 DSS systems mentioned in the ToR are listed below in Table 2-1.

Table 2-1: List of DSS Modules

Component	S. No.	DSS	Technical Partners
Hydrology	1	Simulation of Water Balance Fluxes Characterization of Watershed	OUAT, Bhubaneswar
	2	Characterization of Watershed	

Component	S. No.	DSS	Technical Partners
	3	DSS for Siting of Soil And Water Conservation Structures	IISWC, Sunabeda
	4	DSS for Hydrologic and hydraulic design of soil and water conservation structures	
	5	DSS for Groundwater modelling and estimation of groundwater recharge, extraction, storage and mapping of groundwater potential and recharge zones	IIT, Bhubaneswar
	6	DSS for siting of groundwater recharge and extraction structures along with their design	
	7	DSS for Estimation of sector-wise water demands, MWS characterization based on water demand and availability	IIWM, Bhubaneswar
	8	Development of DSS for water allocation, crop planning and agro-advisory services	
LRI	9	DSS for Crop Suitability	NBSS & LUP, Kolkata
	10	DSS for Nutrient management	

The DSS will focus on the integration of multiple modules that allow users to assess water availability, demand, groundwater recharge and extraction zone, surface conservation structure design and location, ground water recharge and extraction structure location, crop suitability, and nutrient management. The system will be built using technologies such as **Geo-Server, PostgreSQL, .NET MVC**.

3 DSS-1: Simulation of Water Balance Fluxes

3.1 Purpose

The purpose is to simulate the water balance fluxes (Runoff, soil moisture, evapotranspiration and deep percolation) at micro-watershed and watershed scales using machine learning models. It integrates advanced AI/ML modeling techniques with spatial and temporal hydro-meteorological datasets to estimate key hydrological fluxes at a daily timescale.

This module aims to provide a scientifically robust and operationally practical foundation for water resources assessment, planning, and decision-making. By generating high-resolution water balance components, the system enables stakeholders to evaluate hydrological responses under varying climatic, land use, and physiographic conditions. The module also supports real-time simulation capabilities, allowing continuous monitoring of water availability, identification of water stress zones, and early insights into hydrological extremes such as droughts or excess runoff conditions.

The outputs from this water balance simulation module serve as critical baseline inputs for subsequent DSS modules related to Watershed Characterization and water demand estimation. Ultimately, the module enhances the decision-support ecosystem by quantifying the spatial distribution and temporal variability of water resources, enabling optimized and sustainable water management at micro-watershed to basin levels.

3.2 Key Functions

- Estimate hydrological fluxes such as runoff, deep percolation, evapotranspiration (ET), and soil moisture using AI/ML models at the MWS scale.
- Develop and validate six AI-based models for water balance prediction at the micro-watershed scale.
- Identify the best-fit model for each micro-watershed based on accuracy, reliability, and model performance metrics.
- Establish a real-time simulation framework for dynamic estimation of water fluxes using continuous datasets.
- Utilize spatial and temporal datasets to model water balance components.
- Provide baseline inputs to the Water characterization and Water demand DSS modules.
- Compute overall water balance and provide input to identify potential water deficits or surpluses at various spatial and temporal scales for effective water management.

3.3 Flow Chart

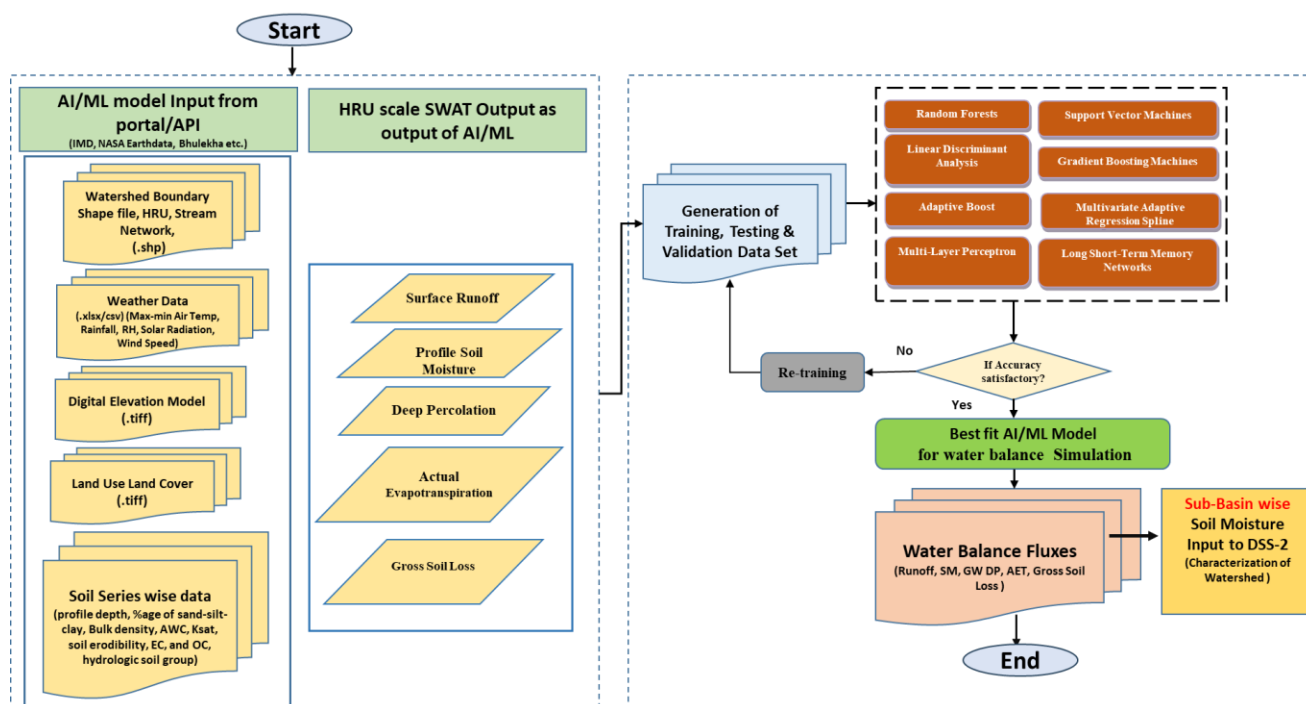


Figure 3-1: Flow Chart for Simulation of Water Balance Fluxes DSS (Source: OUAT)

3.4 Input Parameters required for the module

The simulation of water balance fluxes in this module requires both climatic and geospatial datasets to accurately estimate the various hydrological components. For the development of the AI/ML model for water balance fluxes simulation, a comprehensive set of 30 years of historical data was utilized to ensure accuracy, robustness, and representativeness of watershed behavior under varying hydro-meteorological conditions. The input data required for model training and validation i.e., Runoff (mm), Soil Moisture (mm), Evapotranspiration (mm), and Deep percolation (mm), were used from SWAT model outputs for a continuous 30-year period. The other input datasets for include Rainfall (mm), Maximum Temperature (°C) and Minimum Temperature (°C), Land Use/Land Cover (LULC), Soil, and Digital Elevation Model (DEM, (m)). The list of input parameters utilized for model development and model simulation in real time are provided in Table 3-1 and Table 3-2.

Table 3-1: List of Input Data used for Training the AIML Model

S. No.	Input Parameter	Unit	Source	Duration
1	Rainfall	mm	AWS / IMD	30 years
2	Maximum Temperature	°C	IMD	30 years
3	Minimum Temperature	°C	IMD	30 years
4	LULC		DSC&WD	-
5	Soil		DSC&WD	-
6	DEM	m	DSC&WD	-
7	Runoff	mm	OUAT (SWAT Model Output)	30 years

8	Soil Moisture	mm	OUAT (SWAT Model Output)	30 years
9	Evapotranspiration	mm	OUAT (SWAT Model Output)	30 years
10	Deep percolation	mm	OUAT (SWAT Model Output)	30 years

Table 3-2: List of Input Parameters used in Simulation of Water Balance Fluxes in real time

S. No.	Input Parameter	Unit	Source
1	Rainfall	mm	AWS / IMD
2	Maximum Temperature	°C	IMD
3	Minimum Temperature	°C	IMD
4	LULC		DSC&WD
5	Soil		DSC&WD
6	DEM	m	DSC&WD

3.5 Methodology of AI/ML Model

1. Fetch the hydrometeorological (Rainfall, Minimum temperature, maximum temperature) and geo-spatial data (LULC, DEM, Soil) for the selected subbasin/Plot.
2. Apply the process of data preprocessing on the input dataset.
3. Perform the input raster processing/ feature engineering on the processed dataset to derive the spatial feature.
4. Downscale the rainfall data from 25 km to 1 km resolution using DEM and LULC to refine the coarse dataset and match the required spatial and temporal resolution.
5. Apply data normalization to ensure the consistent numerical ranges for all predictor variables.
6. Divides the dataset into training and testing sets (80% and 20%), ensuring proper model evaluation without data leakage.
7. Deploy all selected models on the dataset and perform hyper parameter tuning to optimize their performance. Deployed models are given below:
 - Random Forest (RF)
 - Support Vector Machine (SVM) / Support Vector Regressor
 - Gradient Boosting Machines (e.g., XGBoost)
 - Adaptive Boost (AdaBoost)
 - Multi-Layer Perceptron (MLP)
 - Long Short-Term Memory networks (LSTM)
8. Evaluate each tuned model on the test set and optionally on a withheld validation set. Use hydrologically relevant metrics:
 - RMSE (Root Mean Squared Error)
 - MAE (Mean Absolute Error)
 - R² (Coefficient of determination)
 - NSE (Nash–Sutcliffe Efficiency)
9. Save the performance summary of each model for all 4 parameters.
10. Choose the best model for the sub-basin for each parameter based on the performance.

The complete step-by-step workflow of the AI/ML model development and implementation is illustrated in Figure 3-2.

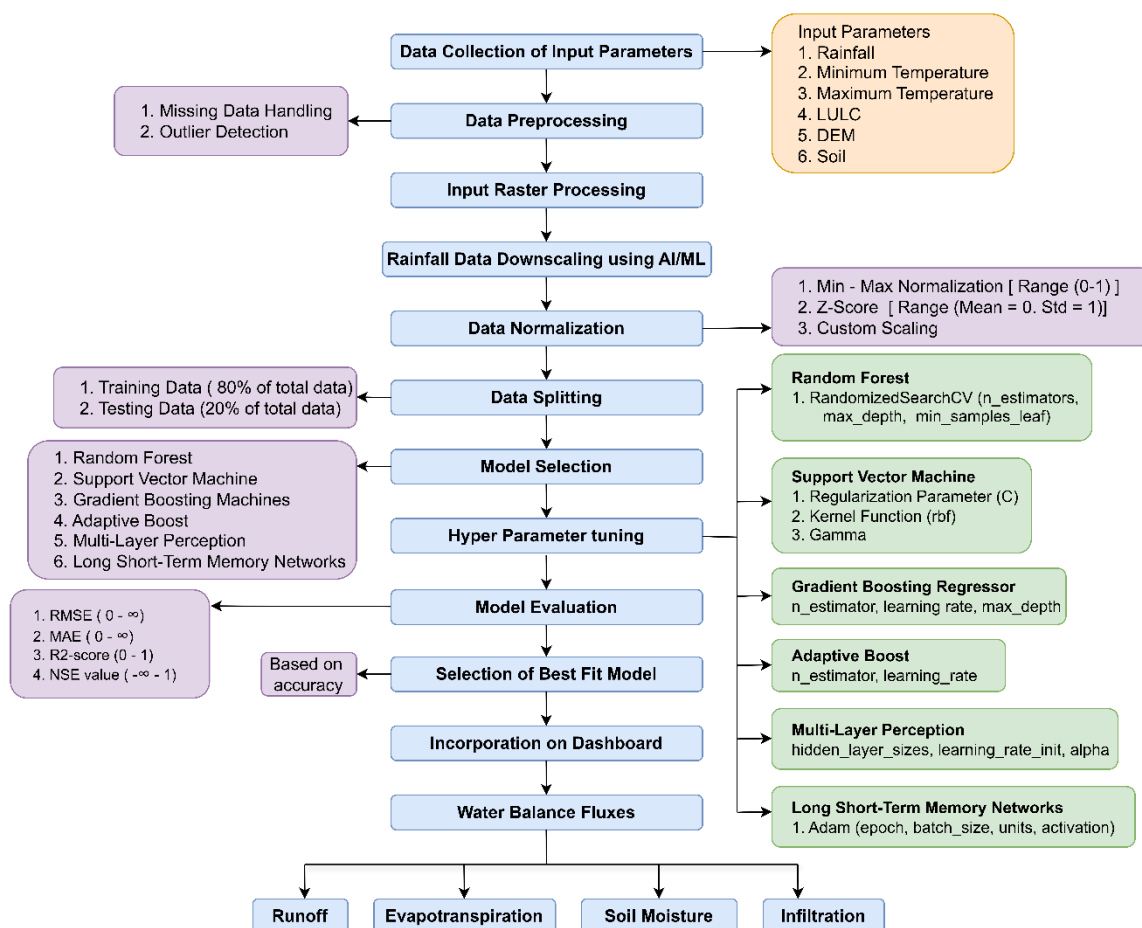
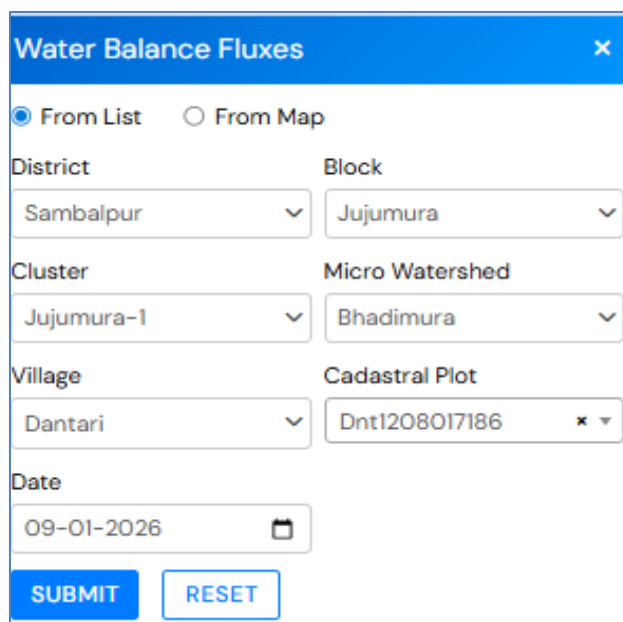


Figure 3-2: Process involved in the AI/ML model development

3.6 Steps for Executing the DSS for Simulating Water Balance Fluxes in the portal

1. After successfully logging into the portal, the user shall select the DSS tab located on the right side of the web page.
2. Once the user clicks on the DSS tab, then two options, "DSS" and "Layers" will be displayed on the left of the web page.
3. The user will select the DSS tab.
4. There will be three options, and the user needs to select the Hydrology option; a list of DSS modules will then drop down under the Hydrology tab.
5. The user shall select the DSS module named **Water Balance Fluxes** from the list. After selecting the module, a dialogue box will appear on the right side of the web page.
6. The dialogue box will have two options to select Plot, "From List" and "From Map". The "From List" option allows the user to select District, Block, Cluster, Micro Watershed, Plot. The details of the input fields in the Web page are as mentioned in the section. The "From Map" option will allow the user to select on the map, which will auto-fill the District, Block, Cluster, Micro Watershed, Plot.

7. The user will select the District, Block, Cluster, Micro Watershed, Plot.
8. The user will enter the date of simulation.



Water Balance Fluxes

☒ From List ☐ From Map

District: Sambalpur Block: Jujumura

Cluster: Jujumura-1 Micro Watershed: Bhadimura

Village: Dantari Cadastral Plot: Dnt1208017186

Date: 09-01-2026

SUBMIT **RESET**

Figure 3-3: Dialogue box for selecting the input fields

9. A query will be executed to find the geo spatial data (Soil, LULC, DEM) from the database for the selected micro watershed.
10. A query will be executed to fetch climate data (rainfall, minimum temperature and maximum temperature) on a real-time basis from the source AWS or IMD for the selected micro-watershed.
11. Once the data is successfully retrieved, the AI/ML model will automatically run for data preprocessing and rainfall data downscaling.
12. When input data is fetched and processed, the best fit model for that micro watershed will be run automatically.
13. Display the results in a table showing information such as Micro Watershed Number, Micro-watershed Name, Runoff (mm), Soil Moisture (mm), Deep Percolation (mm), and Evapotranspiration (mm).
14. Display the result in a bar chart showing the output parameters (Runoff (mm), Soil Moisture (mm), Deep percolation (mm), and Evapotranspiration (mm)).

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dnt1208017186

Result **Chart**

EXPORT TO EXCEL **DOWNLOAD REPORT**

SR No.	Plot	Micro Watershed	MWS Code	Date	Runoff (mm)	Evapotranspiration (mm)	Deep Percolation (mm)	Soil Moisture (mm)
1	Dnt1208017186	Bandijharan	0407010207140203	07/01/2026	0.14	0.15	285.18	11
2	Dnt1208017186	Bandijharan	0407010207140203	08/01/2026	0.24	0.11	284.98	11
3	Dnt1208017186	Bandijharan	0407010207140203	09/01/2026	0.19	0.15	286.66	109

Showing 1 to 3 of 3 entries

Previous **1** Next

The process flow for execution of the DSS for Simulating Water Balance Fluxes in the portal is given in Figure 3-4.

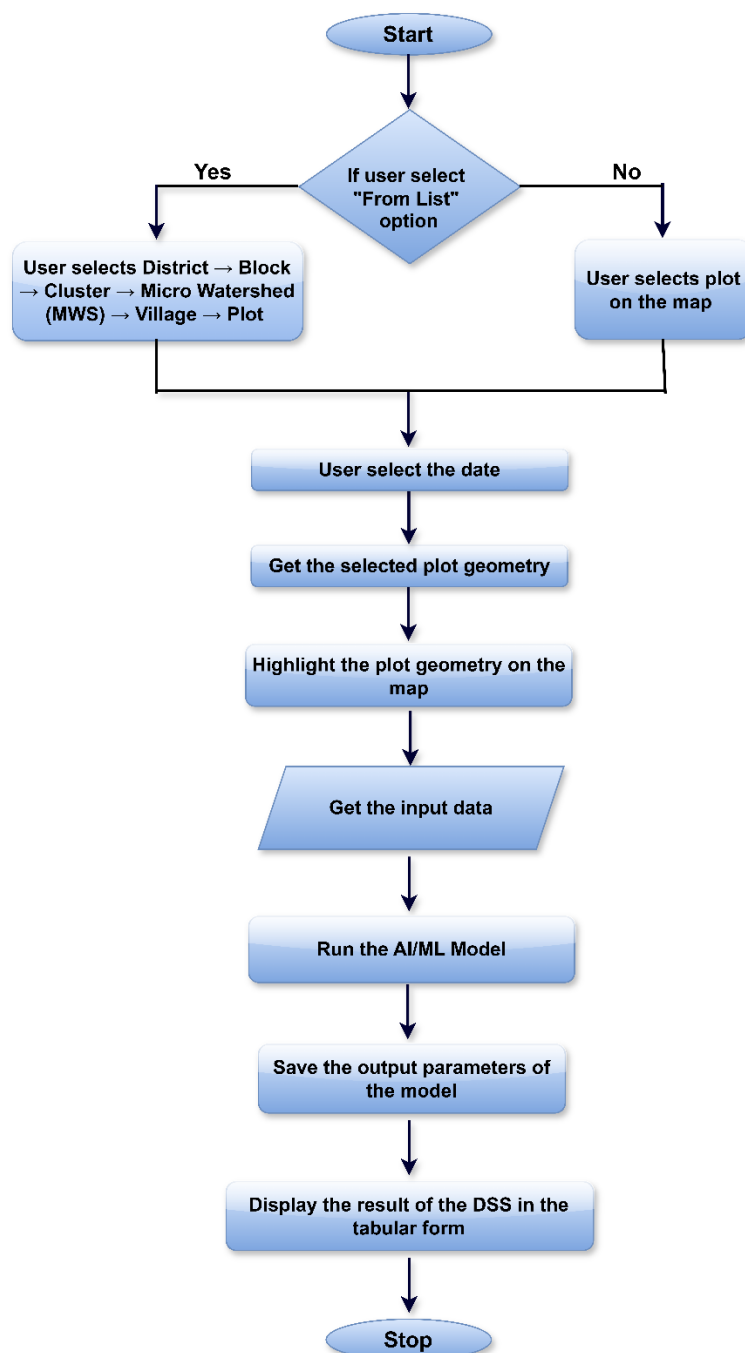


Figure 3-4: Flow diagram for the execution of DSS on simulation of water balance fluxes in the portal

4 DSS-2: Characterization of Watershed

4.1 Purpose

This module classifies watersheds based on soil moisture availability into Deficit, Adequate, and Surplus zones. The classification is derived from daily soil moisture time-series, soil physical properties, and the monsoon withdrawal date. By identifying areas with deficit, adequate, or surplus soil moisture, the module supports water resource planning, crop selection, irrigation scheduling and provides agricultural advisory services.

A watershed is a land area that drains all the water, rainfall, and streams into a common outlet, such as a river or reservoir. This module characterizes watersheds based on soil moisture availability, classifying them into three zones:

- **Deficit:** Soil moisture is insufficient for crop growth;
- **Adequate:** Soil moisture meets crop requirements;
- **Surplus:** Excess soil moisture is available.

This classification is important because it supports efficient water resource management, informed agricultural planning, drought and flood mitigation, and improved crop yield through data-driven decision-making.

4.2 Input Parameters required for the module

Table 4-1: List of Input Parameters Used in Characterization of Watershed

S. No.	Input Parameter	Unit
1	Daily Soil Moisture Data	mm
2	Field Capacity (FC)	mm
3	Permanent Wilting Point (PWP)	mm
4	Fraction for Readily Available Water	
5	Monsoon Withdrawal date	DDMMYYYY

4.3 Flow Chart

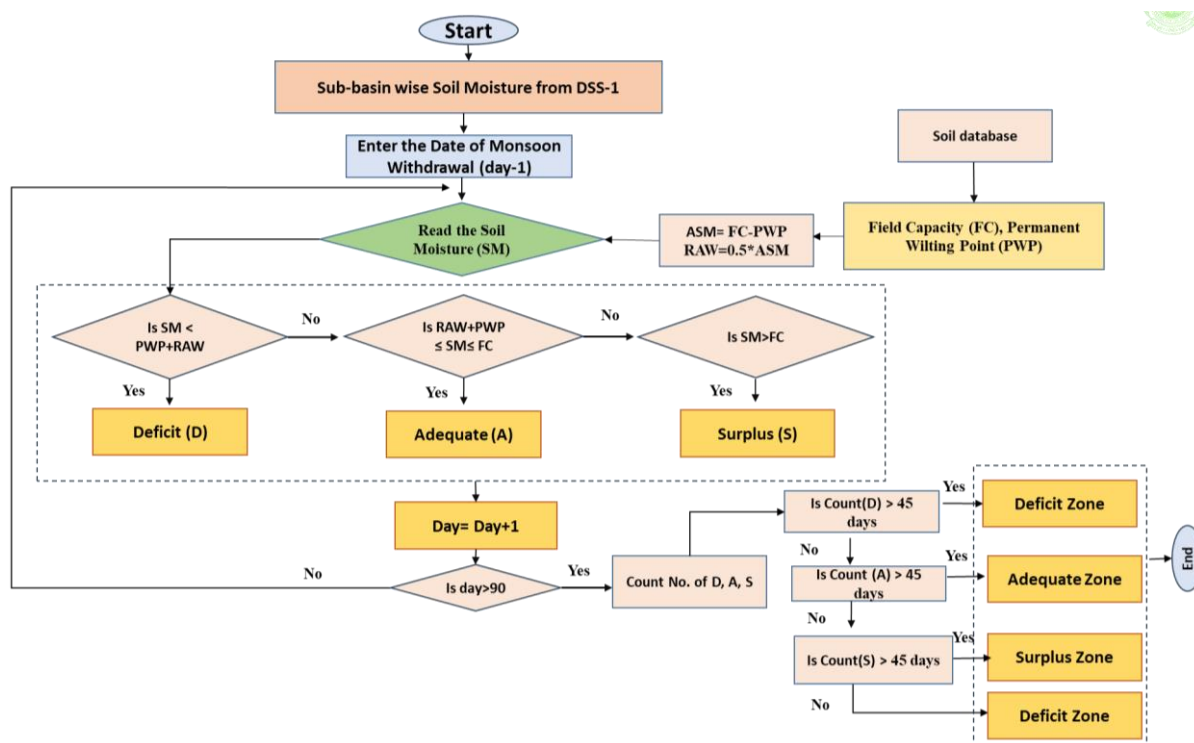


Figure 4-1: Flow Chart for Characterization of Watershed DSS (Source: OUAT)

4.4 Step-by-step process to characterize the watershed

Table 4-2: Steps for watershed characterization

S. NO.	Steps for watershed characterization
1	Select Plot
2	User will enter start and end year (30 years) to compute average daily soil moisture
3	User will enter FC and PWP value, if not entered by user value of FC and PWP will be fetched from database
4	User will enter Date of monsoon withdrawal, if not entered by user it will be fetched from database
5	Calculate daily average soil moisture for user defined years
6	Check soil moisture for the next 90 days after monsoon withdrawal
7	calculate Readily Available Water (RAW) : $RAW = (\text{Field Capacity} - \text{Permanent Wilting Point}) * p$ (p is a factor, often 0.5).
8	Then check the normalized daily SM after withdrawal of the monsoon up to next 90 days with conditions if $SM < (RAW + PWP)$ assign it as D (Deficit), if SM is between $(RAW + PWP)$ to FC assign it as A (Adequate), If $SM > FC$ assign it S (Surplus)
9.	Then count the number of soil moisture days under various category with the condition if Number days with Deficit (D) SM > 45 days, it is the moisture

S. NO.	Steps for watershed characterization
	deficit Zone, if Number days with Adequate (A) SM > 45 days, assign it as Adequate Zone, if Number days with Surplus (S) SM > 45 days, assign it as Surplus Zone, if none of the category is dominant means not more than 45 days, then also assign it as deficit zone.
9	Assign a Zone (Surplus, Adequate, Deficit) to the MWS based on the rule match shown in Table 4-3
10	Visualize and disseminate the results on the web page.

A watershed is classified based on soil moisture availability into three zones shown in Table 4-3: Deficit, Adequate, and Surplus. After the withdrawal of the monsoon, normalized daily soil moisture (SM) was analyzed for the subsequent 90 days and classified into Deficit (D), Adequate (A), or Surplus (S) based on threshold conditions: $SM < (RAW + PWP)$ was considered Deficit, SM between $(RAW + PWP)$ and Field Capacity (FC) was considered Adequate, and $SM > FC$ was considered Surplus. The number of days under each category was then counted, and moisture zones were assigned based on category dominance. If Deficit, Adequate, or Surplus conditions persisted for more than 45 days, the area was classified as a Moisture Deficit Zone, Adequate Zone, or Surplus Zone, respectively. When none of the categories exceeded 45 days, the area was conservatively classified as a Moisture Deficit Zone.:

Table 4-3: Criteria table for Zone Classification (Source: OUAT)

Soil Moisture Condition (ASM)	Zone Classification	Count of days	Final Zone
$ASM \leq (RAW + PWP)$	Deficit	Deficit (D) SM > 45 days	Deficit
$(RAW + PWP) < ASM < \text{Field Capacity (FC)}$	Adequate	Adequate (A) SM > 45 days	Adequate
$ASM > \text{Field Capacity (FC)}$	Surplus	Surplus (S) SM > 45 days	Surplus

4.5 Steps for Executing the DSS for Characterization of Watershed in the portal

1. After successfully logging into the portal, the user shall select the DSS tab located on the right side of the web page.
2. Once the user clicks on the DSS tab, then two options, "DSS" and "Layers" will be displayed on the left of the web page.
3. The user will select the DSS tab.
4. There will be three options, and the user needs to select the Hydrology option; a list of DSS modules will then drop down under the Hydrology tab.
5. The user shall select the DSS module named **Characterization of Watershed** from the list shown in Figure 4-2. After selecting the module, a dialogue box will appear on the right side of the web page.
6. The dialogue box will have two options to select Plot, "From List" and "From Map" shown in Figure 4-2. The "From List" option allows the user to select District, Block, Cluster, Micro Watershed, Plot. The details of the input fields in the Web page are as mentioned in the

section. The “From Map” option will allow the user to select on the map, which will auto-fill the District, Block, Cluster, Micro Watershed, Plot.

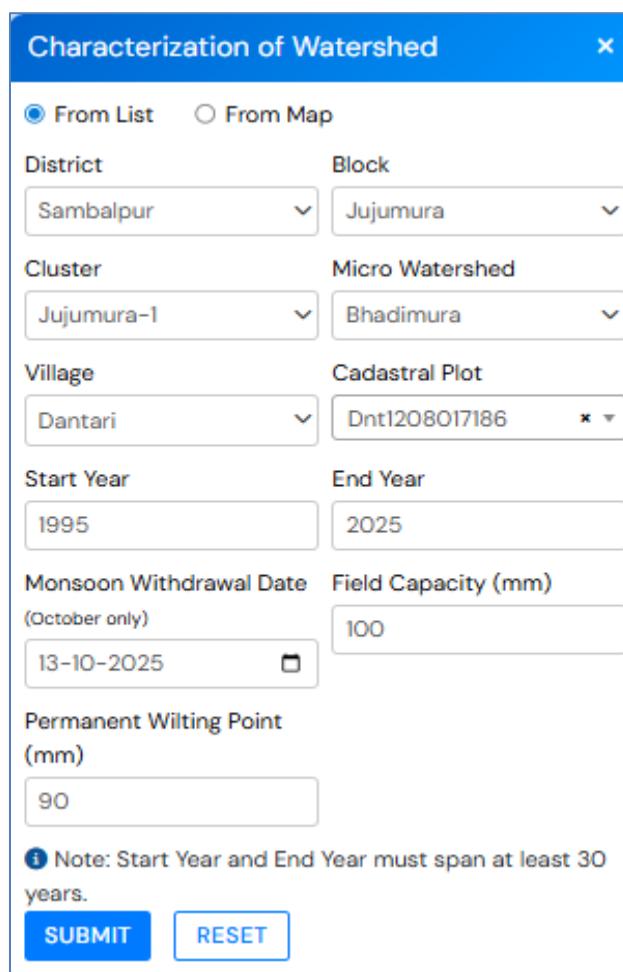


Figure 4-2: Dialogue box for selecting the input fields

7. The user will select the District, Block, Cluster, Micro Watershed, Plot.
8. A query will be executed to fetch input parameters (FC, PWP) from the master table or user defined for the selected Plot.
9. A query will be executed to retrieve the average daily soil moisture for the 90 days after monsoon withdrawal date.
10. A query will be executed to retrieve the monsoon withdrawal date from table or user defined value.
11. Calculate the readily available moisture (RAW) by using the formula mentioned below.

$$RAW = 0.5 * (FC - PWP)$$

12. Calculate the average daily soil moisture using 30 years historical data
13. Assign a zone to the selected micro-watersheds (MWS) by applying the conditions given in Table 4-3.
14. Display the results on the web page in the form of a map and a table (MWS Name, MWS Code, Classification Zone) as shown in Figure 4-3.
15. Users can export the generated report through the “Download Report” option.

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dnt1208017186				
DOWNLOAD REPORT ■ Deficit ■ Adequate ■ Surplus 				
S. No.	Micro Watershed Name	Micro Watershed Code	Plot	Classification-Zone
1	Bhadimura	0407010207140201	Dnt1208017186	Deficit

Figure 4-3: Output view of the Characterization of Watershed DSS

The process flow for execution of the DSS for Characterization of Watershed in the portal is given in Figure 4-4.

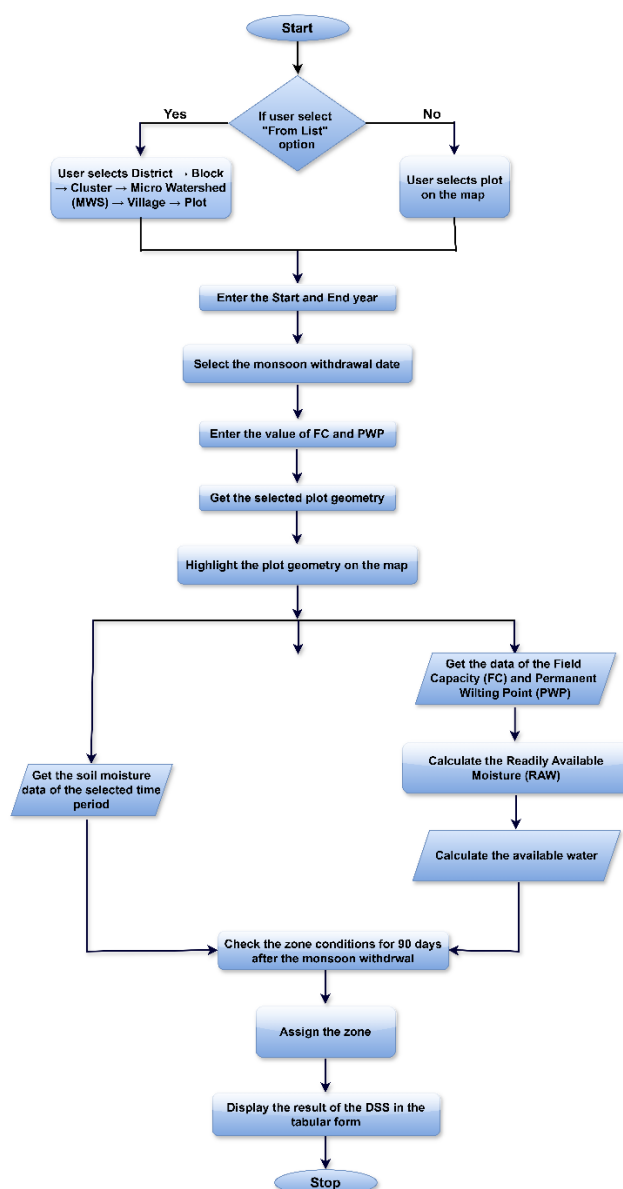


Figure 4-4: Flow diagram for the execution of DSS on characterization of watersheds in the portal

5 DSS-3: Siting of Soil and Water Conservation Structure

5.1 Purpose

The purpose of this DSS module is to identify the most suitable locations for soil and water conservation interventions within a plot/watershed using various parameters like land use, slope, and rainfall for SWC and Stream order and catchment area for DLT. By matching site characteristics with validated technical criteria, the DSS ensures that structures are placed where they provide maximum benefits in reducing erosion, improving soil moisture, moderating runoff, and enhancing agricultural sustainability.

5.2 Key functions:

- Identifies the suitable SWC interventions at the plot level based on the land use, slope, and annual rainfall.
- Identifies the suitable DLT interventions at the micro watershed level based on the catchment area and stream order.

5.3 Criteria for Selecting Suitable Soil Conservation Structure

For selecting soil and water conservation (SWC) structures requires annual rainfall, slope, and land use/land cover (LULC).

Table 5-1: Criteria for selecting arable and non-arable SWC structures (IISWC, Sunabeda)

Land use	Slope (%)	Rainfall (mm)	Suitable Structure
Arable	<2		Field Bunding
	2-6		Contour Bunding
	6-10		Graded Bunding
	10-50	>1000	Inward Sloping Terrace
	10-50	<1000	Outward Sloping Terrace
Non-Arable	<10		Trench Cum Bund
	>10	>800	Staggered Trench
	>10	<800	Continuous Trench

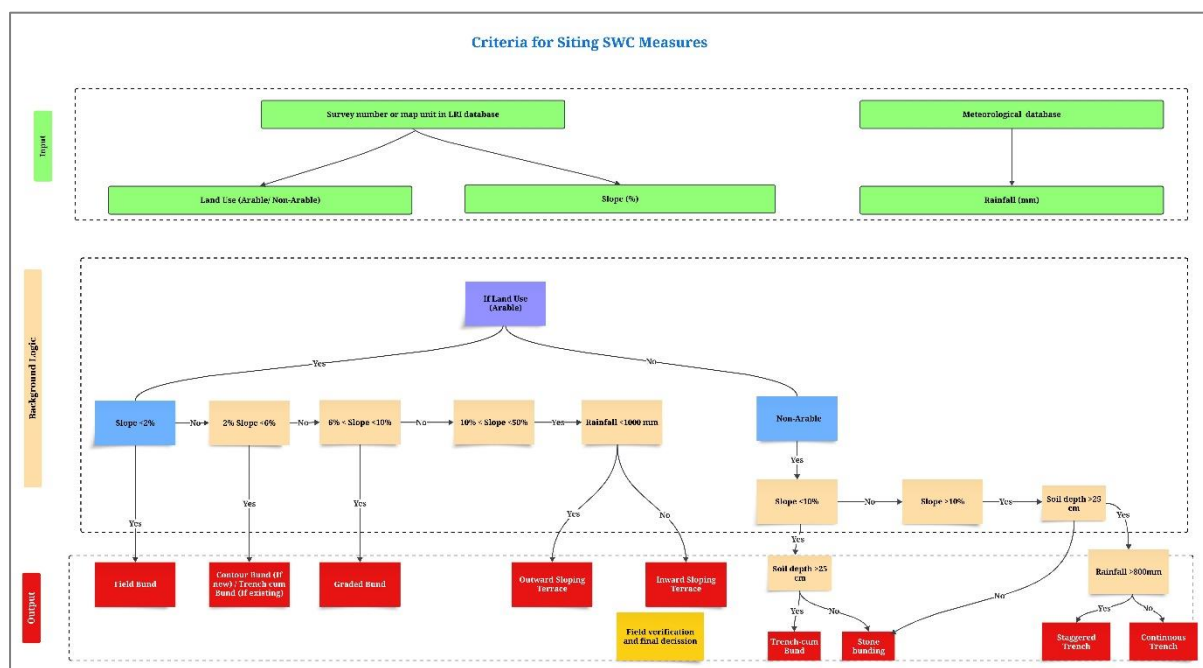


Figure 5-1: Criteria for selecting the suitable SWC structures for the arable and non-arable land use (IISWC, Sunabeda)

The siting of Soil and Water Conservation (SWC) structures in this DSS is based on a set of clearly defined, scientifically validated criteria that reflect the interaction between land use, slope, and rainfall. These parameters collectively determine the hydrological behaviour of a plot and thus govern the suitability of different conservation interventions. The following criteria have been integrated into the DSS to generate reliable, plot-level structure recommendations (see Table 5-1 and Figure 5-1).

- **Land Use:** It serves as the primary classification parameter, as the type of conservation treatment differs significantly between cultivated (arable) and uncultivated (non-arable) areas.
 - **Arable land:** requires bunding and terracing interventions that support crop cultivation and improve in-situ moisture conservation.
 - **Non-arable land:** requires trench-based measures that focus on reducing runoff and enhancing groundwater recharge.
- **Slope (%):** Slope is the most critical geomorphological parameter influencing runoff velocity, soil erosion risk, and structural stability. Different slope ranges correspond to different SWC structures, as shown below:
 - **Arable Lands:**
 1. < 2%: Suitable for Field Bunding
 2. 2% – 6%: Suitable for Contour Bunding
 3. 6% – 10%: Suitable for Graded Bunding
 4. 10% – 50%: Terracing is preferred, with type determined by rainfall
 - **Non-Arable Lands:**
 1. < 10%: Suitable for Trench-cum-Bund
 2. ≥ 10%: Type of trench system depends on annual rainfall

- **Annual Rainfall (mm):** Annual rainfall is used to refine the structure recommendation and it influences both terrace design and trench spacing.
 - Arable Lands (Terraces):
 1. Annual rainfall < 1000 mm: Outward Sloping Terraces
 2. Annual rainfall ≥ 1000 mm: Inward Sloping Terraces
 - Non-Arable Lands (Trenches):
 1. Rainfall ≥ 800 mm: Staggered Trenches
 2. Rainfall > 800 mm: Continuous Trenches

5.4 Criteria for selecting drainage line treatment structures

For selecting drainage line treatment structure (DLT), the stream order and catchment area are required. The criteria for selection of DLT structure is shown in Table 5-2.

Table 5-2: Criteria table for Drainage Line Treatment (IISWC, Sunabeda)

Stream Order	Catchment Area (ha)	Structure Recommendation
2	< 20	Loose Boulder Check Dam
2	>20	Gabion Structure
3		Masonry Check Dam
1	<5	Brushwood Check Dam
1	>5	Loose Boulder Check Dam

The criteria for selecting suitable drainage line treatment structures for a given watershed is shown in Figure 5-2.

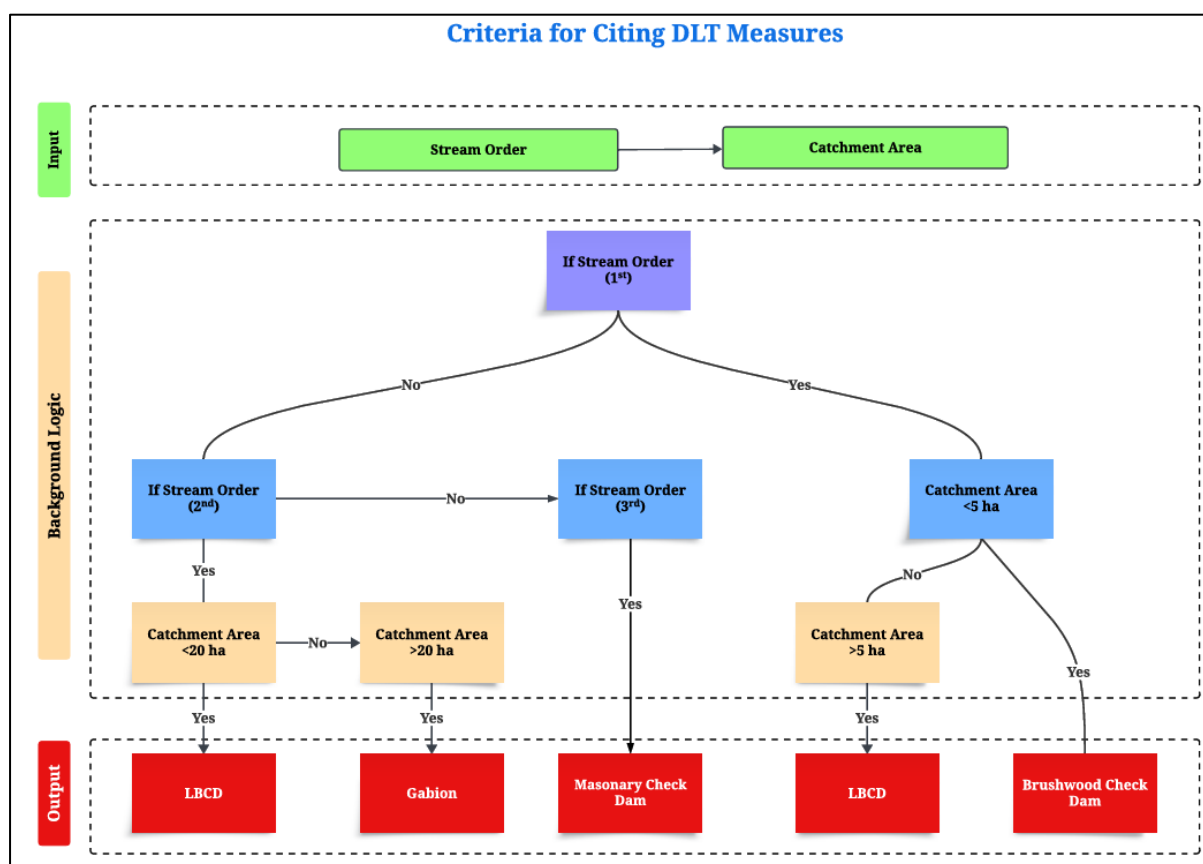


Figure 5-2: Criteria for selecting suitable drainage line treatment structure for a given watershed (IISWC, Sunabeda)

The selection of Drainage Line Treatment (DLT) structures is guided by a clearly defined set of hydrological and geomorphological criteria. These criteria integrate two fundamental parameters — **stream order** and **catchment area** — which together determine runoff concentration, sediment load, and the structural capacity required to effectively stabilize drainage lines. The following logic has been embedded into the DSS to generate accurate, plot-specific recommendations for DLT interventions as given in Table 5-2.

- **Stream Order:**
 - Stream order is the primary determinant because it reflects the relative position and size of the drainage channel within the watershed network. As the stream order increases, runoff volume and flow energy also increase, necessitating stronger structural interventions.
 - **1st-order streams:** Small ephemeral channels; suitable for lightweight to moderate structures depending on catchment area.
 - **2nd-order streams:** Carry larger accumulated flow; require stronger structures such as gabions.
 - **3rd-order streams:** Form the main trunk drainage lines; require high-capacity structures like masonry check dams.
- **Catchment Area (ha):**

Catchment area quantifies the upstream contributing area and directly influences discharge, sediment yield, and structural stability requirements. The DSS uses specific thresholds for selecting appropriate structures

- **< 5 ha:** Suitable for lightweight barriers such as Brushwood Check Dams.
- **5–20 ha:** Suitable for Loose Boulder Check Dams (LBCD).
- **>20 ha:** Requires durable structures like Gabion Check Dams or masonry constructions depending on stream order.

Based on the Stream order and catchment area, suitable structure is recommended

- i. For 1st-Order Streams:
 - If **Catchment Area < 5 ha** → *Brushwood Check Dam*
 - If **Catchment Area ≥ 5 ha** → *LBCD*
- ii. For 2nd-Order Streams:
 - If Catchment Area < 20 ha → *LBCD*
 - If Catchment Area ≥ 20 ha → *Gabion Check Dam*
- iii. For 3rd-Order Streams:
 - If **Catchment Area ≥ 20 ha** → *Masonry Check Dam*
(Higher order implies larger flows; thus masonry structures provide stability.)

Output Table of DSS-3:

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dnt1208017186				
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:
S. No.	Micro Watershed Name	Micro Watershed Code	Plot	Recommended Structure
1	Bhadimura	0407010207140201	Dnt1208017186	Trench cum Bund
Showing 1 to 1 of 1 entries				Previous 1 Next

The process flow for execution of the DSS for Siting of Soil and Water Conservation Structure in the portal is given in Figure 5-3.

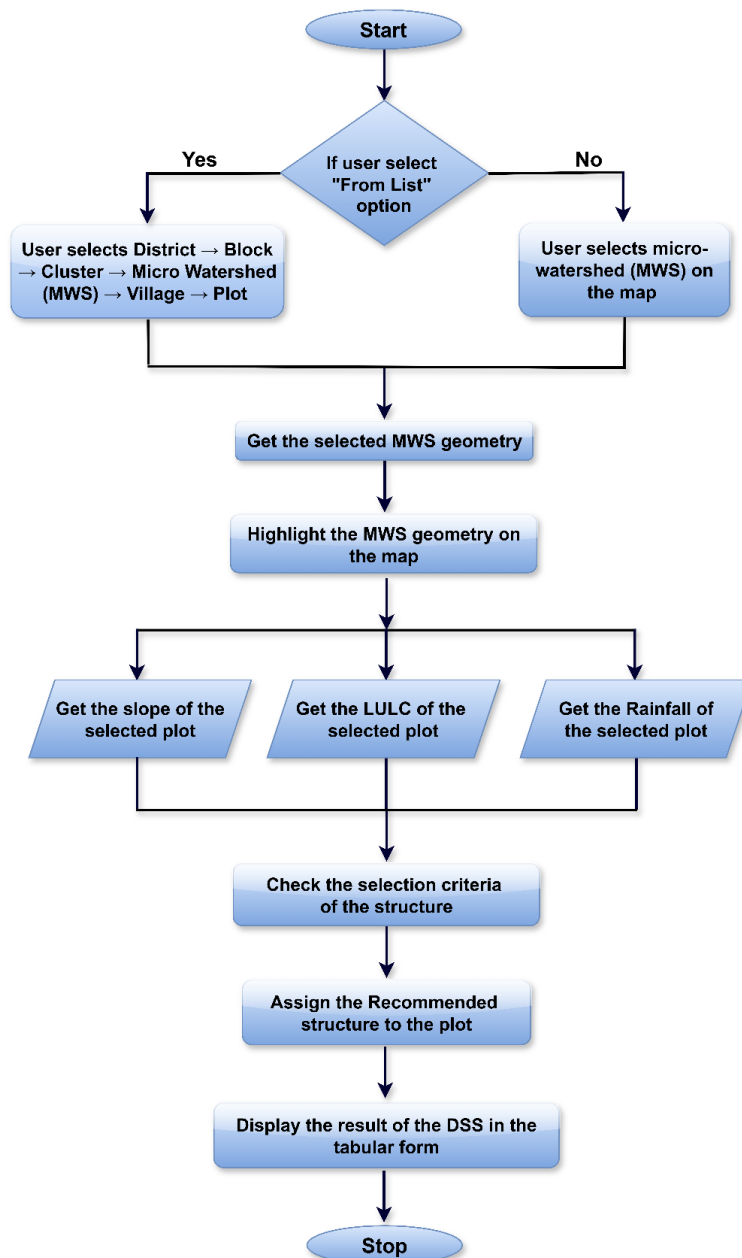


Figure 5-3: Flow diagram for the execution of DSS on the siting of soil and water conservation structure in the portal

6 DSS-4: Hydrologic and Hydraulic Design of Soil and Water Conservation Structures

6.1 Purpose

The purpose of this DSS is to support sustainable soil and water conservation in watersheds by guiding the planning, design, and implementation of appropriate conservation and drainage line treatment structures. It evaluates site-specific characteristics such as soil, land use, slope, rainfall, and drainage features to recommend suitable interventions that reduce erosion, manage runoff, and improve land productivity.

6.2 Key functions

- Analyze site characteristics (land use, slope, rainfall, stream order, and catchment area) for informed decision-making.
- Recommends suitable SWC structures like field bunds, contour bunds, graded bunds, terraces, and trenches at the plot level based on land-use, slope conditions and annual rainfall.
- Recommends suitable DLT structures such as brushwood, gabion, masonry, and loose boulder check dams at the micro watershed level based on stream order and catchment area.
- Generates design parameters for the selected SWC and DLT structures based on established guidelines.

Table 6-1: Recurrence interval for different conservation structures (Source: Sujala Manual)

Type of structure	Frequency of occurrence (years)
Storage and diversion dams having permanent spillways	50 - 100
Earth fill storage dams having natural spillways.	25 - 50
Stock water dam (Nala bund, Check dam, Percolation tank & Vented dam)	25
Small permanent masonry gully control structure and silt retention structure (Ravine reclamation structure)	10
Bunds, Water ways, Farm ponds & Diversion channel.	10

6.3 Design of SWC Structures

6.3.1 STEPS INVOLVED IN EXECUTING THE DSS FOR THE DESIGN OF SWC STRUCTURES IN THE PORTAL

- After successfully logging into the portal, the user should click the DSS tab located at the top right side of the webpage.
- Once the DSS tab is selected, two options—DSS and Layers—will appear on the left side of the webpage.
- The user should click on the DSS option.
- Three categories will be displayed. The user must select Hydrology, which will expand to show a list of DSS modules available under the hydrology category.

- From this list, the user should select Design of Soil and Water Conservation Structures. After selection, a dialogue box will appear with two options. The user should choose Soil Water Conservation.
- A Soil Water Conservation dialogue box will then appear, providing two options for selecting the cadastral plot: From List and from Map.
- From List allows the user to manually select the District, Block, Cluster, Micro Watershed, village and plot.
- Using the from Map option, the user can simply click on the desired location on the map. The system instantly auto-populates all relevant administrative attributes, District, Block, Cluster, Micro Watershed, village and Plot Number, eliminating the need for manual entry.
- For the selected plot, the system automatically extracts a suitable structure for that plot from the output table of siting of the structure

6.3.1.1 If contour bund is the suitable structure

- The step-by-step procedure to find design parameters and cost estimation of the contour bund are given in detail in the following steps.
- The VI and HI are calculated depending on the recommended treatment. These values are derived using standard empirical formulas (Ramser, Cox, and USDA), considering:
- Ramser formula:

$$VI = 0.3 \left(\frac{S}{a} + b \right)$$

$$HI = \frac{100 * VI}{S}$$

- Where, S is slope in (%), a and b are constants based on the soil infiltration rate as shown in Table 6-5.

- USDA formula:

$$VI = 0.3 \left(\frac{S}{a} + b \right)$$

$$HI = \frac{100 * VI}{S}$$

Where, S is slope in (%), a and b are constants based on the soil infiltration rate as shown in Table 6-6.

- Cox formula:

$$VI = 0.3 (XS + Y)$$

$$HI = \frac{100 * VI}{S}$$

Where, S is slope in (%), X and Y are constants based on the average annual rainfall, soil infiltration rate, and crop cover as shown in Table 6-7.

- Finding the height of impoundment (h): Calculated using rainfall excess:

$$\text{Height of Impoundment } (h) = \sqrt{\frac{R_e * VI}{50}}$$

- Where, R_e is the excess rainfall in cm
- R_e is the excess rainfall in cm is calculated using the SCS-CN curve number method.

$$S(mm) = \frac{25400}{CN} - 254$$

$$I_a (mm) = 0.2 * S$$

$$R_e (mm) = \frac{(P - I_a)^2}{P - I_a + S}$$

- S is the Potential maximum retention.
- I_a is the Initial Abstraction.
- P is the maximum 1-day 10-year return period rainfall.
- Finding the total height of the bund by including the free board and settlement height

$$H = h + \text{free board} + \text{settlement height}$$

- Where, free board is the (15 to 20%) of the height of impoundment and settlement height is (15 to 20%) of the height of impoundment.
- Finding cross-sectional area of main bunds (A_m) and area of side bunds (A_s)

$$A_m = \left(\frac{T + B}{2} \right) * H$$

$$A_s = \left(\frac{2}{3} \right) * A_m$$

Where,

$B = T + 2 * n * H$; when the upstream side slope and downstream side slopes are Equal;

$B = T + 2 (n_1 + n_2) * H$; When the upstream side slope and downstream side slopes are not equal; n, n_1 , and n_2 are the side slopes based on the soil type as shown in Table 6-8, Table 6-9, and Table 6-10.

T = Top width of bund ranges from 0.3 to 0.75 m.

- Finding Length of bund per ha (L_b) (m/ha)

$$L_b = \frac{10000}{HI}$$

- Finding total length of the bund for the area to be bunded (L_t) (m)

$$L_t = \frac{L_b * \text{Length along the slope} * \text{Length across the slope}}{10000}$$

- Finding Number of bunds (N)

$$N = \frac{\text{Length along the slope}}{HI}$$

- Finding number of side bunds (N_{sb})

$$N_{sb} = N * 2$$

- Length of side bund (L_{sb})

$$L_{sb} = \text{Length along the slope} * 2$$

- Volume of earthwork for main bund (V_m) (m³)

$$V_m = L_t * A_m$$

- Volume of earthwork for side bund (V_s) (m³)

$$V_s = A_s * L_{sb}$$

- Total volume of earthwork for the main and side bunds (V_t) (m³)

$$V_t = V_m + V_s$$

- Plot Area (A) (Ha)

$$A = \frac{\text{Length along the slope} * \text{Length across the slope}}{10000}$$

- Cost of earthwork (Rs.)

$$\text{Cost of earthwork (Rs.)} = V_t * \text{rate of earthwork per m}^3$$

- Cost for layout (Rs.)

$$\text{Cost for layout (Rs.)} = A * \text{man days required per Ha} * \text{rate of mandays}$$

- Total cost (Rs.)

Total cost (Rs.)

= (cost of earthwork (Rs.) + Cost for layout (Rs.))

** GST (%)*

- The system displays the results in a consolidated table that includes key information such as the Watershed Name, Watershed ID, Plot Number, Plot Area, Length of bund, treatment, and total cost.

Table 6-2: Classification of soil texture based on Hydrologic Soil Group
(Source: Engineering Hydrology, K.Subramanya)

Soil Texture	Hydrologic Soil Group
Sand	A
Loamy Sand	
Sandy Loam	
Silty Loam	B
Loam	
Sandy Clay Loam	C
Clay Loam	D
Silty Clay Loam	
Sandy Clay	
Silty Clay	
Clay	

Table 6-3: Curve Number based on Land Use and Soil Texture (Source: Engineering Hydrology, K.Subramanya)

Land Use	Hydrologic Soil Group			
	A	B	C	D
Arable Lands	76	86	90	93
Dense Forest	26	40	58	61
Open Forest	28	44	60	64
Wasteland	71	80	85	88
Scrub Lands/Shrub Lands	63	77	85	88
Plantation	45	53	67	72
Waterbody	98	98	98	98
River	98	98	98	98
Stream	98	98	98	98

Table 6-4: Range of user input parameters in the Contour Bund

Input Parameter	Range
Free Board (%)	15 -20
Settlement height (%)	10 -20
Top width (T) (m)	0.3 - 0.9
Length along the slope (m)	0 to 200
Length across the slope (m)	0 to 200
Man days required per (ha)	4 – 12 man days / ha

Input Parameter	Range
Rate of man-days	300 – 600 / day
Cost of earthwork	₹ 80 to ₹ 1,200 per m ³

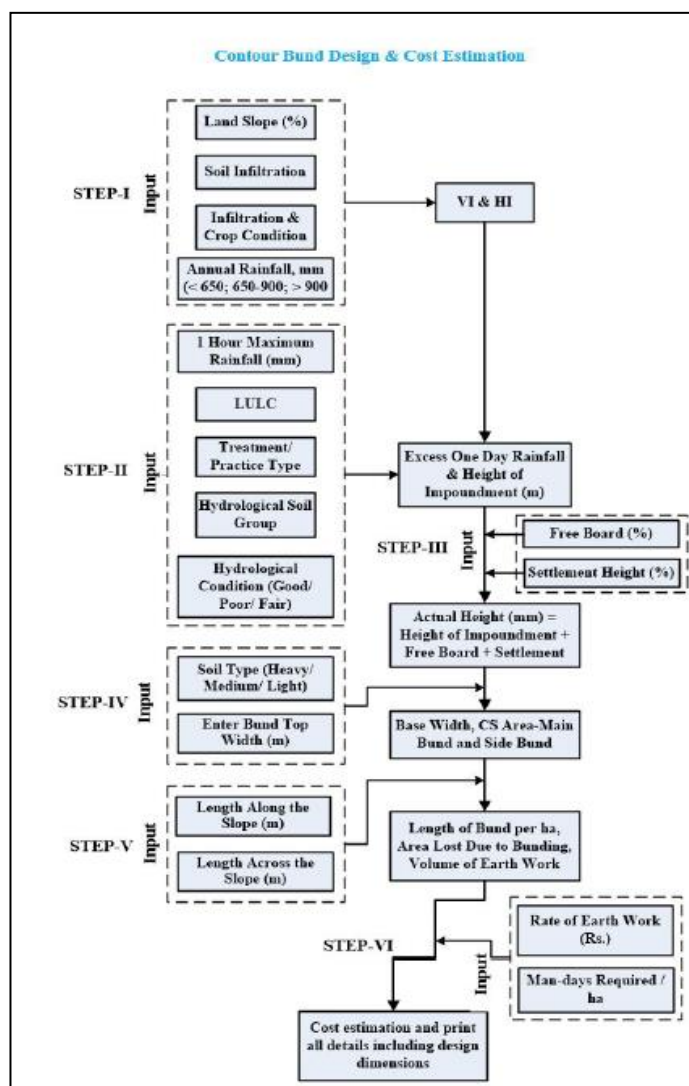


Figure 6-1: Flow diagram for the execution of the DSS for contour bund design and cost estimation (Source: IISWC Sunabeda)

Table 6-5: Ramser's Formula constants (Source: IISWC, Sunabeda)

Soil Infiltration	a	b
Soil with good infiltration	3	2
Soil with low infiltration	4	2

Table 6-6: USDA Formula (Source: IISWC, Sunabeda)

Soil Infiltration	a	b
Good infiltration	4	2
Average infiltration	4	2.5
Poor infiltration	4	3

Table 6-7: Cox's Formula (Source: IISWC, Sunabeda)

Annual Rainfall	X	Infiltration and Crop Cover	Y
Low rainfall (<650 mm)	0.8	Below average infiltration and low crop coverage	1
Medium rainfall (650 to 900mm)	0.6	average or average infiltration and good coverage	2
Heavy rainfall (>900 mm)	0.4	One of the above factors favorable and other unfavorable	1.5

Table 6-8: Side slope considering seepage line (Source: IISWC, Sunabeda)

Soil Type	Side Slope (n)
Heavy Soil (Clay/Clay Loam/Black Soil/Vertis oil)	01:01
Medium Soil (Loam/Silt/Silty Clay Loam/Sandy Loam)	1.5:1
Light Soil (Sandy)	02:01

Table 6-9: Side slope without seepage line (Upstream and downstream slopes are equal) (Source: IISWC Software) ¹

Soil Type	Upstream Side Slope (n1)	Upstream Side Slope (n2)
Heavy Soil (Clay/Clay Loam/Black Soil/Vertis oil)	01:01	01:01
Medium Soil (Loam/Silt/Silty Clay Loam/Sandy Loam)	1.5:1	1.5:1
Light Soil (Sandy)	02:01	02:01

Table 6-10: Side slope without seepage line (upstream and downstream side slopes are not equal) (Source: IISWC Software)

Soil Type	Upstream Side Slope (n1)	Upstream Side Slope (n2)
Heavy Soil (Clay/Clay Loam/Black Soil/Vertis oil)	01:01	1.5:1
Medium Soil (Loam/Silt/Silty Clay Loam/Sandy Loam)	1.5:1	02:01
Light Soil (Sandy)	02:01	2.5:1

¹ https://rewardiiswc.in/online_software.php

6.3.1.2 If Field Bund is the suitable structure

- **Design and Cost Estimation of Field Bund:** After finding the field bund treatment, a new dialogue box will appear prompting the user to enter:

- a) Bund height (h): 0.3–0.6 m
- b) Top width (T): 0.3–0.5 m
- c) Settlement height: 15–20% of h

- If the user does not provide inputs, the system automatically uses default values and calculates the cross-sectional area (A) of the bund using:

$$A = \left(\frac{T+B}{2} \right) * H;$$

$$B = (T + 2 * n * H);$$

$$H = h * \text{settlement height}$$

Where, H = Total height of bund; B= base width of bund; n = side slope (based on the soil type, as provided in Table 6-12;

1. **Calculate Earthwork Volume:** Once the cross-sectional area is computed, another dialogue box appears requesting the user to enter the length of the bund (L). Then, the system calculates the volume of earthwork (V) using:

$$V = A * L$$

2. **Cost Estimation:** After calculating the volume, the user must provide:

- a) Cost of earthwork (Rs/m³)
- b) Man-days required per hectare
- c) Rate per man-day in INR

3. If the user does not enter these values, the system applies default values and computes the total cost using:

$$\text{Cost of earthwork (Rs.)} = V * \text{Rate of earthwork (Rs./m}^3\text{)}$$

$$\text{Cost for Layout} = \text{Mandays required for layout} * \text{rate of mandays (Rs.)}$$

$$\text{Total cost (Rs.)}$$

$$= \text{cost for earthwork} + \text{cost for layout} + \text{cost for labours}$$

- **View and Export Output:** The system displays the results in a consolidated table that includes:

1. Watershed Name
2. Watershed ID
3. Plot Number
4. Plot Area
5. Bund Length

6. Selected Treatment
 7. Total Cost
- Users are also provided with options to download the report and export the results to Excel.

Table 6-11: Range of user input parameters in the Field Bund

Input Parameter	Range
Enter Bund Length (L) (m)	20 to 300
Rate of earthwork (Rs.)	₹ 80 to ₹ 1,200 per m ³
Man-days required	4 – 12 man days / ha
Rate of man days	300 – 600 / day

Table 6-12: Side slope of different types of soils (Source: IISWC Software) ²

Soil Type	Side Slope
Clayey Soils	1:1
Loamy Soils	1.5:1
Sandy Soils	2:1

6.3.1.3 If Graded Bund is suitable structure

- Design and Cost Estimation of Graded Bund
 - Calculation of Horizontal Interval (HI) and Vertical Interval (VI): After the graded bund treatment is selected, a new dialogue box appears for calculating the Horizontal Interval (HI) and Vertical Interval (VI). The user must select one of the following empirical formulas from a drop-down list:
 - a. Ramser formula:

$$VI = 0.3 \left(\frac{S}{a} + b \right)$$

$$HI = \frac{100 * VI}{S}$$

Where, S is slope in (%), a and b are constants based on soil infiltration rate (see Table 6-6).

- b. USDA formula:

$$VI = 0.3 \left(\frac{S}{a} + b \right)$$

$$HI = \frac{100 * VI}{S}$$

² https://rewardiiswc.in/online_software.php

Where, S is slope in (%), a and b are constants based on soil infiltration rate (see Table 6-7)

c. Cox formula:

$$VI = 0.3 (XS + Y)$$

$$HI = \frac{100 * VI}{S}$$

Where, S is slope in (%), X and Y are constants based on average annual rainfall, infiltration rate, and crop cover.

- **Calculate design discharge (Qd):** Once HI and VI are calculated, the user must enter the ponding depth (d) and select the type of surface to fetch the appropriate Manning's coefficient (N). The system then calculates the design discharge (Qd) and checks whether: Qd>Qp. If Qd is greater than Qp (Qp is calculated using the Rational formula for a 10-year return period), the process continues to the next step. If Qd is less than Qp, an error message prompts the user to adjust the ponding depth, and the calculations are repeated until the condition is satisfied. Formulas used for design discharge are:

$$\begin{aligned} A &= A_1 + A_2 \\ A_1 &= \frac{1}{2} * d * \left(\frac{100 * d}{S} \right) \\ A_2 &= \frac{1}{2} * n * d^2 \\ P_1 &= \sqrt{\left(\frac{100 * d}{S} \right)^2 + d^2} \\ P_2 &= \sqrt{(n * d)^2 + d^2} \\ P &= P_1 + P_2 \\ R &= \frac{A}{P} \\ V &= \frac{1}{N} * R^{2/3} * \sqrt{0.01 * S_c} \\ Q_d &= A * V \end{aligned}$$

Where, A1 = Pondered Area 1 (m²); A2 = Pondered Area 2 (m²); A = Total Area (m²); P1= Wetted Perimeter of A1 (m); P2 = Wetted Perimeter of A2 (m); P = Total Wetted Perimeter (m); R = Hydraulic Mean Radius (m); V = Velocity (m/s); Qd = Design Discharge (m³/s); Sc = grade depends on the permeability of soil; (see Table 6-15) d = ponding depth; N = Manning's roughness coefficient (see Table 6-14).

- **Calculation of Cross-Sectional Area of Main Bund and Side Bunds:** after the design discharge is validated, a new dialogue box prompts the user to enter the freeboard (FL), ranging from 15–20%. The system then computes the cross-section areas using:

$$F_L = d + F_L$$

$$B = (n + n_s) * d$$

$$T = B - (2 * n * d)$$

$$A_m = \left(\frac{T + B}{2} \right) * H$$

$$H = d + F_L$$

$$A_s = \left(\frac{2}{3} \right) \times A_m$$

Where, FL= freeboard; B = base width; n and ns = side slopes based on soil type (see Table 6-13); H = Bund Height (m); Am = Cross Sectional Area of Main Bund (m2); As = Cross Sectional Area of Side Bund (m2); T = top width.

- **Calculate volume of earthwork: After computing the cross-sectional areas, another dialogue box prompts the user to enter:**
 - a) Length along the slope
 - b) Length across the slope
- The system then calculates the volume of earthwork as follows:

$$V = V_s + V_m$$

$$V_m = L_t \times A_m$$

$$V_s = L_{sb} \times A_s$$

$$L_b = \frac{10000}{HI}$$

$$L_t = \left(\frac{L_b * P_a}{10000} \right)$$

$$P_a = L_{LS} \times L_{CS}$$

$$A_L = L_t * B$$

$$A_L(\%) = \left(\frac{A_L}{P_a} \right) * 100$$

$$N_b = \frac{L_{LS}}{HI}$$

$$N_{sb} = N_b * 2$$

$$L_{sb} = L_{LS} * 2$$

$$R_{S/M} = \frac{V_s}{V_m}$$

Where, LLS = Length along the slope (m); Lcs = Length across the slope (m); Pa = Plot Area (m²); Lb = Length of Bund per ha (m/ha); Lt = Length of Bund (m); Nb = number of bunds; Nsb = number of side bunds; AL = area lost due to bunding; AL (%) = area lost due to bunding; Vm = Volume of Earth Work for Main Bund (m³); VS = Volume of Earth Work for side Bund (m³); RS/M = Ratio of Vs and Vm.

- Calculation of cost: After the earthwork volume is calculated, a new dialogue box prompts the user to enter:
 - i. Rate of earthwork (Rs/m³)
 - ii. Man-days required for layout per ha
 - iii. Earthwork per ha
- The total cost is calculated as:

$$T_c = C_L + C_E$$

$$C_E = R_E \times E$$

$$C_L = R_M \times M$$

$$E = \left(\frac{V}{P_a} \right) * 10000$$

Where, RE = Rate of Earthwork (Rs/m³); M = Man days Required for Layout per ha; Rm = Rate of Man days (Rs); E = Earthwork per ha; CE = Cost of earthwork per ha; CL = Cost for layout per ha; Tc = Total Cost Required (Rs).

- **View and Export Output:** The system displays the results in a consolidated table that includes:
 1. Watershed Name
 2. Watershed ID
 3. Plot Number
 4. Plot Area
 5. Bund Length
 6. Selected Treatment
 7. Total Cost
- Users are also provided with options to download the report and export the results to Excel.

Table 6-13: Side slope seepage line slope based on soil type (Source: IISWC Software) ³

Soil Type	Side Slope (n)	Seepage Line Slope (ns)
Clayey Soil	01:01	03:01
Loamy soil	1.5:1	05:01
Sand/Silty clay soil	1.5:1	05:01
Sandy Soil	02:01	06:01

³ https://rewardiiswc.in/online_software.php

Table 6-14: Manning's Roughness Coefficient based on soil surface (Source: IISWC Software) ⁴

Type of surface	Manning's N
Smooth, impervious surface	0.02
Channel	0.04
Smooth, bared packed soil	0.1
Pasture or average grass	0.4
Deciduous timber land	0.6
Timber land with deep forest litter or dense grass	0.8

Table 6-15: Grade (%) for Different Types of Soils (Source: IISWC, Sunabeda)

Soil Type	Permeability Group	Grade (%)
Sand	Permeable	0 to 0.5
Loamy	Permeable	
Sandy Loam	Permeable	
Silty Loam	Permeable	
Sandy Clayey Loam	Permeable	
Silty Clayey Loam	Impermeable	0.2 to 0.4
Clay Loam	Impermeable	
Silty Clay	Impermeable	
Clay	Impermeable	

Table 6-16: Criteria table for runoff coefficients (Source: Sujala Manual)

Land Use	Slope (°)	Texture	Runoff Coefficients
Arable, Plantation, Scrub	1–3	Clay	0.6
Arable, Plantation, Scrub	3–5	Clay	0.6
Arable, Plantation, Scrub	5–10	Clay	0.7
Arable, Plantation, Scrub	10–15	Clay	0.82
Arable, Plantation, Scrub	15–25	Clay	0.82
Arable, Plantation, Scrub	25–33	Clay	0.82

⁴ https://rewardiiswc.in/online_software.php

Land Use	Slope (°)	Texture	Runoff Coefficients
Arable, Plantation, Scrub	33–50	Clay	0.82
Arable, Plantation, Scrub	>50	Clay	0.82
Arable, Plantation, Scrub	<1	Sandy Loam	0.3
Arable, Plantation, Scrub	1–3	Sandy Loam	0.3
Arable, Plantation, Scrub	3–5	Sandy Loam	0.3
Arable, Plantation, Scrub	5–10	Sandy Loam	0.4
Arable, Plantation, Scrub	10–15	Sandy Loam	0.52
Arable, Plantation, Scrub	15–25	Sandy Loam	0.52
Arable, Plantation, Scrub	25–33	Sandy Loam	0.52
Arable, Plantation, Scrub	33–50	Sandy Loam	0.52
Arable, Plantation, Scrub	>50	Sandy Loam	0.52
Wasteland	<1	Clay	0.4
Wasteland	1–3	Clay	0.4
Wasteland	3–5	Clay	0.4
Wasteland	5–10	Clay	0.55
Wasteland	10–15	Clay	0.6
Wasteland	15–25	Clay	0.6
Wasteland	25–33	Clay	0.6
Wasteland	33–50	Clay	0.6
Wasteland	>50	Clay	0.6
Dense, Open Forest	<1	Clay	0.4
Dense, Open Forest	1–3	Clay	0.4
Dense, Open Forest	3–5	Clay	0.4
Dense, Open Forest	5–10	Clay	0.5
Dense, Open Forest	10–15	Clay	0.6
Dense, Open Forest	15–25	Clay	0.6
Dense, Open Forest	25–33	Clay	0.6
Dense, Open Forest	33–50	Clay	0.6
Dense, Open Forest	>50	Clay	0.6
Wasteland	<1	Sandy Loam	0.1
Wasteland	1–3	Sandy Loam	0.1
Wasteland	3–5	Sandy Loam	0.1
Wasteland	5–10	Sandy Loam	0.16
Wasteland	10–15	Sandy Loam	0.22
Wasteland	15–25	Sandy Loam	0.22
Wasteland	25–33	Sandy Loam	0.22
Wasteland	33–50	Sandy Loam	0.22
Wasteland	>50	Sandy Loam	0.22
Dense, Open Forest	<1	Sandy Loam	0.1
Dense, Open Forest	1–3	Sandy Loam	0.1
Dense, Open Forest	3–5	Sandy Loam	0.1
Dense, Open Forest	5–10	Sandy Loam	0.25
Dense, Open Forest	10–15	Sandy Loam	0.3

Land Use	Slope (°)	Texture	Runoff Coefficients
Dense, Open Forest	15–25	Sandy Loam	0.3
Dense, Open Forest	25–33	Sandy Loam	0.3
Dense, Open Forest	33–50	Sandy Loam	0.3
Dense, Open Forest	>50	Sandy Loam	0.3
Arable, Plantation, Scrub	<1	Clay Loam	0.5
Arable, Plantation, Scrub	1–3	Clay Loam	0.5
Arable, Plantation, Scrub	3–5	Clay Loam	0.5
Arable, Plantation, Scrub	5–10	Clay Loam	0.6
Arable, Plantation, Scrub	10–15	Clay Loam	0.72
Arable, Plantation, Scrub	15–25	Clay Loam	0.72
Arable, Plantation, Scrub	25–33	Clay Loam	0.72
Arable, Plantation, Scrub	33–50	Clay Loam	0.72
Arable, Plantation, Scrub	>50	Clay Loam	0.72
Arable, Plantation, Scrub	<1	Silt Loam	0.5
Arable, Plantation, Scrub	1–3	Silt Loam	0.5
Arable, Plantation, Scrub	3–5	Silt Loam	0.5
Arable, Plantation, Scrub	5–10	Silt Loam	0.6
Arable, Plantation, Scrub	10–15	Silt Loam	0.72
Arable, Plantation, Scrub	15–25	Silt Loam	0.72
Arable, Plantation, Scrub	25–33	Silt Loam	0.72
Arable, Plantation, Scrub	33–50	Silt Loam	0.72
Arable, Plantation, Scrub	>50	Silt Loam	0.72
Wasteland	<1	Clay Loam	0.3
Wasteland	1–3	Clay Loam	0.3
Wasteland	3–5	Clay Loam	0.3
Wasteland	5–10	Clay Loam	0.36
Wasteland	10–15	Clay Loam	0.42
Wasteland	15–25	Clay Loam	0.42
Wasteland	25–33	Clay Loam	0.42
Wasteland	33–50	Clay Loam	0.42
Wasteland	>50	Clay Loam	0.42
Dense, Open Forest	<1	Clay Loam	0.3
Dense, Open Forest	1–3	Clay Loam	0.3
Dense, Open Forest	3–5	Clay Loam	0.3
Dense, Open Forest	5–10	Clay Loam	0.35
Dense, Open Forest	10–15	Clay Loam	0.5
Dense, Open Forest	15–25	Clay Loam	0.5
Dense, Open Forest	25–33	Clay Loam	0.5
Dense, Open Forest	33–50	Clay Loam	0.5
Dense, Open Forest	>50	Clay Loam	0.5
Wasteland	<1	Silt Loam	0.3
Wasteland	1–3	Silt Loam	0.3
Wasteland	3–5	Silt Loam	0.3

Land Use	Slope (°)	Texture	Runoff Coefficients
Wasteland	5–10	Silt Loam	0.36
Wasteland	10–15	Silt Loam	0.42
Wasteland	15–25	Silt Loam	0.42
Wasteland	25–33	Silt Loam	0.42
Wasteland	33–50	Silt Loam	0.42
Wasteland	>50	Silt Loam	0.42
Dense, Open Forest	<1	Silt Loam	0.3
Dense, Open Forest	1–3	Silt Loam	0.3
Dense, Open Forest	3–5	Silt Loam	0.3
Dense, Open Forest	5–10	Silt Loam	0.35
Dense, Open Forest	10–15	Silt Loam	0.5
Dense, Open Forest	15–25	Silt Loam	0.5
Dense, Open Forest	25–33	Silt Loam	0.5
Dense, Open Forest	33–50	Silt Loam	0.5
Dense, Open Forest	>50	Silt Loam	0.5
Arable, Plantation, Scrub	5–10	Silty Clay	6.7
Arable, Plantation, Scrub	3–5	Sandy Clay	NULL

Table 6-17: Range of user input parameters in the Graded Bund

Input Parameter	Range
Ponding Depth (m)	0 to 1
Free board (%)	15 -20
Length along the slope (m)	10 to 1000
Length across the slope (m)	5 to 500
Rate of Earthwork per ha (Rs)	₹ 80 – 1200 / m ³
Man-days Required for Layout per ha	2 – 50 man-days / ha
Rate of Man-days (Rs)	₹ 200 – 1200/man days

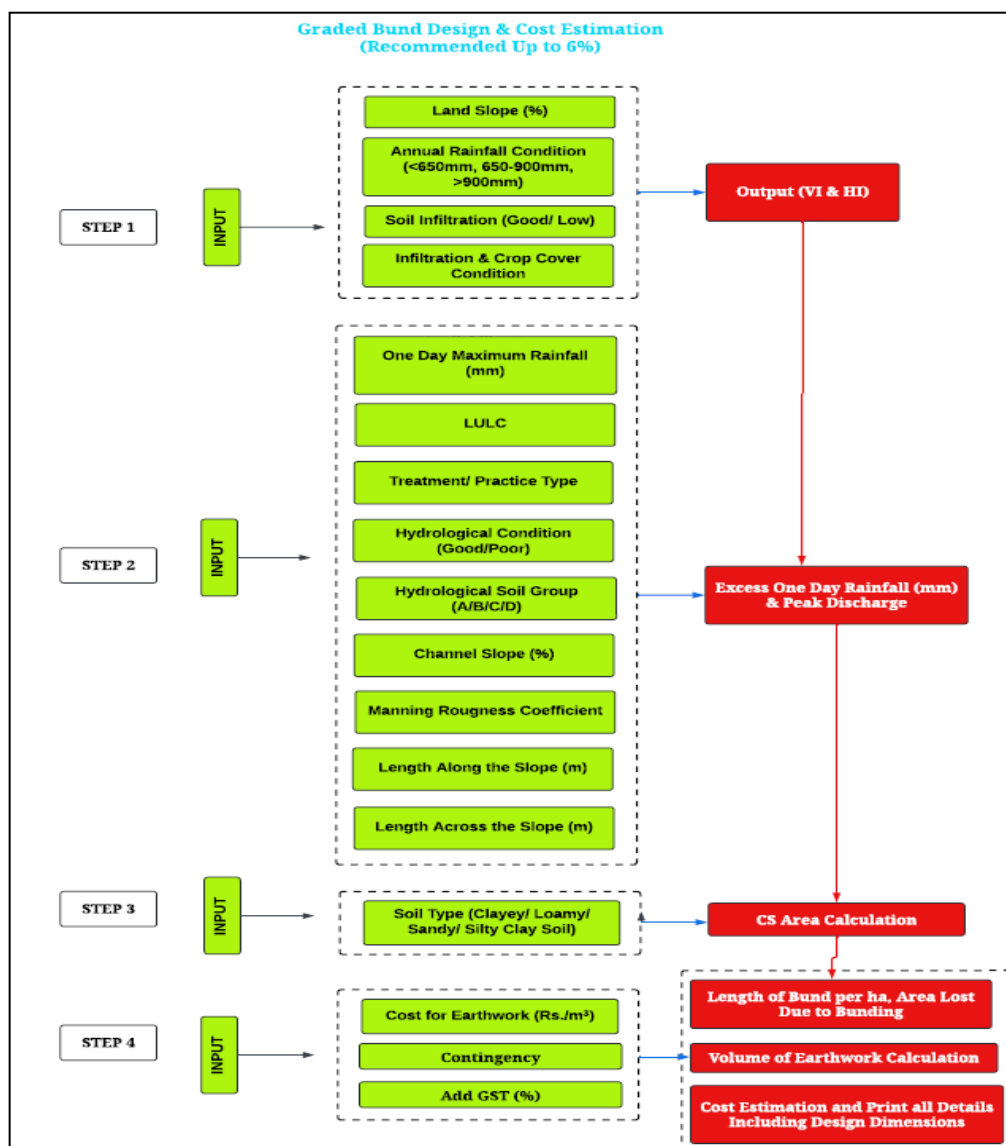


Figure 6-2: Flow diagram for the execution of the DSS for graded bund design and cost estimation (Source: IISWC, Sunabeda)

6.3.1.4 If Inward Sloping Terrace is suitable structure

- Design and Cost Estimation of Inward Sloping Terrace
- Calculation of VI, HI and Terrace Length:** After the inward sloping terrace treatment is selected, a new dialogue box appears to calculate the Horizontal Interval (HI), Vertical Interval (VI), terrace width, and terrace length. The formulas used are:

$$d = D \times 0.7$$

$$W = 200 \times \frac{d}{S}$$

$$VI = \frac{W \times S}{100 - (n \times S)}$$

$$HI = \frac{100 \times VI}{S}$$

$$L = \frac{100 \times S}{VI}$$

$$S_L = \sqrt{VI^2 + n \times VI^2}$$

- Where, D = depth of soil; W = width of terrace; d= depth of cut; S = slope; n = batter slope based on soil type (See Table 6-18); L = Length of terrace; SL = Slinting length
- Calculating Base width and cross-sectional area of shoulder bund:** After VI, HI, and terrace length are computed, a new dialogue box prompts the user to enter the top width and height of the shoulder bund. If the user does not enter values, the system uses default ranges:
 - Top width (Tsb): 0.15 – 0.30 m
 - Height (Hsb): 0.15 – 0.30 m

$$B_{sb} = T_{sb} + (2 \times n \times H_{sb})$$

$$A_{sb} = \left(\frac{T_{sb} + B_{sb}}{2} \right) \times H_{sb}$$

- Where, Tsb = Top width of the shoulder Bund (m); Hsb = Height of the shoulder Bund (m); Bsb = Base width of the shoulder Bund (m); Asb = Cross-sectional area of shoulder bund.
- Design of Runoff Disposal Drain (RDD):** Once the shoulder bund dimensions are calculated, a new dialogue box prompts the user to enter length of plot, width of plot, Terrace cross-sectional slope, Slope of the channel. Based on these inputs, the system computes the RDD parameters:

$$A_{RDD} = \left(\frac{T_{RDD} + B_{RDD}}{2} \right) \times H_{RDD}$$

$$N_{BT} = \frac{L_p}{HI}$$

$$N_{DP} = \frac{L}{2 \times k}$$

$$V = \frac{Q_{peak}}{A_{RDD}}$$

$$L_{RDD} = N_{DP} \times HI$$

Where, T_{RDD} = Top width of RDD; B_{RDD} = Base width of RDD; H_{RDD} = Height of RDD; L_p = Length of Plot (m); A_{RDD} = area of RDD; K = critical length based on soil type (See Table 6-19); Q_{peak} = peak runoff rate (Calculating using the rational formula); N_{BT} = number of bench terraces; N_{DP} = number of drop pits; L_{RDD} = length of RDD.

- **Area Lost and Area Available for Cultivation:** After RDD design, the system automatically calculates the areas associated with terrace construction:

$$A_{LT} = n \times S \times 100$$

$$A_{CT} = (L_P \times B_P) - A_{LT}$$

$$A_{CTS} = VI \times L \times \sqrt{1 + n^2}$$

$$T_{AC} = A_{CT} + A_{CTS}$$

- Where, ALT = Area Lost in Terrace (m²); ACT = Area Available for Cultivation on Terrace (m²); $ACTS$ = Area Available for Cultivation on Terrace Better Slope/ha (m²); TAC = Total Area Available for Cultivation (m²)
- **Calculation of Earthwork:** The system then calculates the total earthwork required using:

$$E_{TC} = 12.5 \times W \times S$$

$$E_{DP} = N_{DP} \times 0.3 \times 0.3 \times 0.3$$

$$E_{CS} = \frac{L \times W \times S_c}{200}$$

$$E_{TD} = L \times 0.2 \times 0.2$$

$$E_{LS} = \frac{L * W * S_{ch}}{200}$$

$$E_{SB} = \left(\frac{T_{sb} + B_{sb}}{2} \right) \times H_{sb} \times (L + (2 \times W))$$

$$E_{RDD} = A_{RDD} \times L_{RDD}$$

$$E_{TQ} = E_{TC} + E_{CS} + E_{LS} + E_{RDD} + E_{DP} + E_{TD} + E_{SB}$$

Where, ETC = E/W Terrace Construction (m3); ECS = E/W Cross Sectional Slope - Inward (m3); ELS = E/W Longitudinal Slope (m3); ERDD = E/W RDD (Runoff Disposal Drain) (m3); EDP = E/W Drop pit (m3); ETD = E/W Toe Drain (m3); ESB = E/W Shoulder Bund (m3); ETQ = E/W Total Quantity (m3).

- Calculation of Total cost: After successful calculation of total earthwork quantity, user needs to enter the rate of earthwork (Rs/m3) and GST (%) to calculate total cost. The formula used for this purpose are:

$$Total\ cost\ required\ (Rs.) = (E_{TQ} \times rate\ of\ earthwork\ (Rs./m3)) * GST$$

- View and Export Output: The system displays the results in a consolidated table that includes:
 1. Watershed Name
 2. Watershed ID
 3. Plot Number
 4. Plot Area
 5. Bund Length
 6. Selected Treatment
 7. Total Cost
- Users are also provided with options to download the report and export the results to Excel.

Table 6-18: Side slopes based on soil types (Source: IISWC Software) ⁵

Soil Type	Side Slope (n)
Clay	0.5:1

⁵ https://rewardiiswc.in/online_software.php

Soil Type	Side Slope (n)
Clay Loam	0.5:1
Black Soil	0.5:1
Vertisol	0.5:1
Loam	01:01
Silt	01:01
Silty Loam	01:01
Silty Clay Loam	01:01
Sandy Loam	01:01
Sandy	1.5:1

Table 6-19: Critical Length based on soil type (Source: IISWC Software)

Soil Type	Critical Length (K)
Clay	300
Clay Loam	300
Black Soil	300
Vertisol	300
Loam	200
Silt	200
Silty Loam	200
Silty Clay Loam	200
Sandy Loam	100
Sandy	100

Table 6-20: Range of user input parameters in the Inward Sloping Terrace Design

Input Parameter	Range
Top width of the shoulder Bund (m)	0.15 - 0.30
Height of the shoulder Bund (m)	0.15 - 0.30
Length of Plot (m)	30-500 m

Input Parameter	Range
Width of Plot (m)	20-200 m
Terrace Cross-Sectional Slope - Inclined (%)	2-2.5
Slope of the Channel (%)	0.1 - 0.5

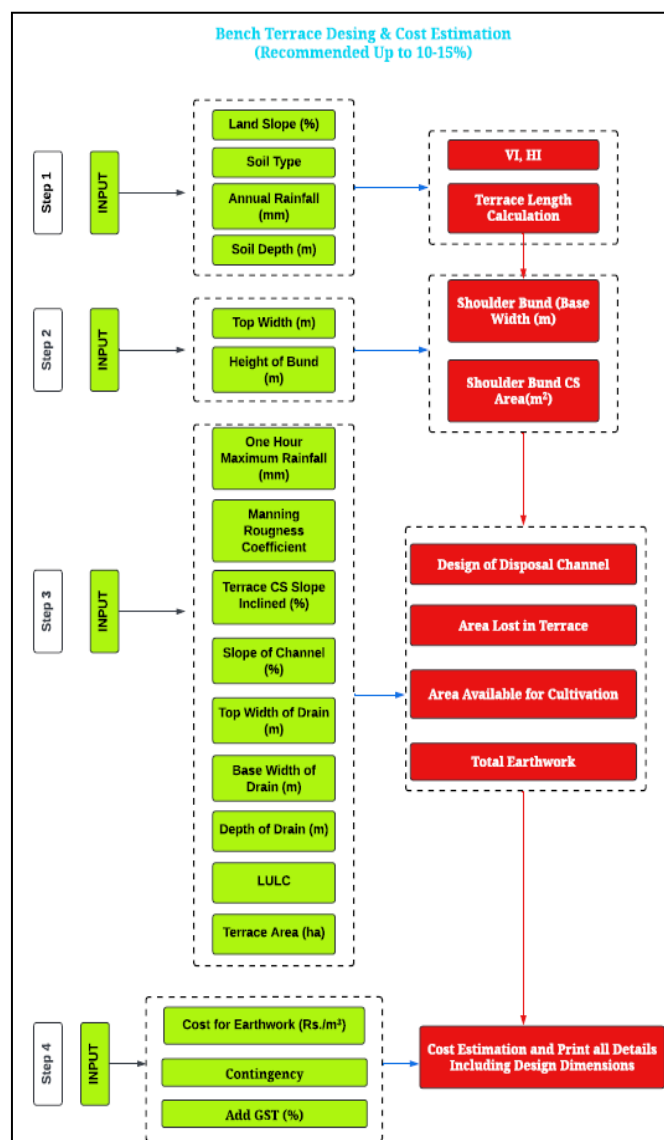


Figure 6-3: Flow diagram for the execution of the DSS for inward sloping terrace design and cost estimation (Source: IISWC, Sunabeda)

6.4 Design of DLT Structures

6.4.1 STEPS INVOLVED IN EXECUTING THE DSS DESIGN OF DLT STRUCTURES IN THE PORTAL

- **Log in to the Portal:** After successfully logging into the portal, the user should click the DSS tab located at the top right side of the webpage.
- **Open DSS Modules:** Once the DSS tab is selected, two options DSS and Layers will appear on the left side of the webpage. The user should click on the DSS option.
- **Select Hydrology Category:** Three categories will be displayed. The user must select Hydrology, which will expand to show a list of DSS modules available under the hydrology category.
- **Select Soil and Water Conservation Module:** From this list, the user should select Design of Soil and Water Conservation Structures. After selection, a dialogue box will appear with two options. The user should choose Drainage Line Treatment.
- **Choose Micro Watershed Selection Method:** A Drainage Line Treatment dialogue box will then appear, providing two options for selecting the Micro Watershed: From List and from Map.
 - a) From List allows the user to manually select the District, Block, Cluster, Micro Watershed.
 - b) From Map option, the user can simply click on the desired location on the map. The system instantly auto-populates all relevant administrative attributes District, Block, Cluster, Micro Watershed, eliminating the need for manual entry.
- For the selected micro watershed, the system automatically extracts suitable DLT structures for that plot from the output table of siting of structures

6.4.1.1 If suitable structure is Brushwood check dam

- **Design and Cost Estimation of Brushwood Check Dam**
- Select single row Brushwood check dam or double row Brushwood check dam: After the Brushwood check dam treatment is selected, a new dialogue box appears and user needs to select the type of structure they want to construct such as single row or double row brushwood.
 - i **Single row Brushwood:** If the user selects the single row brushwood, then user needs to provide the input data like length, width, height, spacing between vertical pole, and spacing between horizontal pole. Also, user needs to provide rate for vertical post, rate for horizontal post, rate of carpenter per pole, and rate of painter for painting per pole. If the user has not provided costs, the system automatically considers the default rates and calculates the total cost.
 - ii **Double row Brushwood:** If the user selects the double row brushwood, then user needs to provide the input data like length, width, height, spacing between vertical pole, spacing between horizontal pole, and type of material. Also, user needs to provide rate for vertical post, rate for horizontal post, rate of carpenter per pole, and rate of painter for painting per pole, rate for cross post, rate of stone bushes, rate of labor for filling of stone in Brushwood check dam. If the

user has not provided costs, the system automatically considers the default rates and calculates the total cost.

- Formulas used for the design and cost estimation of single row brushwood:

$$\text{No of vertical poles (VP)} = \frac{\text{Length}}{\text{Spacing between each vertical pole}}$$

$$\text{No of horizontal poles (HP)} = \frac{\text{Height}}{\text{spacing between each horizontal pole}}$$

$$\text{Total cost for vertical post (Rs.)} = \text{Rate for vertical post} \times \text{VP}$$

$$\text{Total cost for horizontal post (Rs.)} = \text{Rate for horizontal post} \times \text{HP}$$

$$\text{Total cost for carpenting (Rs.)} = \text{Rate of carpenter per pole} \times (\text{VP} + \text{HP} + \text{CP})$$

$$\text{Total cost for painting (Rs.)} = \text{Rate painting per pole} \times (\text{VP} + \text{HP} + \text{CP})$$

$$\text{Total cost of structure (Rs.)} = \text{sum of all of the above costs}$$

- Formulas used for the design and cost estimation of double row brushwood:**

$$\text{No of vertical poles (VP)} = \frac{\text{Length}}{\text{Spacing between each vertical pole}} \times 2$$

$$\text{No of horizontal poles (HP)} = \frac{\text{Height}}{\text{spacing between each horizontal pole}} \times 2$$

$$\text{No of cross post (CP)} = \frac{\text{No of vertical poles}}{2}$$

$$\text{Volume of stone} = \text{Height} \times \text{Length} \times \text{distance between two rows}$$

$$\text{Total cost for vertical post (Rs.)} = \text{Rate for vertical post} \times \text{VP}$$

$$\text{Total cost for horizontal post (Rs.)} = \text{Rate for horizontal post} \times \text{HP}$$

$$\text{Total cost for cross post (Rs.)} = \text{Rate for cross post} \times \text{CP}$$

Total cost for stone bushes (Rs.) = Rate for stonebushes × volume of stone

Total cost for carpenting (Rs.) = Rate of carpenter per pole × (VP + HP + CP)

Total cost for painting (Rs.) = Rate painting per pole × (VP + HP + CP)

Total cost of labour for filling stone in BCD (Rs.)
= Rate of labour for filling stone in BCD × volume of stone

Total cost of structure (Rs.) = sum of all of the above costs

- **Display of Results:** As soon as the user submits the required data, the system displays the output results contains attributes:
 - i. Micro Watershed Name
 - ii. Micro Watershed code
 - iii. Treatment
 - iv. Length
 - v. Total Cost of Structure (Rs.)
- **Download and Export Results:** Users are also provided with options to download the report and export the results to Excel.

Table 6-21: Range of user input parameters in the Brushwood Check Dam

Input Parameter	Range
Length (m)	Less than 4
Height (m)	Less than 2
Enter the Spacing between each Vertical Pole (m)	0.5 to 1
Enter the Spacing between each Horizontal Pole (m)	0.2 to 0.4
Enter the distance between two rows	Less than 0.9
Rate for Vertical Post	₹ 20 – 120 / pole
Rate for Horizontal Post	₹ 10 – 80 / pole
Rate for Cross Post	₹ 15 – 90 / pole
Rate of Stone Bushes	₹ 800 – 4,000 / m ³
Rate of Carpenter per pole	₹ 5 – 40 / pole
Rate of Painter for painting per pole	₹ 8 – 50 / pole
Rate of Labor for Filling of Stone in BCD	₹ 150 – 900 / m ³

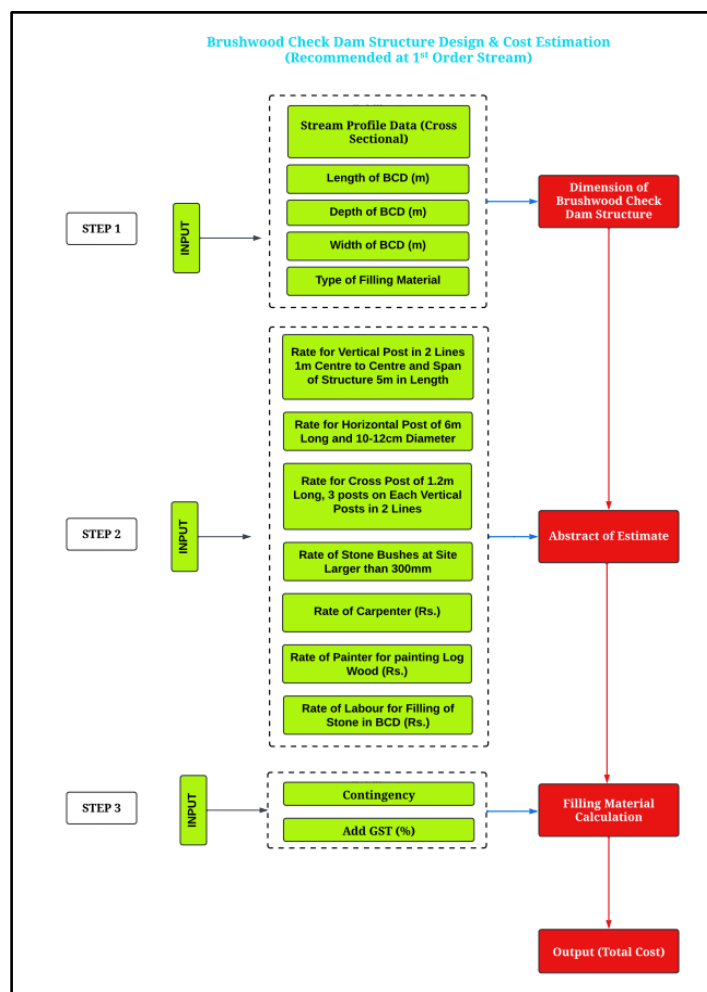


Figure 6-4: Flow diagram for the execution of the DSS for Brushwood check dam design and cost estimation (Source: IISWC, Sunabeda)

6.4.1.2 If Gabion structure is suitable

- **Design and Cost Estimation of Gabion Structure:** After the Gabion structure treatment is selected, a new dialogue box appears and user needs to enter various inputs such as length, height, width, and foundation depth of retaining head wall, downstream unit (Box1), Upstream unit (Box2), and cost for different particulars such as labour cost for earthwork, labour cost for wire netter, cost of gabion wire per Kg, cost of supplying stones, labour cost for filling stone in LBCD, and Labour cost for carriage of stones. If the user has not provided the costs of particulars, then the system automatically uses the default values and calculates the total cost.

- **Formulas used for the design and cost estimation of gabion structure:**

$$\begin{aligned} \text{Volume of earthwork for foundation trench (m}^3\text{)} \\ &= \text{Length} \times \text{Width} \times \text{Foundation Depth} \end{aligned}$$

$$\begin{aligned} \text{Area of Gabion Mesh Work bottom and top (m}^2\text{)} \\ &= \text{no. of faces} \times \text{Length} \times \text{Width} \end{aligned}$$

$$\begin{aligned} \text{Area of Gabion Mesh Work (m}^2\text{)} \\ &= \text{No. of faces} \times \text{Length} \times (\text{Height} + \text{Foundation Depth}) \end{aligned}$$

$$\begin{aligned} \text{Area of Gabion wire mesh work both sides} \\ &= \text{No. of faces} \times \text{Width} \times (\text{Height} + \text{Foundation Depth}) \end{aligned}$$

$$\begin{aligned} \text{Surface area of Box1 bottom and top} \\ &= \text{No. of faces} \times \text{Length} \times \text{Width} \end{aligned}$$

$$\begin{aligned} \text{Surface area of Box1 front and back} \\ &= \text{No. of faces} \times \text{Length} \times (\text{Height} + \text{Foundation Depth}) \end{aligned}$$

$$\begin{aligned} \text{Surface area of Box1 both sides} \\ &= \text{No. of faces} \times \text{Width} \times (\text{Height} + \text{Foundation Depth}) \end{aligned}$$

$$\begin{aligned} \text{Total Area Box 1} \\ &= \text{Surface area of Box1 (Bottom and Top} \\ &\quad + \text{Front and Back} + \text{Both Sides)} \end{aligned}$$

$$\begin{aligned} \text{Surface area of Box2 bottom and top} \\ &= \text{No. of faces} \times \text{Length} \times \text{Width} \end{aligned}$$

$$\begin{aligned} \text{Surface area of Box2 front and back} \\ &= \text{No. of faces} \times \text{Length} \times (\text{Height} + \text{Foundation Depth}) \end{aligned}$$

$$\begin{aligned} \text{Surface area of Box2 both sides} \\ &= \text{No. of faces} \times \text{Width} \times (\text{Height} + \text{Foundation Depth}) \end{aligned}$$

$$\begin{aligned} \text{Total Area Box 2} \\ &= \text{Surface area of Box2 (Bottom and Top} \\ &\quad + \text{Front and Back} + \text{Both Sides)} \end{aligned}$$

$$\text{Total wire mesh area} = \text{Total Area Box1} + \text{Total Area Box2}$$

$$\begin{aligned} \text{Volume of dry stone masonry below ground level} \\ &= \text{Length} \times \text{Width} \times \text{Foundation depth} \end{aligned}$$

$$\begin{aligned} \text{Volume of dry stone masonry above ground level} \\ &= \text{Length} \times \text{Width} \times \text{Height} \end{aligned}$$

$$\begin{aligned} \text{Total volume of stone} \\ &= \text{volume of dry stone above ground level} \\ &\quad + \text{volume of dry stone below ground level} \end{aligned}$$

$$\text{Cost of earthwork} = \text{Foundation trench} * \text{Labour cost for earthwork} \left(\frac{\text{Rs}}{\text{m}^3} \right)$$

Cost of wire netting

$$= \text{total wire mesh area} * \text{Labour cost of wire netter} \left(\frac{\text{Rs}}{\text{m}^2} \right)$$

$$\text{Total cost of gabion wire @ } 1.28 \frac{\text{kg}}{\text{m}^2}$$

$$= 1.28 * \text{Total Wire mesh area} * \text{cost of gabion wire @ } 1.28 \frac{\text{kg}}{\text{m}^2}$$

Total cost of boulder

$$= 1.2 \times \text{Total stone volume}$$

$$\times \text{cost of supplying stones carrying stones} \left(\frac{\text{Rs}}{\text{m}^3} \right)$$

Total Labour cost for filling stone in LBCD

$$= 1.2 \times \text{Total stone volume}$$

$$\times \text{Labour cost for filling stone in LBCD} \left(\frac{\text{Rs}}{\text{m}^3} \right)$$

Total Labour cost for carriage of stones upto the site

$$= 1.2 \times \text{Total stone volume}$$

$$\times \text{Labour cost for carriage of stones upto the site} \left(\frac{\text{Rs}}{\text{m}^3} \right)$$

Total cost of structure = Sum of all of the above

- **Display of Results:** As soon as the user submits the required data, the system displays the output results contains attributes:
 - vi. Micro Watershed Name
 - vii. Micro Watershed code
 - viii. Treatment
 - ix. Length
 - x. Total Cost of Structure (Rs.)
- **Download and Export Results:** Users are also provided with options to download the report and export the results to Excel.

Table 6-22: Range of input parameters for the design of Gabion Structure

Input Parameter	Range
Length (m)	1.0 to 6.0 m
Height (m)	0.3 to 1.5 m
Width (m)	0.3 to 1.0 m
Foundation Depth (m)	0.3 to 1.5 m
Labor cost for earthwork (RS/ M3)	₹ 150 – 600 / m ³
Labor cost of wire netter (RS/ M2)	₹ 20 – 120 / m ²
Cost of gabion wire per kg	₹ 60 – 120 / kg
Cost of supplying stones carrying stones (RS/ M3)	₹ 800 – 4,000 / m ³
Labor cost for filling stone in LBCD (RS/M3)	₹ 200 – 900 / m ³
Labor cost for carriage of stones up to the site (RS/M3)	₹ 150 – 1,200 / m ³

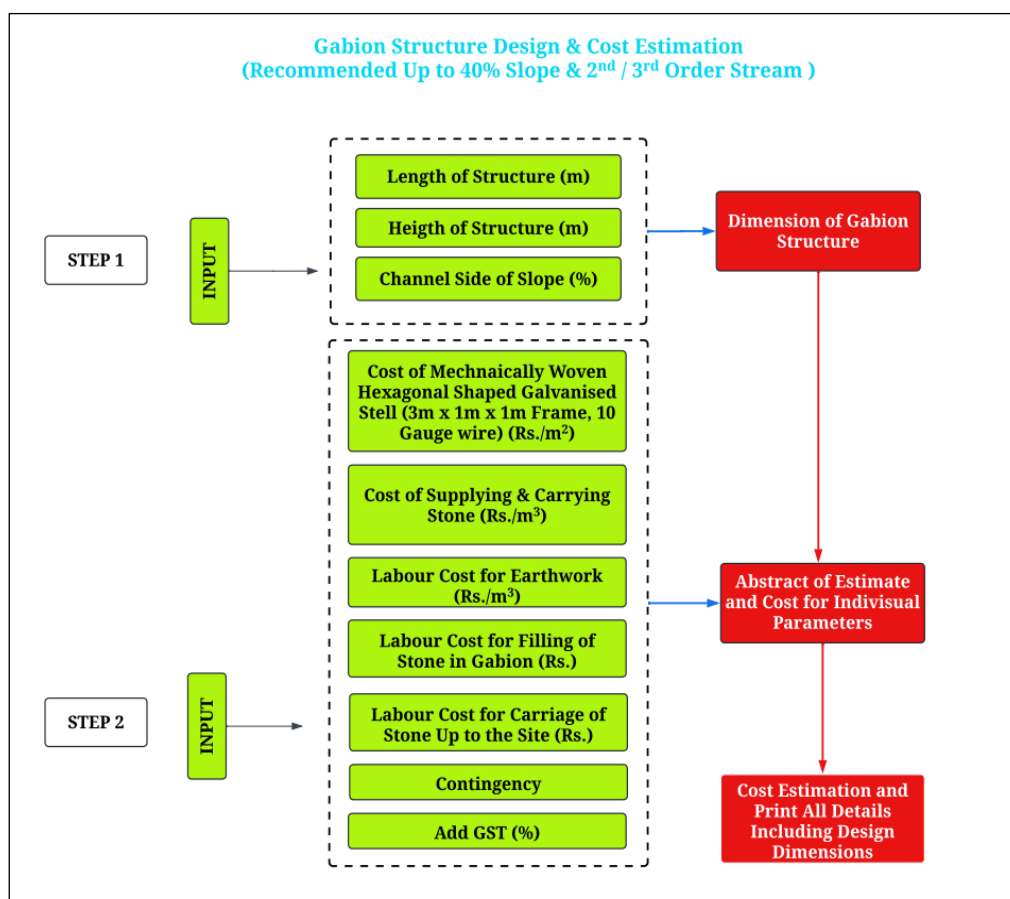


Figure 6-5: Flow diagram for the execution of the DSS for Brushwood check dam design and cost estimation (Source: IISWC, Sunabeda)

6.4.1.3 If LBCD is suitable structure

- **Design and Cost Estimation of LBCD :** After the LBCD structure treatment is selected, a new dialogue box appears and user needs to enter various inputs such as length, height, top width, bottom width, foundation depth, upstream slope, downstream slope, and cost of supplying and carrying stones, labour cost for earthwork, labour cost

for filling stone in LBCD, labour cost for carriage of stones. If the user has not provided the costs of particulars, then the system automatically uses the default values and calculates the total cost (Table 6-23).

▪ **Formulas used for the design and cost estimation of LBCD structure:**

$$\begin{aligned} \text{Volume of earthwork for the foundation of head wall (V1)} \\ = \text{Length} * \text{Bottom Width} * \text{Foundation Depth} \end{aligned}$$

$$\begin{aligned} \text{Volume of boulder for the construction of foundation (V2)} \\ = \text{Length} * \text{Bottom Width} * \text{Foundation Depth} \end{aligned}$$

$$\begin{aligned} \text{Volume of boulder for the construction of superstructure (V3)} \\ = \text{Length} * \text{Height} * \left(\frac{\text{Top width} + \text{Bottom width}}{2} \right) \end{aligned}$$

$$\begin{aligned} \text{Total Boulder work} \\ = \text{Volume of boulder for construction of foundation and superstructure} \end{aligned}$$

$$\text{Cost of earthwork for foundation (Rs.)} = V1 * \text{Labour cost for earthwork} \left(\frac{\text{Rs}}{\text{m}^3} \right)$$

$$\begin{aligned} \text{Cost of boulder for foundation (Rs.)} \\ = 1.2 * V2 * \text{cost of supplying and carrying stone} \left(\frac{\text{Rs}}{\text{m}^3} \right) \end{aligned}$$

$$\begin{aligned} \text{Cost of earthwork for the superstructure (Rs.)} \\ = 1.2 * V3 * \text{cost of supplying and carrying stones} \left(\frac{\text{Rs}}{\text{m}^3} \right) \end{aligned}$$

$$\begin{aligned} \text{Total labour cost for filling stone in LBCD (Rs.)} \\ = 1.2 * (V2 + V3) * \text{Labour cost for filling stone in LBCD} \left(\frac{\text{Rs}}{\text{m}^3} \right) \end{aligned}$$

$$\begin{aligned} \text{Total labour cost for carriage of stones upto the site (Rs.)} \\ = 1.2 * (V2 + V3) \\ * \text{Labour cost for carriage of stones upto the site} \left(\frac{\text{Rs}}{\text{m}^3} \right) \end{aligned}$$

$$\text{Total cost of the structure (Rs.)} = \text{sum of all of the above costs}$$

▪ **Display of Results:** As soon as the user submits the required data, the system displays the output results contains attributes:

1. Micro Watershed Name
2. Micro Watershed code
3. Treatment
4. Length

5. Total Cost of Structure (Rs.)

- **Download and Export Results:** Users are also provided with options to download the report and export the results to Excel.

Table 6-23: Range of input parameters for the design of LBCD structure

Input Parameter	Limits
Length (m)	0.5 to 6
Height (m)	0.25 – 1.00 m
Top Width (m)	0.15 – 0.80 m
Bottom Width (m)	0.6 – 2.5 m
Foundation Depth (m)	0.3 – 1.0 m
Upstream Slope	1 – 2.0
Downstream Slope	1 – 2.0
Cost of supplying and carrying stones (RS/ M3)	₹ 800 to ₹ 4,000 per m ³
Labor cost for earthwork (RS/ M3)	₹ 150 to ₹ 600 per m ³
Labor cost for filling stones in LBCD (RS/ M3)	₹ 200 to ₹ 900 per m ³
Labor cost for carriage of stones up to the site (RS/M3)	₹ 150 to ₹ 1,200 per m ³

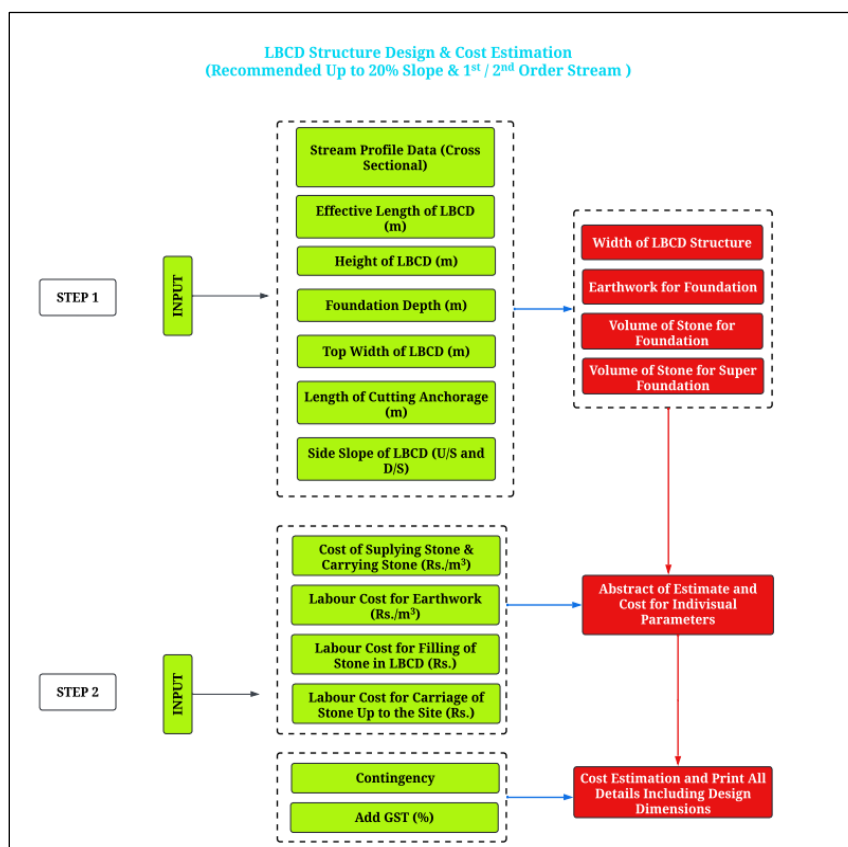


Figure 6-6: Flow diagram for the execution of the DSS for Brushwood check dam design and cost estimation (Source: IISWC, Sunabeda)

Output tables:

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura					
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:	
S. No.	Micro Watershed Name	Micro Watershed Code	Treatment	Length (m)	Total Cost of Structure (Rs.)
1	Bhadimura	0407010207140201	LBCD	1	₹4,048.22
Showing 1 to 1 of 1 entries				Previous	1 Next

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Gadgadabahal Village:Dhadumunda Plot:Ddm1208014430					
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:	
Micro Watershed	Micro Watershed Code	Plot No.	Treatment	Length (m)	Total Cost of Structure (Rs.)
Gadgadabahal	0407010207140101	Ddm1208014430	Graded Bund	10.06	₹264.77
Showing 1 to 1 of 1 entries				Previous	1 Next

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura					
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:	
S. No.	Micro Watershed Name	Micro Watershed Code	Treatment	Length (m)	Total Cost of Structure (Rs.)
1	Bhadimura	0407010207140201	GABION	1	₹27,863.08
Showing 1 to 1 of 1 entries				Previous	1 Next

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Kansar Village:Garagada Bahala Plot:Ggb1208007701					
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:	
Micro Watershed	Micro Watershed Code	Plot No.	Treatment	Length (m)	Total Cost of Structure (Rs.)
Kansar	0407010207180202	Ggb1208007701	Field Bunding	12	₹5,800.52
Showing 1 to 1 of 1 entries				Previous	1 Next

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Gadgadabahal Village:Dhadumunda Plot:Ddm120801412					
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:	
Micro Watershed	Micro Watershed Code	Plot No.	Treatment	Length (m)	Total Cost of Structure (Rs.)
Gadgadabahal	0407010207140101	Ddm120801412	Contour Bunding	96.00	₹2.18
Showing 1 to 1 of 1 entries				Previous	1 Next

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura					
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:	
S. No.	Micro Watershed Name	Micro Watershed Code	Treatment	Length (m)	Total Cost of Structure (Rs.)
1	Bhadimura	0407010207140201	Brushwood Single Row	1	₹110.00
Showing 1 to 1 of 1 entries				Previous	1 Next

Note: These rates are based on the literature available. Portal provides functionality to the user to input actual rates.

7 DSS-5: Groundwater Recharge and Extraction Zone Mapping

7.1 Purpose

The purpose of this DSS is to identify groundwater recharge and extraction potential zones using high-resolution thematic datasets and validated multi-criteria decision-making frameworks. By integrating hydrogeological parameters such as slope, drainage density, lineament density, geomorphology, geology, surface texture, elevation, and land use with AHP-derived weights and the ranks, the system helps planners and groundwater engineers determine where artificial recharge structures can be effectively implemented and where groundwater extraction may be feasible or restricted. The DSS provides an objective, replicable, and efficient approach for sustainable groundwater management at watershed, block, village, and plot scales.

7.2 Key Functions:

- Integrates multiple hydrogeological and terrain datasets including DEM, slope, drainage density, lineament density, geomorphology, geology, soil texture, and LULC for groundwater suitability assessment.
- Applies standardized AHP weights and thematic class rankings developed through research and expert consultation to ensure consistent evaluation of recharge and extraction potential.
- Performs automated GIS processing such as preprocessing, reclassification, normalization, and weighted overlay analysis to generate recharge and extraction index layers.
- Generates thematic and classified output maps including recharge indices, extraction indices, potential zone maps, and summary tables for easy interpretation and planning.

7.3 Methodology for mapping of groundwater recharge potential zones and extraction potential zones

The following standardized workflow was adopted for the preparation of Groundwater Recharge Potential Zones (GRPZ) and Groundwater Extraction Potential Zones (GEPZ). All geospatial operations were performed using raster-based geo-processing techniques to ensure uniformity, reproducibility, and analytical consistency across thematic datasets.

1. Preprocessing of Thematic Raster Layers:

- 1) **Re-projection of Input Layers:** All thematic raster layers including Land Use/Land Cover (LULC), slope, elevation, lineament density, drainage density, surface texture, subsurface texture, geology, and geomorphology—were re-projected to a common Coordinate Reference System (CRS).
- 2) **Spatial Resolution Standardization:** Each re-projected raster layer was resampled to a uniform spatial resolution of 10 m.
- 3) **Spatial Realignment:** All thematic layers were realigned to a common spatial extent and grid alignment.

2. Thematic Reclassification and Weighting:

- 1) **Reclassification of Thematic Layers:** Each thematic raster was reclassified into standard classes as per the protocols prescribed by IIT Bhubaneswar.
- 2) **Assignment of AHP Weights:** The Analytic Hierarchy Process (AHP) was employed to assign weights to the thematic layers. The weights differed for recharge potential and extraction potential analyses (Table 7-1).

Ranking of Reclassified Classes: Within each thematic layer, reclassified classes were assigned ranks based on their influence on groundwater recharge and extraction. Rank values differ for recharge and extraction scenarios (Table 7-2 to Table 7-9). Higher ranks represent more favorable conditions for recharge/extraction.

3. Index Generation and Classification:

- 1) **Computation of Normalized Indices:** Using raster attribute tables and weighted overlay techniques, two index rasters were generated: Normalized Recharge Potential Index (nRPI) and Normalized Groundwater Extraction Potential Index (nGEPI). These indices integrate all weighted and ranked thematic information into a single normalized value for each pixel.
 - 2) **Reclassification of Index Rasters:** Both nRPI and nGEPI rasters were reclassified into five standardized potential classes: very low, low, mild, high, and very high (See Table 7-9).
4. **Final Output Generation:** The final outputs of the workflow consist of: Groundwater Recharge Potential Raster and Groundwater Extraction Potential Raster. These raster layers serve as the definitive spatial representations of groundwater recharge and extraction suitability across the study area.

Table 7-1: AHP Weights for recharge and extraction (Source: IIT Bhubaneswar)

Thematic Layer	AHP weights for recharge	AHP weights for extraction
Lithology	0.14	0.13
Geomorphology	0.17	0.12
LULC	0.13	0.12
Surface Texture	0.14	0.14
Slope	0.10	0.10
Drainage Density	0.09	0.12
Lineament Density	0.10	0.11
Elevation	0.14	0.16

Table 7-2: Recharge and Extraction potential ranks for Lithology Layer (Source: IIT Bhubaneswar)

Lithology Class	Recharge Rank	Extraction Rank
Alluvium / Valley Fill	7	9
Weathered/Fractured Granitoids & Gneiss	4	4
Khondalite & Metasediments	2	1

Lithology Class	Recharge Rank	Extraction Rank
Charnockite & Other Crystalline Rocks	5	3

Table 7-3: Recharge and Extraction potential ranks for Geomorphology Layer
(Source: IIT Bhubaneswar)

Geomorphology Class	Recharge Rank	Extraction Rank
Pediplain Shallow Weathered	5	9
Lateritic Upland	9	5
Pediment	7	4
Valley Fill	3	3
Upland	8	2
Valley	1	1

Table 7-4: Recharge and Extraction potential ranks for LULC Layer (Source: IIT Bhubaneswar)

LULC Class	Recharge Rank	Extraction Rank
Agricultural	9	9
Forest & Plantation	6	7
Built up Area	3	5
Scrub Land	7	4
Waterbodies	1	1

Table 7-5: Recharge and Extraction potential ranks for Surface Texture Layer
(Source: IIT Bhubaneswar)

Surface Soil Texture class	Recharge Rank	Extraction Rank
Clay Loam	1	9
Sandy Clay Loam	4	8
Silty Clay Loam	3	6
Sandy Loam	7	4

Surface Soil Texture class	Recharge Rank	Extraction Rank
Sandy Clay	5	4
Loamy Sand	9	3
Loam	6	1

Table 7-6: Recharge and Extraction potential ranks for Slope Layer (Source: IIT Bhubaneswar)

Slope Class	Recharge Rank	Extraction Rank
Flat	9	9
Gentle	7	7
Steep	3	5
Moderate	8	3
Very Steep	1	1

Table 7-7: Recharge and Extraction potential ranks for Drainage Density Layer (Source: IIT Bhubaneswar)

Drainage Density Class	Recharge Rank	Extraction Rank
Very Low	8	9
Low	6	7
Mild	4	5
High	3	3
Very High	1	1

Table 7-8: Recharge and Extraction potential ranks for Lineament Density Layer (Source: IIT Bhubaneswar)

Lineament Density Class	Recharge Rank	Extraction Rank
Very High	8	9
High	5	7
Mild	3	5
Low	2	3

Lineament Density Class	Recharge Rank	Extraction Rank
Very Low	1	1

Table 7-9: Recharge and Extraction potential ranks for Elevation Layer
(Source: IIT Bhubaneswar)

Elevation Class	Recharge Rank	Elevation Class
Very Low	1	9
Low	3	7
Mild	5	5
High	7	3
Very High	9	1

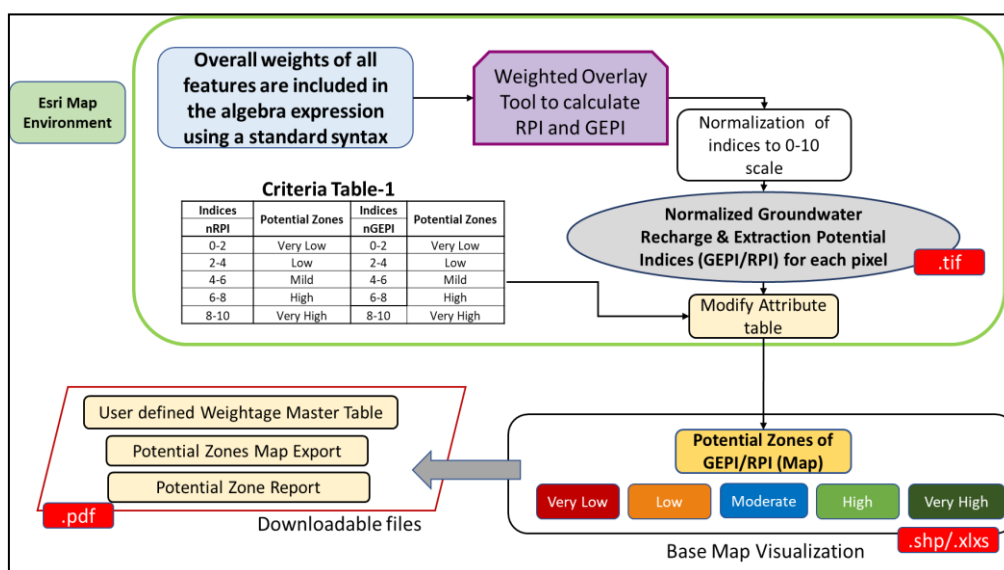


Figure 7-1: Flow diagram for the execution of the DSS for identifying groundwater recharge potential zones and groundwater extraction potential zones
(Source: IIT Bhubaneswar)

7.4 Steps involved in executing the DSS for Identifying the groundwater recharge potential zones and extraction potential zones in the portal

- 1. Log in to the Portal:** After successfully logging into the portal, the user should click the DSS tab located at the top right side of the webpage.
- 2. Open DSS Modules:** Once the DSS tab is selected, two options DSS and Layers will appear on the left side of the webpage. The user should click on the DSS option.

3. **Select Hydrology Category:** Three categories will be displayed. The user must select Hydrology, which will expand to show a list of DSS modules available under the hydrology category.
4. **Select Groundwater Recharge and Extraction Module:** From this list, the user should select Groundwater Recharge and Extraction.
5. **Choose Plot Selection Method:** A groundwater recharge and extraction dialogue box will then appear, providing two options for selecting the cadastral plot: From List and from Map.
 - **From List:** allows the user to manually select the District, Block, Cluster, Micro Watershed, village, and plot.
 - **From Map:** allows user can simply click on the desired location on the map. The system instantly auto-populates all relevant administrative attributes District, Block, Cluster, Micro Watershed, Village, and Plot Number eliminating the need for manual entry.

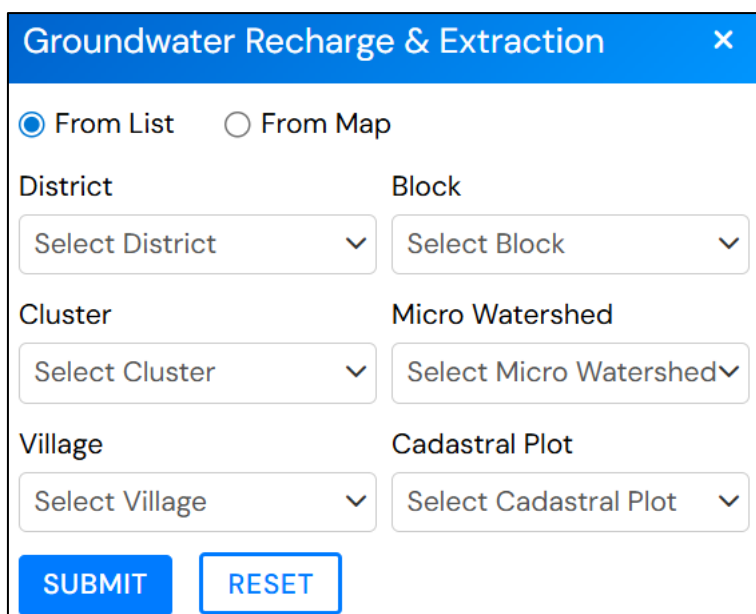


Figure 7-2: Dialogue box for input fields

6. **Display of Results:** As soon as the user submit the plot number, the system displays the output results contains attributes:
 - i. Micro Watershed
 - ii. Micro Watershed code
 - iii. Plot
 - iv. Groundwater extraction zone
 - v. Groundwater potential zone
- **Download and Export Results:** Users are also provided with options to download the report and export the results to Excel.

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dnt1208017186					
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:	
S. No	Micro Watershed	Micro Watershed Code	Plot	Ground Water Extraction	Ground Water Recharge
1	Bhadimura	O407010207140201	Dnt1208017186	Mild	High
Showing 1 to 1 of 1 entries					
				Previous	Next

The process flow for execution of the DSS for Groundwater Recharge and Extraction Zone Mapping in the portal is given in Figure 7-3.

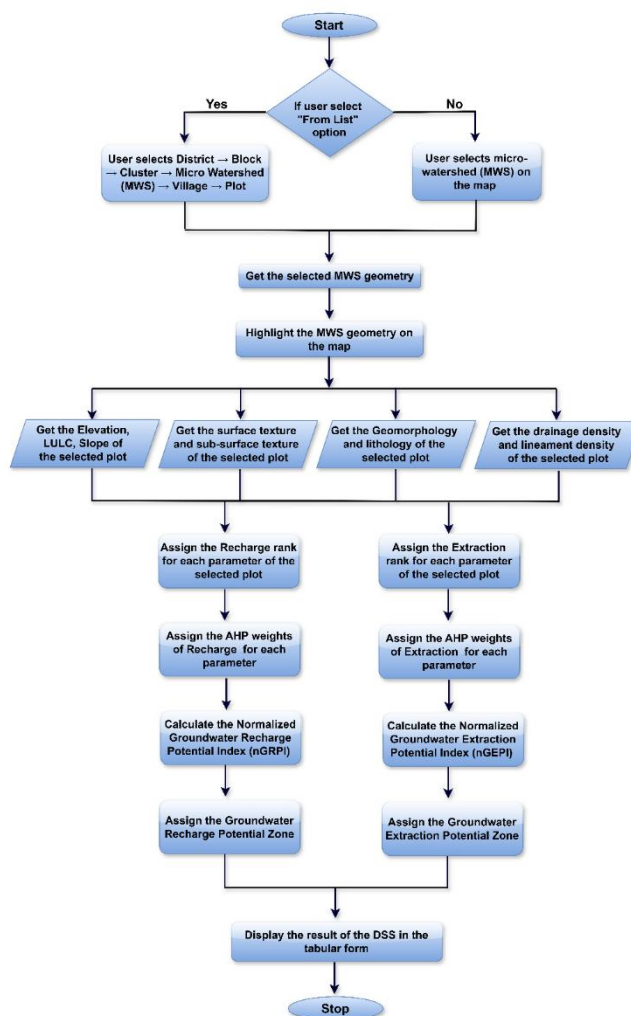


Figure 7-3: Flow diagram for the execution of DSS on groundwater recharge and extraction zone mapping in the portal

8 DSS-6: Siting of Groundwater Recharge & Extraction Structure

8.1 Purpose

The purpose of this DSS is to identify appropriate locations for groundwater recharge and extraction structures by integrating land use, slope, and hydrogeological. Using inputs such as LULC, slope, nGRPI, and nGEPI, the system evaluates the suitability of each area within a watershed for interventions like recharge pits, recharge shafts, percolation ponds, recharge basins, and dug wells.

8.2 Key Functions

- Analyze spatial parameters such as LULC, slope, nGRPI, and nGEPI to determine suitability for recharge and extraction structures.
- Apply hydro geologically validated criteria for selecting specific interventions including recharge pits, shafts, ponds, basins, and dug wells.
- Generate plot-level siting recommendations for both recharge and extraction interventions.
- Support preparation of groundwater management plans by providing consistent, scientifically grounded outputs.

8.3 Methodology for Siting Groundwater Recharge and Extraction Structures

- i. **Prepare Input Data:** Load the required spatial layers into the GIS environment:
 - LULC Class
 - Slope Class
 - Delineated Ground Water Recharge Potential Indices (GRPI)
 - Delineated Ground Water Extraction Potential Indices (GEPI)
- ii. **Standardize and Classify Layers:** Ensure that LULC and slope layers are properly classified and that GRPI/GEPI values are normalized as required.
- iii. **Perform Spatial Intersection:** Use a spatial intersection/overlay tool to combine LULC, slope, GRPI, and GEPI into a single output layer. This creates a unified dataset where each spatial unit has all required attributes.
- iv. **Apply Suitability Criteria:** Based on the combined attributes, apply the predefined criteria table (Table 8-1) to determine the suitable recharge or extraction structure.
- v. **Generate Suitability Output:** Export the results as maps and tables showing suitability for:
 - Recharge structures
 - Extraction wells

**Table 8-1: Criteria Table for Siting of Well and Artificial Recharge Structure
(Source: IIT Bhubaneswar)**

LULC	Slope (%)	Normalized GRPI (nRPI)	Normalized GEPI (nGEPI)	Recommendation
Agriculture/Shrub Land	Slope Less than 20%	0-2	0-2	No Intervention
			2-4	No Intervention
			4-6	Recharge Pit, Recharge Shaft
			6-8	Recharge Pit, Recharge Shaft
			8-10	Dug Well
		2-4	0-2	No Intervention
			2-4	No Intervention
			4-6	Recharge Pit, Recharge Shaft, Percolation Pond
			6-8	Dug Well
			8-10	Dug Well
		4-6	0-2	No Intervention
			2-4	Recharge Pit, Recharge Shaft, Percolation Pond
			4-6	Recharge Pit, Recharge Shaft, Percolation Pond
			6-8	Dug Well
			8-10	Dug Well
		6-8	0-2	No Intervention
			2-4	Recharge Pit, Recharge Basins
			4-6	Dug Well, Recharge Pit, Recharge Basins
			6-8	Dug Well
			8-10	Dug Well
		8-10	0-2	No Intervention
			2-4	No Intervention

LULC	Slope (%)	Normalized GRPI (nRPI)	Normalized GEPI (nGEPI)	Recommendation
			4–6	Dug Well
			6–8	Dug Well
			8–10	Dug Well
Habitation	Any slope	–	–	Recharge Shaft, Gravity Head Recharge Well
Water Bodies	Any slope	–	–	No Intervention
Forest	Any slope	–	–	No Intervention
Any Other	Greater than 20%	–	–	No Intervention
Habitation	Any slope	–	–	Recharge Shaft, Gravity Head Recharge Well

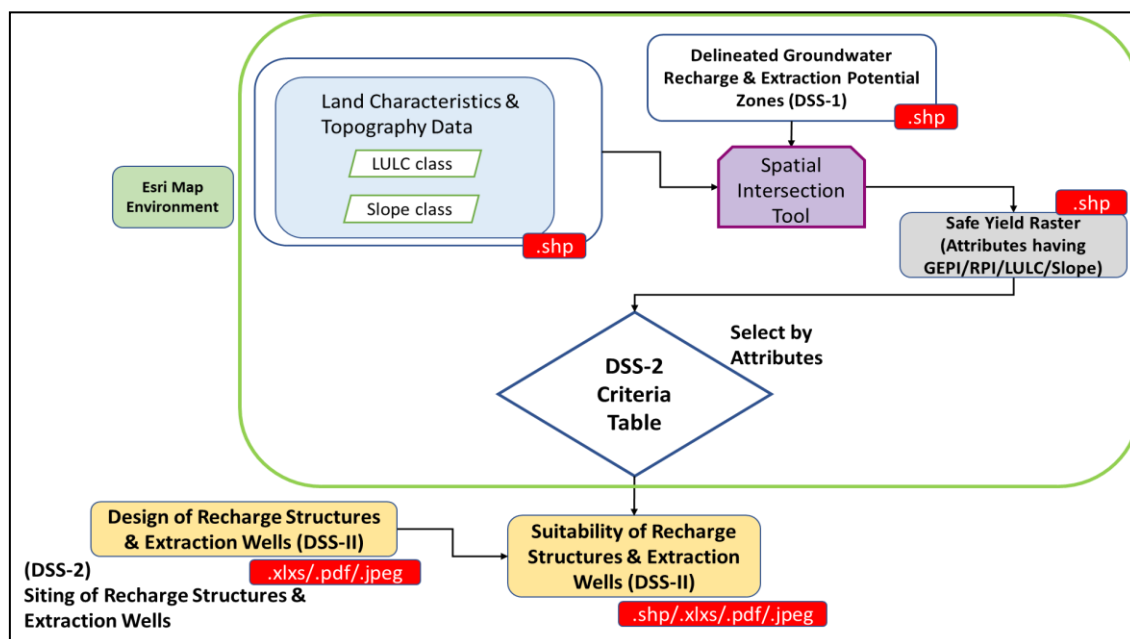


Figure 8-1: Flow diagram for the execution of the DSS for identifying groundwater recharge potential zones and groundwater extraction potential zones (Source: IIT Bhubaneswar)

8.4 Steps involved in executing the DSS for siting the groundwater recharge and extraction structures in the portal

1. **Log in to the Portal:** After successfully logging into the portal, the user should click the DSS tab located at the top right side of the webpage (Figure 8-3)
2. **Open DSS Modules:** Once the DSS tab is selected, two options DSS and Layers will appear on the left side of the webpage. The user should click on the DSS option.
3. **Select Hydrology Category:** Three categories will be displayed. The user must select Hydrology, which will expand to show a list of DSS modules available under the hydrology category.
4. **Select Siting of Groundwater Recharge and Extraction Structures Module:** From this list, the user should select Siting of Groundwater Recharge and Extraction Structure.
5. **Choose Plot Selection Method:** A groundwater recharge and extraction dialogue box will then appear, providing two options for selecting the cadastral plot: From List and from Map.
 - **From List:** allows the user to manually select the District, Block, Cluster, Micro Watershed, village, and plot.
 - **From Map:** allows user can simply click on the desired location on the map. The system instantly auto-populates all relevant administrative attributes District, Block, Cluster, Micro Watershed, Village, and Plot Number eliminating the need for manual entry.

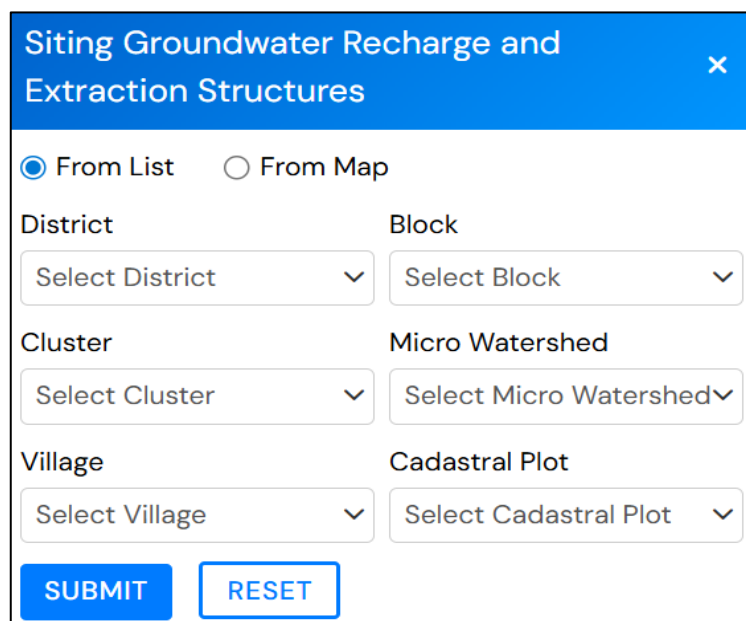


Figure 8-2: Dialogue box for input fields

6. **Display of Results:** As soon as the user submit the plot number, the system displays the output results contains attributes:
 - i Micro Watershed
 - ii Micro Watershed Code
 - iii Plot Number

iv Structure Recommended

7. **Download and Export Results:** Users are also provided with options to download the report and export the results to Excel.

District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dnt1208017186

EXPORT TO EXCEL

DOWNLOAD REPORT

Search:

Micro Watershed	Micro Watershed Code	Plot	Structure Recommended
Bhadimura	O407010207140201	Dnt1208017186	No Intervention

Showing 1 to 1 of 1 entries

Previous

1

Next

The process flow for execution of the DSS for Siting of Groundwater Recharge & Extraction Structure in the portal is given in Figure 8-3.

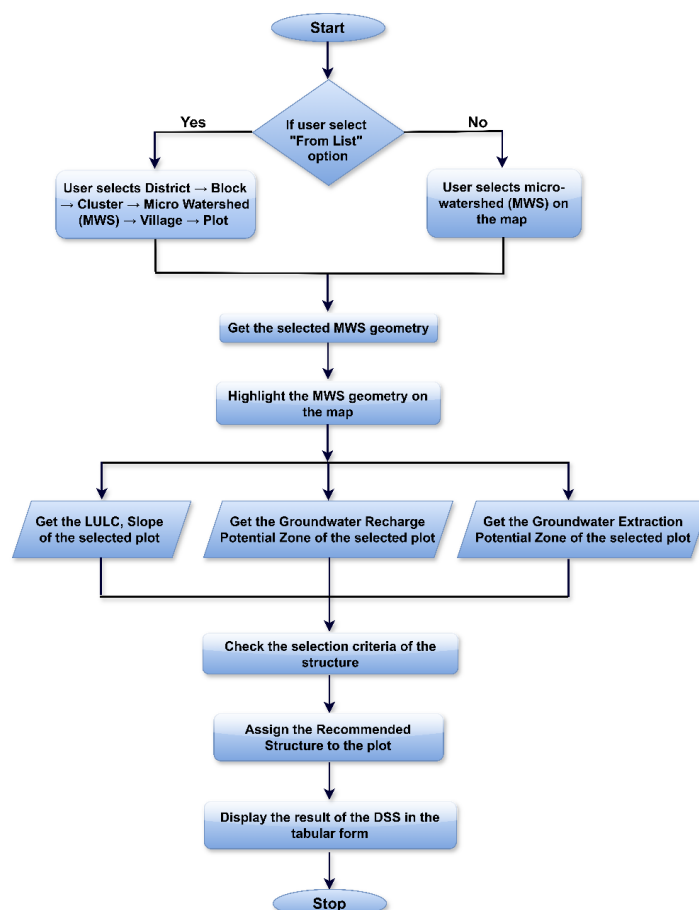


Figure 8-3: Flow diagram for the execution of DSS on groundwater recharge and extraction structures in the portal

9 DSS-7: Sector-wise Water Demand Estimation

9.1 Purpose

The purpose of this module is to estimate water demand for various sectors, including domestic water demand, livestock water demand, and crop water demand. It helps in understanding sector-wise water requirements for better planning, management, and allocation of water resources.

9.2 Definitions

- **Domestic Water Demand (DWD):** Domestic water demand refers to the water required by the population to meet their basic needs. It is calculated by multiplying the population by the respective per-capita water demand factor.
- **Livestock Water Demand (LWD):** Livestock water demand refers to the amount of water required by different livestock animals to meet their drinking and basic physiological needs. It is calculated by multiplying the livestock population by the respective per-animal water demand factor.
- **Crop Water Demand (CWD):** Crop water demand refers to the amount of water required by crops to grow properly and complete their life cycle. It is calculated based on the crop area, crop type, and the crop water requirement (CWR) for the specific region and season.
- **Evapotranspiration (ET_0):** Evapotranspiration is the combined flux of water vapour from the land surface to the atmosphere, resulting from the simultaneous processes of soil and water surface evaporation and plant transpiration.
- **Crop Evapotranspiration (ET_c):** Crop Evapotranspiration is the evapotranspiration from a disease-free, well-fertilised crop, grown in large fields under optimum soil water conditions, and achieving full production under the given climatic conditions.

9.3 Source of This Module

1. Allen, R.G., Pereira, L.S., Raes, D., & Smith, M. (1998). FAO 56—Crop Evapotranspiration. FAO Irrigation and Drainage Paper 56.
2. Paredes, P. et al. (2024). Single and basal crop coefficients for tropical legumes. Agricultural Water Management.
3. Aiswarya, L. et al. (2019). Estimation of Actual Crop Evapotranspiration and Kc of Green Chilli. IJCMAS.
4. Deepika Yadav, M.K. Awasthi, & R.K. Nema (2017). Crop water requirement of micro-irrigated orchard crops including mango.
5. Kumar, Rohitash et al. "Development of Crop Coefficients for Precise Estimation of Evapotranspiration for Mustard in Mid Hill Zone- India." (2012).
6. Singh, R. & Singh, R.P. (2015). Growth, development, and water requirements of sorghum. Indian Journal of Agronomy.

9.4 Flow Charts

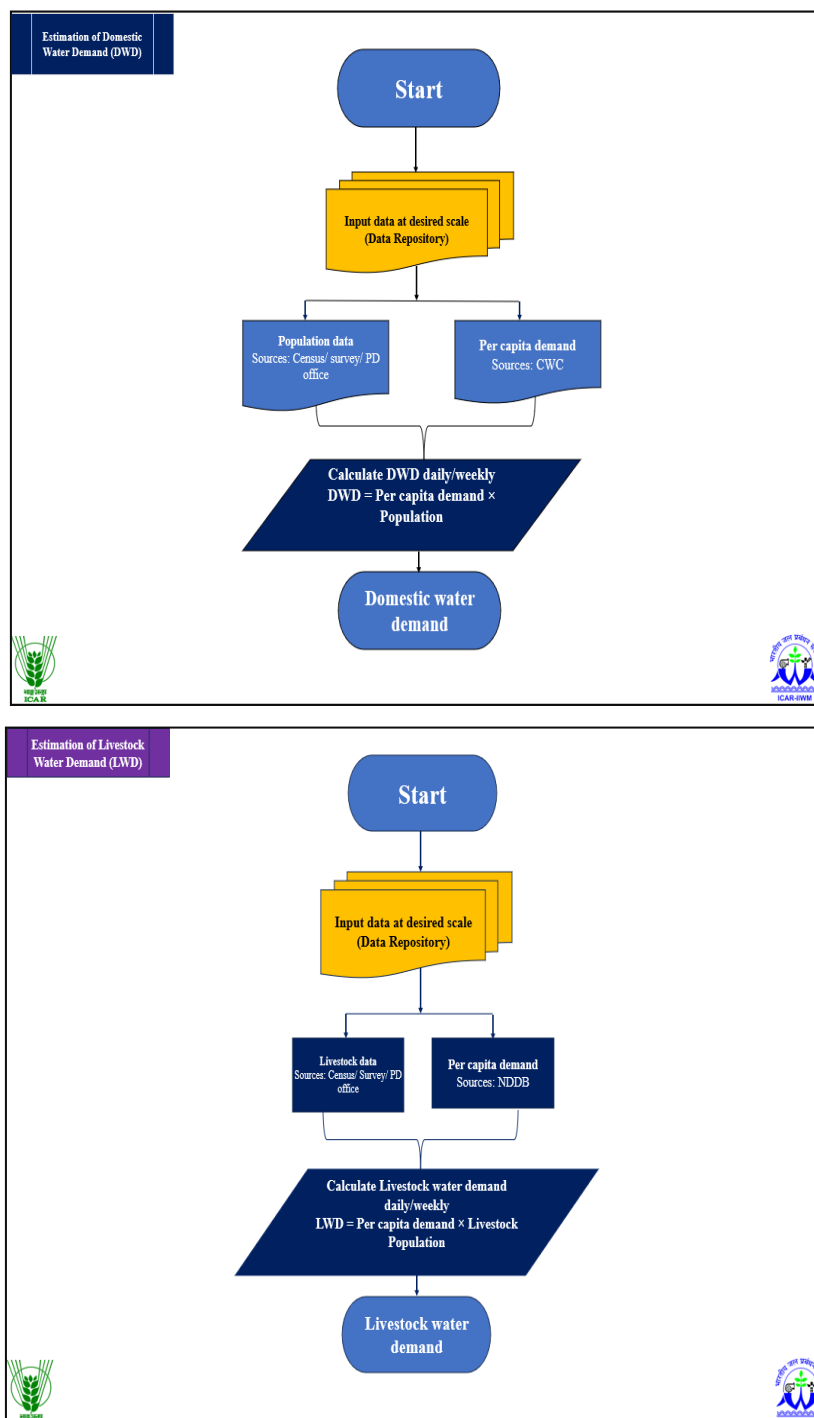


Figure 9-1: Estimation of domestic water demand (DMD) and livestock water demand (LWD) (Source: IIWM, Bhubaneswar)

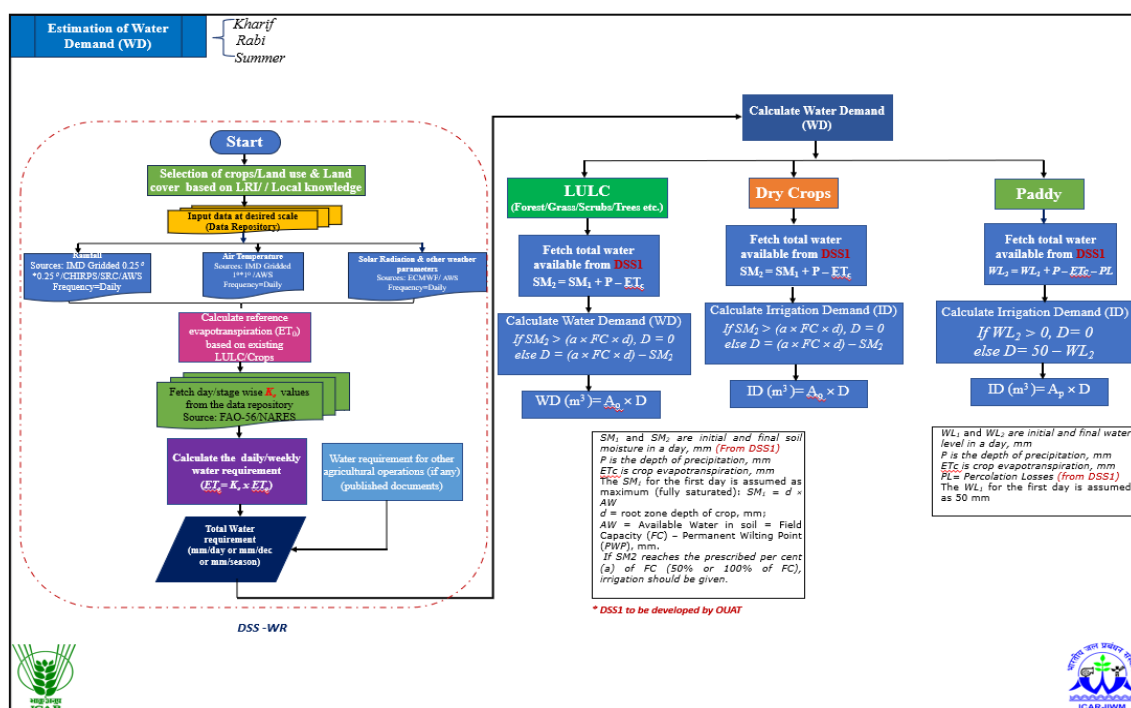


Figure 9-2: Estimation of crop water demand (Source: IIWM, Bhubaneswar)

9.5 Input Required

To generate the water demand estimation in the Decision Support System (DSS), multiple datasets related to climate, topography, crop growth, and demographic factors are required. These inputs are used to compute domestic water demand, livestock water demand and crop water demand within the selected catchment. The list of input parameters utilized in the DSS is presented Table 9-1

Table 9-1: List of input parameters used in the DSS

S. No.	Category	Input Parameter
1	Climate and Meteorological Data	Maximum Temperature Minimum Temperature Solar Radiation
2	Topographical Data	Catchment Area
3	Socio-Economic Data	Domestic Population Livestock Population
4	Crop Details	Crop Name
5	Crop Growth Parameter	Crop Coefficient values Development Stages
6	Population Factor	Domestic Population Per Capita Factor Livestock Population Per Capita Factor

9.6 Steps involved in the estimation of Water Demand for domestic, livestock and crop

Table 9-2: Description of steps involved in water demand estimation

S. No.	Description of the steps involved
1.	Select the plot
2.	Fetch the MWS data associated with this plot.
3.	Fetch the domestic population and livestock population associated with the MWS from the database.
4	Estimate the domestic population water demand by multiplying the domestic population by the per capita domestic water requirement.
5	Estimate the livestock population water demand by multiplying the livestock population by the per capita livestock water requirement.
6	Fetch the climate parameters (solar radiation, maximum temperature and minimum temperature) for the selected plot.
7	Estimate the daily evapotranspiration.
8	Estimate crop evapotranspiration by multiplying the evapotranspiration with the crop coefficient.
9	Estimate the stage-wise crop evapotranspiration by multiplying the crop evapotranspiration with the crop duration for different stages.
10	Estimate the stage-wise crop water demand by multiplying the stage-wise crop evapotranspiration with the plot area.
11	Display the domestic water demand and livestock water demand at the MWS scale and stage-wise crop water demand for the selected plot.

9.6.1 PER CAPITA FACTORS

Per capita factors represent the average daily amount of water needed per person or animal, and are used to estimate the total water demand. These factors help quantify domestic water needs as well as livestock water consumption. The calculation involves multiplying the population of each category by its respective per capita value. In this module, a factor of 135 L/day is used for the domestic population. For livestock, the assumed daily water requirements are 75 L/day for cows and buffaloes, 14 L/day for sheep and goats, 30 L/day for pigs, and 0.75 L/day for poultry. These standardized values enable the accurate estimation of total water demand, as given in Table 9-3.

Table 9-3: List of per capita factors (Source: IIWM, Bhubaneswar)

Population	Per Capita Factor (lpcd)
Domestic Population	135
Cow	75
Buffalo	75
Sheep	14
Goat	14
Pig	30
Poultry	0.75

9.6.2 ESTIMATION OF EVAPOTRANSPIRATION

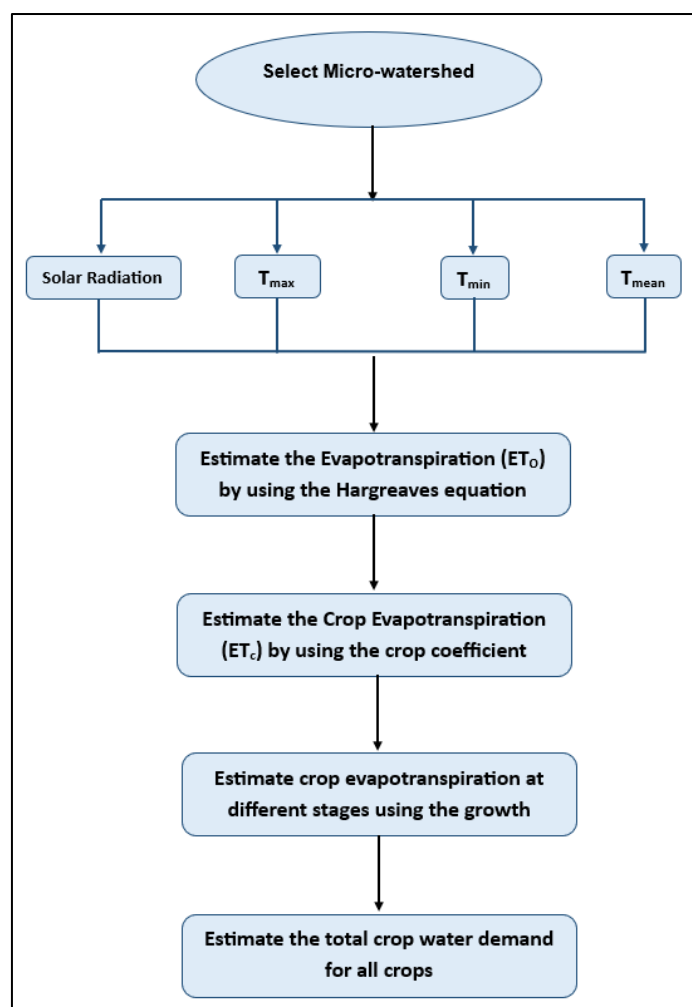


Figure 9-3: Process of Calculating the crop water demand

Evapotranspiration is a fundamental hydrological process representing the combined loss of water from a land surface through soil evaporation and plant transpiration. In this module, Hargreaves method is used for estimating the evapotranspiration. This method provides an empirical approach for estimating evapotranspiration (ET_0) based primarily on temperature and solar radiation.

Hargreaves Equation

$$ET_0 = \frac{0.0023 * R_a * (T_{mean} + 17.8) * (T_{max} - T_{min})^{0.5}}{2.26}$$

- ET_0 = Evapotranspiration mm/day
- R_a = Solar Radiation, W/m^2
- T_{mean} = Daily mean air temperature $^{\circ}C$
- T_{max} = Daily maximum temperature $^{\circ}C$
- T_{min} = Daily minimum temperature $^{\circ}C$
- The constant 2.26 is used to convert solar radiation from energy units (W/m^2) into equivalent water depth in mm/day.

Mean air temperature (T_{mean}) is calculated as:

$$T_{mean} = \frac{T_{min} + T_{max}}{2}$$

9.6.3 CROP COEFFICIENT VALUES AND GROWTH PERIOD

Crop coefficient (K_c) values represent the ratio between crop evapotranspiration and evapotranspiration. These values indicate how much water a specific crop requires at different growth stages. Since each crop has a unique water demand pattern, K_c values vary during initial, mid, and end growth periods, as given in the Table 9-4. In this module, the crop evapotranspiration (ET_c) is estimated by multiplying the evapotranspiration (ET_0) with the corresponding crop coefficient (K_c) of the given crops.

Table 9-4: Crop name and its coefficient values (Source: Section 9.3)

Crop Name	KC_initial	KC_mid	KC_end
Paddy	1.05	1.2	0.75
Blackgram	0.4	1.05	0.35
Redgram	0.4	1.15	0.35
Maize	0.3	1.2	0.5
Groundnut	0.4	1.5	0.6
Sesame	0.35	1.1	0.25
Millets	0.3	1	0.3
Sorghum	0.3	1.15	0.4
Mustard	0.4	1.2	0.6
Cowpea	0.4	1.05	0.35
Greengram	0.4	1.05	0.35
Rabi_Veg			

Crop Name	KC_initial	KC_mid	KC_end
Cashewnut	0.65	0.9	0.75
Citrus	0.8	1.05	0.8
Mango	0.6	0.8	0.7
Pearl Millet	0.3	1	0.3
Finger Millet	0.3	1	0.3
Little	0.3	1	0.35
French Bean	0.5	1.05	0.9
Chili	0.6	1.05	0.8
Cabbage	0.7	1.05	0.95
Banana	1	1.25	1
Guava	0.8	1	0.8

Table 9-5: Crop name and its growth period (Source: Section 9.3)

Crop Name	KC_initial	KC_dev	KC_mid	KC_end
Paddy	30	40	50	20
Blackgram	15	30	40	15
Redgram	20	40	40	25
Maize	20	35	40	30
Groundnut	25	35	45	25
Sesame	20	30	40	20
Millets	15	20	40	25
Sorghum	20	30	40	30
Mustard	25	30	40	20
Cowpea	20	30	30	20
Greengram	20	30	30	20
Rabi_Veg				
Cashewnut	30	45	60	30
Citrus	60	90	120	95
Mango	35	60	100	45
Pearl Millet	15	20	40	25
Finger Millet	15	20	40	25
Little	15	20	40	25
French Bean	20	30	30	10
Chili	30	40	90	25
Cabbage	40	60	50	15
Banana	120	90	120	60
Guava	40	60	90	45

9.7 Steps for the execution of DSS on sector-wise water demand in the portal

1. After successfully logging into the portal, the user shall select the DSS tab located on the right side of the web page.

2. Once the user clicks on the DSS tab, then two options, “DSS” and “Layers” will be displayed on the left of the web page.
3. The user will select the DSS tab.
4. There will be three options, and the user needs to select the Hydrology option; a list of DSS modules will then drop down under the Hydrology tab.
5. The user shall select the DSS module named **Sector-wise water demand** from the list. After selecting the module, a dialogue box will appear on the right side of the web page.
6. The dialogue box will have two options to select Micro Watershed, “From List” and “From Map”. The “From List” option allows the user to select District, Block, Cluster, Micro Watershed, Village and Cadastral Plot. The details of the input fields in the Web page are as mentioned in the section. The “From Map” option will allow the user to select on the map, which will auto-fill the District, Block, Cluster, Micro Watershed, Village and Cadastral Plot.

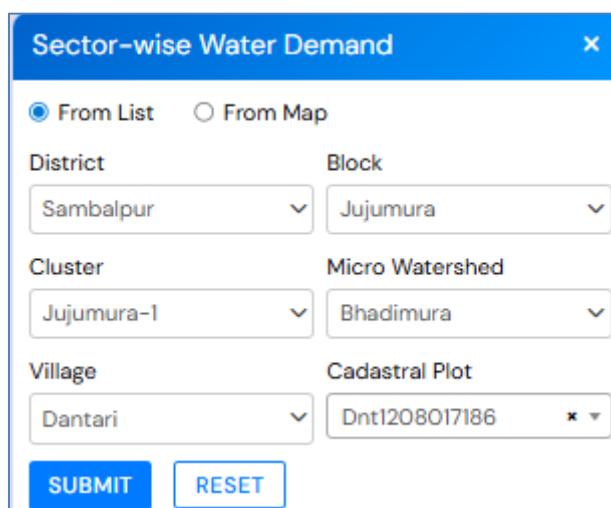


Figure 9-4: Dialogue box for selecting the input fields

7. The user will select the District, Block, Cluster, Micro Watershed, Village and Cadastral Plot.
8. A database query will be executed to retrieve the MWS associated with this plot.
9. A database query will be triggered to retrieve the domestic population records from the master table linked to the selected micro-watershed.
10. Once the domestic population data is retrieved, the Domestic Water Demand (DWD) is computed by multiplying the population count with its corresponding per capita water requirement factor as mentioned in Table 9-3.

$$DWD = \text{Domestic population} * \text{per capita water requirement}$$

11. A database query will be triggered to retrieve the livestock population records from the master table linked to the selected micro-watershed.

12. Once the livestock population data is retrieved, the Livestock Water Demand (LWD) is computed by multiplying the population count with its corresponding per capita water requirement factor as mentioned in Table 9-3.

$$LWD = \text{Livestock population} * \text{per capita water requirement}$$

13. A database query will be triggered to retrieve the climate parameters (maximum temperature, minimum temperature and solar radiation) from the master table linked to the micro watershed associated with the plot.
14. In the master table, the long-term climatic datasets are stored as 30-year averages (e.g., 1995–2024). For instance, when a query retrieves temperature data, the system returns the 30-year-averaged temperature values for that period in the micro-watershed.
1. Estimate the evapotranspiration by applying the Hargreaves equation to the retrieved temperature and solar radiation parameters.

$$ET_o = \frac{0.0023 * R_a * (T_{mean} + 17.8) * (T_{max} - T_{min})^{0.5}}{2.26}$$

- ET_o = Evapotranspiration mm/day
 - R_a = Solar Radiation, W/m^2
 - T_{mean} = Daily mean air temperature $^{\circ}C$
 - T_{max} = Daily maximum temperature $^{\circ}C$
 - T_{min} = Daily minimum temperature $^{\circ}C$
2. Estimate the crop evapotranspiration (ET_c) by multiplying the reference evapotranspiration (ET_o) with the crop coefficient (K_c) corresponding to the specific crop and its growth stage.

For example, if the selected crop is paddy and it is currently in the initial growth stage, then the crop evapotranspiration (ET_c) is calculated by multiplying the reference evapotranspiration (ET_o) with the crop coefficient (K_c) of paddy corresponding to its initial stage.

$$ET_c = K_c * ET_o$$

3. Estimate the crop evapotranspiration (ET_c) mm/day for the different crop development stages.
4. Estimate the crop water demand by summing the crop evapotranspiration (ET_c) mm/day values computed for the different growth stages.
5. A database query will be triggered to retrieve the area from the master table linked to the selected plot.
6. Estimate the total crop water demand (CWD) m^3/day by multiplying the crop water demand with the area of all stages for the selected plot.
7. Display the results in a tabular format using the fields listed below.

- Plot ID
 - Micro Watershed Name
 - Micro Watershed Code
 - Domestic Water Demand (m³/day)
 - Livestock Water Demand (m³/day)
 - Stage-wise Crop Water Demand (m³/day)
 - Total Water Demand (m³/day)
8. Display the results on the web page in the form of Table view and Chart view.
 9. The Micro watershed will be visually highlighted on the map in the web application.

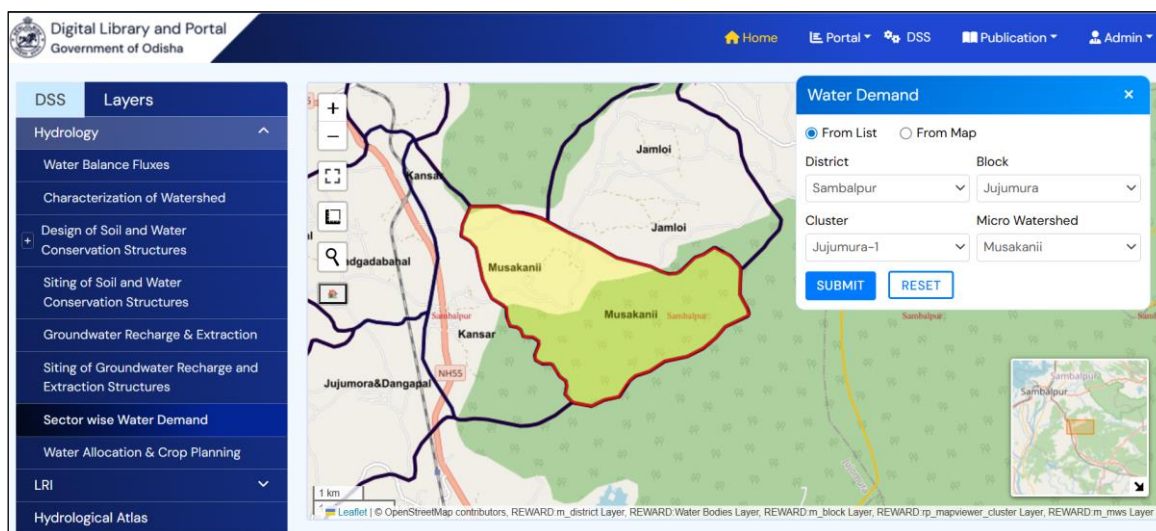


Figure 9-5: Selected Micro-Watershed Highlighted on the Map

10. If the user selects the table view option, a tabular output will be displayed on the web page showing the Micro Watershed Name, Micro Watershed Code, Total Water Demand, Domestic Water Demand (DWD), Livestock Water Demand (LWD), and Crop Water Demand (CWD) for all crops, as shown in Figure 9-6.

$$\text{Total Water Demand} = \text{DWD} + \text{LWD} + \text{CWD}$$

Table View										
Chart View										
District:Sambalpur Block:Jujumura Cluster:Jujumura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dnt1208017186										
EXPORT TO EXCEL DOWNLOAD REPORT										
S. No.	Plot	Micro Watershed Name	Micro Watershed Code	Domestic Water Demand - MWS (m ³ /day)	Livestock Water Demand - MWS (m ³ /day)	Crop Name / Water Demand (m ³ /day)				
						Crop Name	Initial Stage	Mid Stage	End Stage	Total
1	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Blackgram	280.59	785.95	362.23	1428.77
2	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Cashewnut	656.37	1527.15	1492.92	3676.44
3	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Citrus	1223.52	1262.74	868.52	3354.78
4	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Cowpea	496.89	587.63	362.23	1446.75
5	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Greengram	496.89	587.63	362.23	1446.75
6	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Groundnut	388.74	1107.91	1224.11	2720.76
7	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Maize	496.89	537.79	417.28	1451.96
8	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Mango	679.73	646.42	760.29	2086.44
9	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Millets	242.89	652.55	310.48	1205.92
10	Dnt1208017186	Bhadimura	0407010207140201	4105	15.69	Mustard	166.91	952.43	628.65	1747.99

Figure 9-6: Output in Tabular View of Sector-wise crop water demand DSS

11. If the user selects the Chart View option, they must first choose a crop. After the crop selection, a bar chart representing Domestic Water Demand (DWD), Livestock Water Demand (LWD), and Crop Water Demand (CWD) will be generated and displayed on the screen, as shown in Figure 9-7.

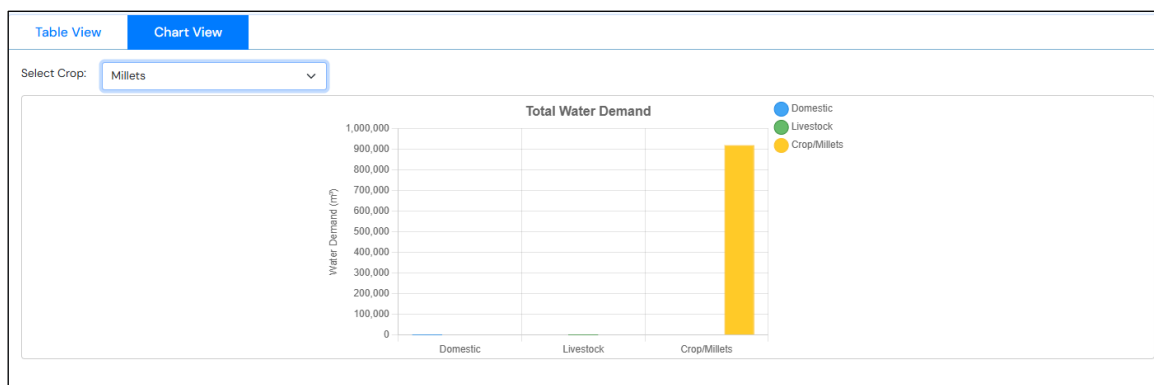


Figure 9-7: Output in Chart View of Sector-wise crop water demand DSS

12. Users can export the Excel sheet by using “EXPORT TO EXCEL” and also export the generated report through the “DOWNLOAD REPORT” option.

The process flow for execution of the DSS for Sector-wise Water Demand Estimation in the portal is given in Figure 9-8.

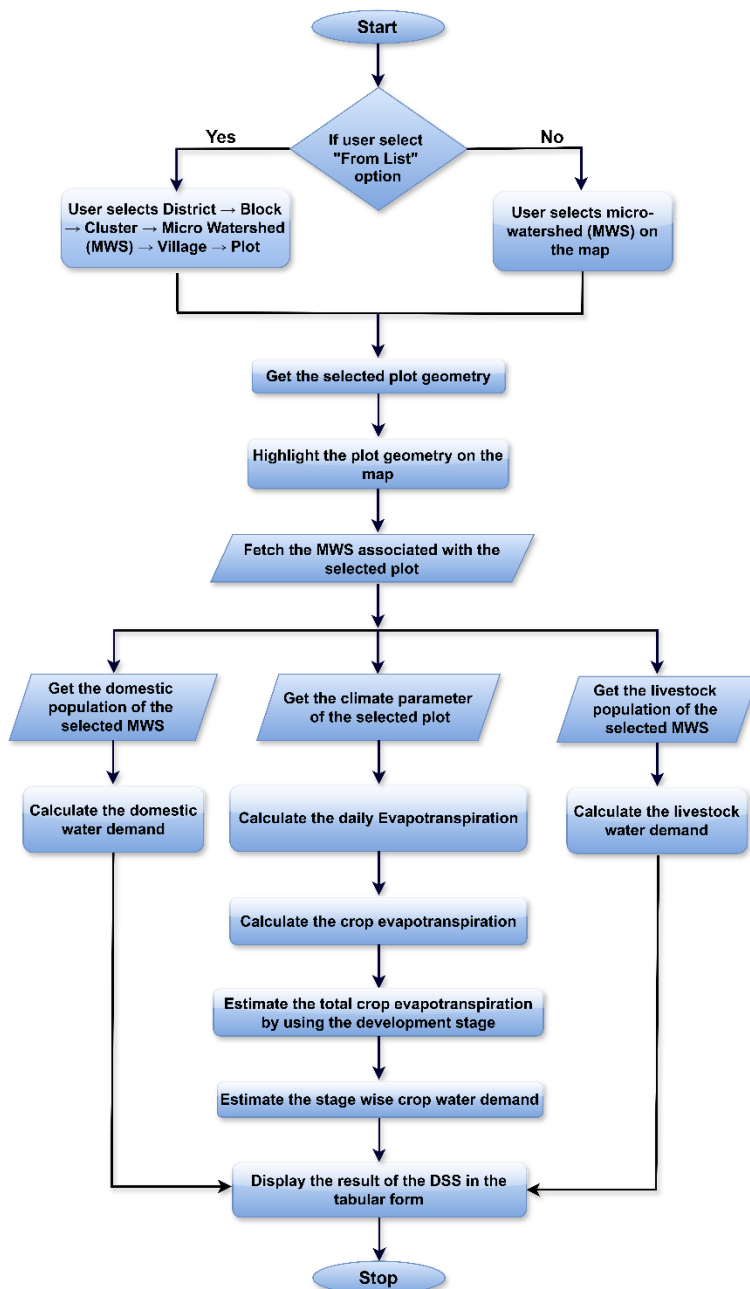


Figure 9-8: Flow diagram for the execution of DSS on sector-wise water demand estimation in the portal

10 DSS-8: Water Allocation and Crop Planning

10.1 Purpose

To allocate water resources efficiently across domestic, livestock, and agricultural sectors and support scientific crop planning. By integrating climate data, crop coefficients, and demand factors, the module recommends suitable cropping options based on available water or provides advisory.

10.2 Key Functions

- The available water is first allocated to meet domestic and livestock water demands before being distributed for agricultural use.
- An advisory will be generated based on the comparison between available water resources and the estimated water demand.
- A suitable crop will be recommended based on the remaining available water after meeting domestic and livestock water demands.

10.3 Flow Chart

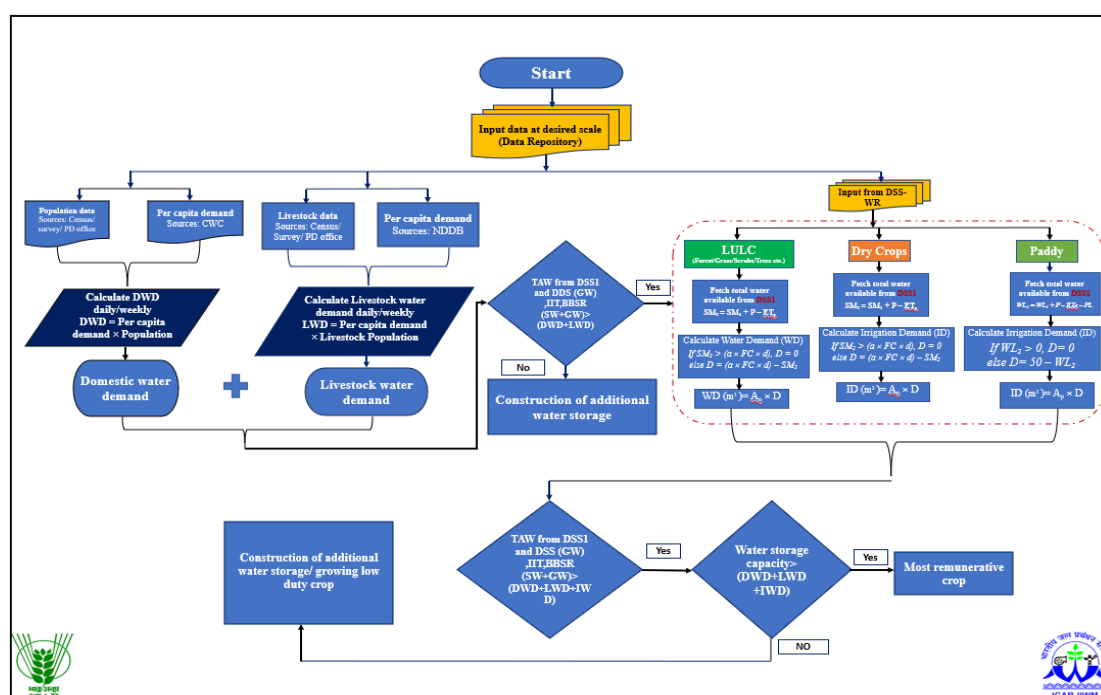


Figure 10-1: Flow Chart of Water Allocation and Crop Planning (Source: IIWM, Bhubaneswar)

10.4 Input Data Required

Table 10-1: Input data used in the DSS8 module

S. No.	Input data	Unit
1	Domestic Water Demand	m/day

S. No.	Input data	Unit
2	Livestock Water Demand	m/day
3	Surface Water	mm
4	Groundwater Water	m
5	Soil Moisture of the Previous Day	mm
6	Soil Moisture of the Current Day	mm
7	Rainfall of the Previous day	mm
8	Percolation Loss	mm
9	Water Level of the Previous Day	mm
10	Crop Coefficient	
11	Stage of Growth	
12	Area of crop	ha
13	Maximum Temperature	$^{\circ}\text{C}$
14	Minimum Temperature	$^{\circ}\text{C}$
15	Solar Radiation	W/m^2
16	Name of Crop	
17	Date of showing the crop	

10.5 Steps involved in the estimation of Water Allocation and Crop Planning

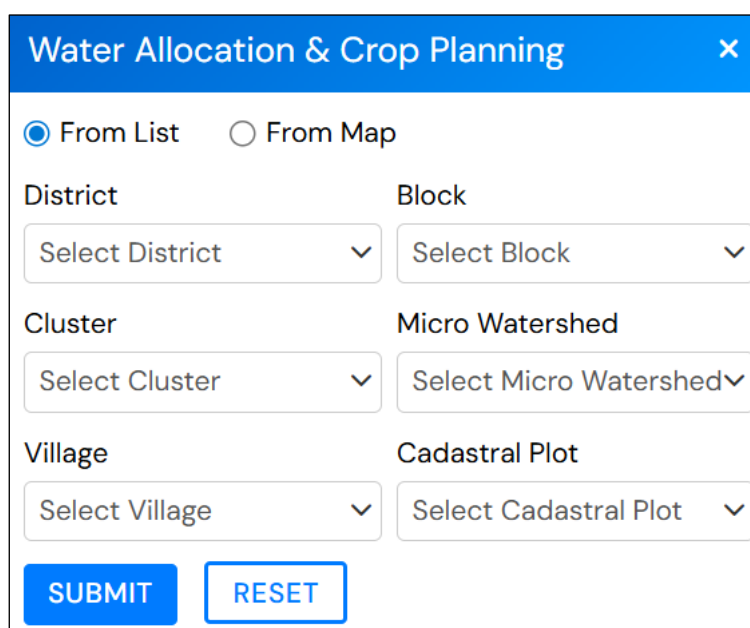
Table 10-2: Description of steps involved in the estimation of Water Allocation and Crop Planning

S. No.	Description of the steps involved
1.	Select the plot number, crop name and date of showing.
2.	A database query will be executed to retrieve the MWS associated with this plot.
3.	Count the number of days since the crop showing to the current date. Case 1: If the number of days is more than the crop period of the selected crop, then IWD is 0. Case 2: If the number of days is less than the crop period of the selected crop, then follow the steps given below
3	A query will be executed to retrieve the DWD and LWD for that MWS from DSS-7
4	Retrieve the runoff (mm) associated with this MWS from the DSS-1 and convert it into meters (m).
5	Retrieve the Groundwater associated with this MWS from the database.
6	Estimate the Total Available Water (TAW) by adding the surface runoff water and groundwater, then multiplying by the MWS area.
7	Compare the Total Available Water (TAW) with the combined Domestic Water Demand (DWD) and Livestock Water Demand (LWD)
8	If TAW is less than OR EQUAL TO THE combined demand (DWD and LWD), the output will be displayed as "Construction of additional water storage."

S. No.	Description of the steps involved
9	If TAW is greater than the combined demand, the crop evapotranspiration (ET _c) will be calculated for the selected crop.
10	Estimate the water demand (D) based on soil moisture status, precipitation, and crop evapotranspiration (ET _c).
11	Fetch the area associated with the selected plot from the master table.
12	Estimate the Irrigation Water Demand (IWD) by multiplying the plot area with the water demand (D).
13	Compare the Total Available Water (TAW) with the combined Domestic Water Demand (DWD), Livestock Water Demand (LWD) and Irrigation Water Demand (IWD).
14	If TAW is less than (DWD + LWD + IWD), the output will be displayed as “Construction of additional water storage or Grow Low duty crop”.
15	If TAW is greater than (DWD + LWD + IWD), the output will be displayed the IWD.

10.6 Steps for execution of Water Allocation and Crop Planning DSS module in the portal

1. After successfully logging into the portal, the user shall select the DSS tab located on the right side of the web page.
2. Once the user clicks on the DSS tab, then two options, “DSS” and “Layers” will be displayed on the left of the web page.
3. The user will select the DSS tab.
4. There will be three options, and the user needs to select the Hydrology option; a list of DSS modules will then drop down under the Hydrology tab.
5. The user shall select the DSS module named **Water Allocation and Crop Planning** from the list. After selecting the module, a dialogue box will appear on the right side of the web page.
6. The dialogue box will have two options to select Micro Watershed, “From List” and “From Map”. The “From List” option allows the user to select District, Block, Cluster, Micro Watershed, Village, Cadastral Plot, Crop name and Date of showing. The details of the input fields in the Web page are as mentioned in the section. The “From Map” option will allow the user to select on the map, which will auto-fill the District, Block, Cluster, Micro Watershed, Village and Cadastral Plot.



The dialog box is titled "Water Allocation & Crop Planning" with a close button (X) in the top right corner. It contains two radio buttons: "From List" (selected) and "From Map". Below these are six dropdown menus arranged in three rows and two columns. The first row contains "District" and "Block", the second row contains "Cluster" and "Micro Watershed", and the third row contains "Village" and "Cadastral Plot". Each dropdown menu has a placeholder text "Select [field name]" and a downward arrow. At the bottom of the dialog are two buttons: "SUBMIT" (solid blue) and "RESET" (outlined blue).

Figure 10-2: Dialogue box for selecting the Input fields

7. The user will select the District, Block, Cluster, Micro Watershed, Village, Cadastral Plot, crop name and date of sowing.
8. When the user clicks the submit button, the system executes a query that determines how many days have passed from the sowing date up to the present day.
 - Case 1: If the number of days is more than the crop period of the selected crop, then IWD is 0.
 - Case 2: If the number of days is less than the crop period of the selected crop, then follow the steps given below
9. A database query will be executed to retrieve the MWS associated with this plot.
10. A query will be executed to retrieve the DWD (m³/day) and LWD (m³/day) for the MWS associated with this plot from DSS-7.
11. A query will be executed to retrieve the surface water runoff-SW (mm) data associated with this MWS from DSS-1 and convert it into meters (m).
12. A query will be executed to retrieve the data of Groundwater-GW (m) associated with this MWS from the database.
13. Fetch the area of the MWS (ha) associated with the selected plot from the database.
14. Estimate the Total Available Water (TAW) in (m³) by using the surface runoff water and groundwater.

$$TAW (m^3) = (SW + GW) * Area * 10000$$

15. Compare the Total Available Water with the combined Domestic Water Demand (DWD) and Livestock Water Demand (LWD).
16. If the Total Available Water (TAW) is less than or equal to the combined Domestic Water Demand (DWD) and Livestock Water Demand (LWD),

$$TAW \leq (DWD + LWD)$$

The output will be displayed as "**Construction of additional water storage**".

17. There will be three cases if the Total Available Water (TAW) is greater than the combined Domestic Water Demand (DWD) and Livestock Water Demand (LWD).

Case 1: If the selected crop is Forest

- A query will be executed to retrieve the Soil Moisture of the previous day (SM_0) associated with this MWS from DSS-1.
- A query will be executed to retrieve the Soil Moisture of the current day (ASM) associated with this MWS from DSS-1.
- A query will be executed to retrieve the Rainfall of the previous day (P) associated with this MWS from IMD.
- Fetch the Evapotranspiration (ET_0) from DSS7 for the selected plot which was calculated using the Hargreaves equation.
- Estimate the crop evapotranspiration by multiplying the evapotranspiration (ET_0) with the respective crop coefficient (K_c).

$$ET_c (mm) = K_c * ET_0$$

- Estimate the calculated soil moisture of the present day (SM_1) by using the formula mentioned below:

$$SM_1 = SM_0 + P - ET_c$$

- If the calculated soil moisture for the present day (SM_1) is greater than the soil moisture of current day (ASM) retrieved from DSS-1, then the water demand (D) will be zero.

$$\text{If } SM_1 > ASM, \text{ then } D = 0$$

- Else, the water demand (D) will be calculated by subtracting the calculated soil moisture for the present day (SM_1) from the soil moisture of the current day (ASM).

$$D (mm) = ASM - SM_1$$

- Fetch the area (ha) of the selected plot from the database.
- Estimate the irrigation water demand (IWD) by multiplying the demand with the area.

$$IWD (m^3) = D * Area * 10$$

Case 2: If the crop selected by the user is other than paddy

- A query will be executed to retrieve the Soil Moisture of the previous day (SM_0) associated with this MWS from DSS-1.

- A query will be executed to retrieve the Soil Moisture of the current day (ASM) associated with this MWS from DSS-1.
- A query will be executed to retrieve the Rainfall of the previous day (P) associated with this MWS from the IMD.
- Fetch the Evapotranspiration (ET_0) from DSS7 for the selected plot which was calculated using the Hargreaves equation.
- Estimate the crop evapotranspiration by multiplying the evapotranspiration (ET_0) with the respective crop coefficient (K_c).

$$ET_c \text{ (mm/day)} = K_c * ET_0$$

- Estimate the calculated soil moisture of the present day (SM_1) by using the formula mentioned below:

$$SM_1 = SM_0 + P - ET_c$$

- If the calculated soil moisture for the present day (SM_1) is greater than the soil moisture of the current day (ASM) retrieved from DSS-1, then the water demand (D) will be zero.

$$\text{If } SM_1 > ASM, \text{ then } D = 0$$

- Else, the water demand (D) will be calculated by subtracting the calculated soil moisture for the present day (SM_1) from the soil moisture of the current day (ASM).

$$D = ASM - SM_1$$

- Fetch the area (ha) of the selected plot from the database.
- Estimate the irrigation water demand (IWD) by multiplying the demand with the irrigated area.

$$IWD(m^3) = D * Area * 10$$

Case 3: If the crop selected by the user, is paddy.

- The user will enter the standing water level (WL_0) in the plot of the previous day. If no value is entered, a default of 50 mm will be used.
- A query will be executed to retrieve the Percolation loss (PL) of the previous day associated with this MWS from DSS-1.
- A query will be executed to retrieve the Rainfall of the previous day (P) associated with this MWS from the IMD.
- Fetch the Evapotranspiration (ET_0) from DSS7 for the selected plot which was calculated using the Hargreaves equation.
- Estimate the crop evapotranspiration by multiplying the evapotranspiration (ET_0) with the respective crop coefficient (K_c).

$$ET_c \text{ (mm/day)} = K_c * ET_0$$

- Estimate the water level of the present day (WL) by using the formula mentioned below:

$$WL (mm) = WL_o + P - ET_c - PL$$

- If the water level (WL) of the present day is greater than zero, then the water demand (D) will be zero.

$$\text{If } WL > 0, \text{ then } D = 0$$

- Else, the water demand (D) will be calculated by subtracting the water level (WL) of the present day from 50.

$$D (mm) = 50 - WL$$

- Fetch the area (ha) of the selected plot from the database.
- Estimate the irrigation water demand (IWD) by multiplying the demand with the irrigated area.

$$IWD (m^3) = D * Area * 10$$

- Compare the Total Available Water with the combined Domestic Water Demand (DWD), Livestock Water Demand (LWD) and Irrigation Water Demand (IWD).
- If the Total Available Water (TAW) is less than the combined Domestic Water Demand (DWD), Livestock Water Demand (LWD) and Irrigation Water Demand (IWD),

$$TAW < (DWD + LWD + IWD)$$

The output will be displayed as two advisories:

- Construction of additional water storage**
- Grow a low-duty crop**

- If the Total Available Water (TAW) is greater than the combined Domestic Water Demand (DWD), Livestock Water Demand (LWD) and Irrigation Water Demand (IWD),

$$TAW > (DWD + LWD + IWD)$$

The output will display the value of the Irrigation water demand (IMD).

- Display the results in a tabular format using the fields listed below.

- Plot ID
- Micro Watershed Name
- Micro Watershed Code
- Crop Name
- Irrigation Water Demand (m³/day)
- Agri Advisory

Plot No	Micro Watershed Name	Micro Watershed Code	Crop Name	Irrigation Water Demand(m ³ /day)	Agri Advisory
Bdp120802236	Bandijharan	407010207140203	NA	0	Construction of additional water storage

Figure 10-3: Output view of Water Allocation and Crop Planning DSS

22. The user can export the table to an Excel sheet using the 'EXPORT TO EXCEL' option and can also download the generated report using the "DOWNLOAD REPORT".

11 DSS-9: Crop Suitability

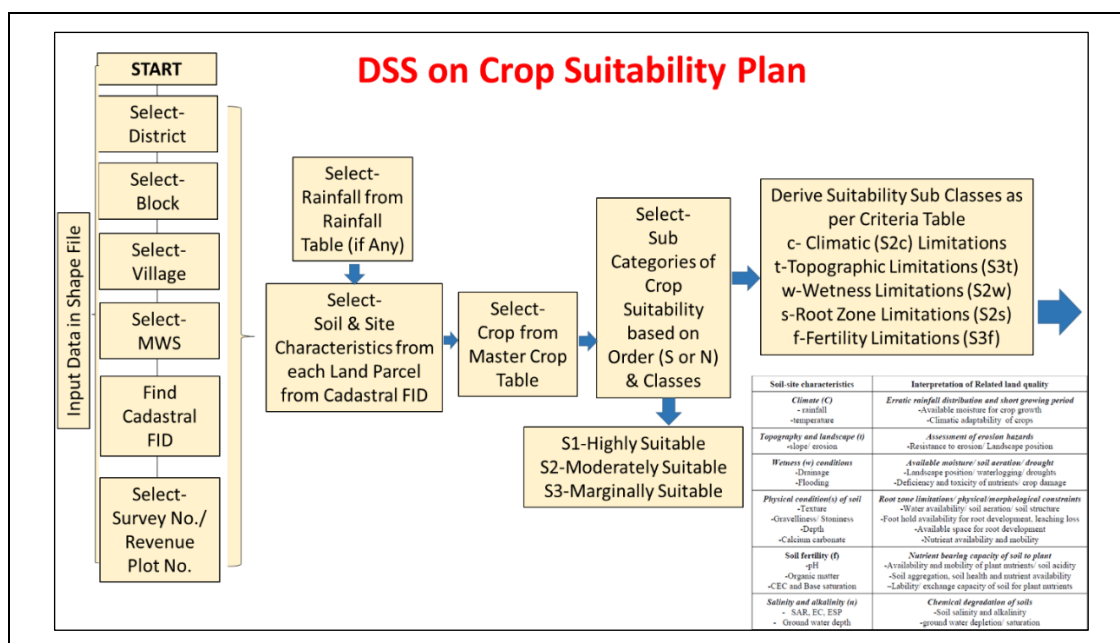
11.1 Purpose

The objective of crop suitability assessment is to provide scientifically validated, site-specific crop recommendations for each survey number or farmer's field. By integrating soil properties, weather parameters, spatial characteristics, and climatic data, the system evaluates the suitability of major crops using pre-defined crop suitability matrices (S1 – Highly Suitable, S2 – Moderately Suitable, S3 – Marginally Suitable, N – Not Suitable).

11.2 Key Functions

- Assessment of land and climate resources to evaluate their potential for agricultural production.
- Identification of suitable crops based on soil properties and climatic conditions.
- Classification of land into suitability classes (e.g., highly suitable, moderately suitable, marginally suitable).
- Detection of limiting factors such as soil fertility constraints, slope, wetness, or climatic stresses affecting crop growth.
- Ranking of crops for each land parcel based on comparative suitability and resource efficiency.
- Generation of suitability maps and tables to support location-specific crop planning.

11.3 Flow Chart



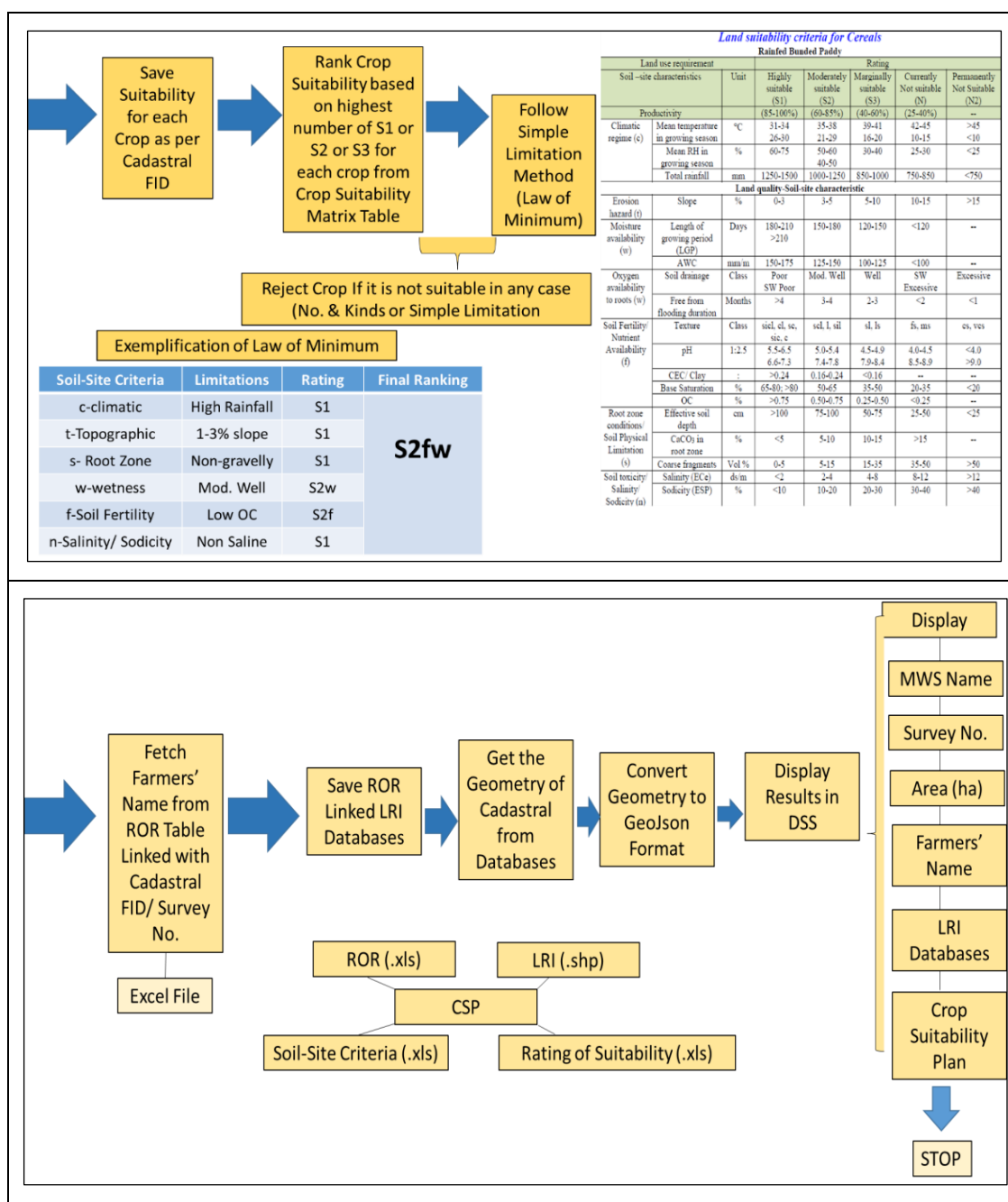


Figure 11-1: Flow Chart of the DSS for Crop Suitability Plan (Source: NBSS & LUP, Kolkata)

11.4 Input Data Required

To assess the suitability of crops for a selected land parcel, the Decision Support System (DSS) requires a set of geo-spatial, soil, and climatic input parameters. These inputs are extracted from the Land Resource Inventory (LRI) database and associated spatial datasets for the selected plot or cadastral unit. The collected parameters enable the system to evaluate land characteristics and classify crop suitability based on standard criteria. The list of essential input parameters used by the DSS is presented in Table 11-1.

Table 11-1: List of Input Parameters for the Crop Suitability Plan DSS

S. No.	Input Parameter
1	Mean Temperature in the growing season
2	Total Rainfall
3	Slope
4	Soil Drainage
5	Texture
7	Soil ph
8	Organic Carbon (OC)
9	Effective Soil Depth
10	Season
11	Crop Name

11.5 Steps involved in the crop suitability

The crop suitability process in the Decision Support System (DSS) follows a systematic sequence to evaluate the potential of a selected plot for a particular crop. The procedure begins with the selection of a cadastral plot and the retrieval of its corresponding soil and climatic attributes from the LRI database. Based on these parameters, the system compares the actual values with the crop-specific criteria table to derive the suitability class for each parameter. The suitability scores are then aggregated to classify and rank crops, while unsuitable crops are automatically discarded. The final results are displayed along with plot information, farmer details, and GIS visualization. The step-wise process is listed in Table 11-2.

Table 11-2: Workflow for Crop Suitability Assessment

S. NO.	Steps for Crop suitability
1	The user will select the plot no.
2	A query will be executed to find the details of the selected plot such as rainfall, temperature, and soil characteristics.
3	The user needs to select the crop.
4	Get the distinct Parameters from the LRI table for the selected Plot.
5	Derive the suitability (i.e. S1/S2/S3/N) using the crop criteria table of the selected crop for each parameter by comparing it with the actual values for the respective Plot no.
6	Count the number of S1, S2, S3 against each crop and rank the crop which get more S1.
7	If the suitability shows N for any parameter, reject that crop.
8	Fetch the Farmer Name from LRI table against the selected Plot Number.
9	Result displays the type of Crop for the particular MWS, Plot Number, farmer name, area with Season, and Suitability Class. The system will also highlight the selected Plot in the GIS map.

11.6 Crop used in the DSS based on the Season

For generating the Crop Suitability Plan in the DSS, crops are selected according to their recommended growing seasons. The cropping calendar is categorized into four seasons: Pre-Kharif, Kharif, Rabi, and Summer. Each season supports different crops depending on rainfall availability, climatic conditions, and soil suitability. Season-wise crop is listed in Table 11-3.

Table 11-3: Seasonal Crop Dataset Used in the DSS (Source: NBSS & LUP, Kolkata)

Season	Crop Name
Pre Kharif	Chilli
Kharif	Paddy, Paddy (Upland), Maize, Little Millet, Red gram, Green gram, Black gram, Cowpea, Field beans, Groundnut, Sesame
Summer	Paddy
Rabi	Paddy, Maize, Little Millet, Red gram, Green gram, Cowpea, Fieldbean, Chilies, Cabbage, Groundnut, Mustard

11.7 Suitability Classes

Crop suitability assessment in the DSS is based on land characteristics and limiting factors such as temperature, rainfall, slope, texture, soil depth, etc. These factors determine whether a land unit can support a specific crop sustainably. A brief description of the suitability classes used in the DSS is presented in Table 11-4.

Table 11-4: Crop Suitability Classes and Descriptions (Source: NBSS & LUP, Kolkata)

Class	Suitability	Descriptions
S1	Highly Suitable	Land unit having no limitation for sustainable use or with not more than three slight limitations.
S2	Moderately Suitable	Land with more than three slight limitations but with not more than three moderate limitations.
S3	Marginally Suitable	Land with more than three moderate limitations but with not more than two severe limitations.
N1	Currently Not Suitable	Land with severe or very severe limitations that may be overcome in time but cannot be corrected with existing knowledge at the current acceptable cost.
N2	Permanently Not Suitable	Land has limitations that will be very difficult to correct and use.

11.8 Land Suitability Criteria for Field Crops

- Rainfed Bunded Paddy

Table 11-5: Crop Suitability Criteria for Rainfed Bunded Paddy (Source: NBSS & LUP, Kolkata)

Land use requirement		Rating				
Soil –site characteristics	Unit	Highly suitable	Moderately suitable	Marginaly suitable	Currently Not suitable	Permanently Not Suitable (N2)

			(S1)	(S2)	(S3)	(N)	
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	31-34	35-38	39-41	42-45	>45
			26-30	21-29	16-20	Oct-15	<10
	Mean RH in growing season	%	60-75	50-60 40-50	30-40	25-30	<25
	Total rainfall	mm	1250-1500	1000-1250	850-1000	750-850	<750
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-3	3-5	5-10	10-15	>15
Moisture availability (w)	Length of growing period (LGP)	Days	180-210 >210	150-180	120-150	<120	--
	AWC	mm/m	150-175	125-150	100-125	<100	--
Oxygen availability to roots (w)	Soil drainage	Class	Poor SW Poor	Mod. Well	Well	SW Excessive	Excessive
	Free from flooding duration	Months	>4	3-4	2-3	<2	<1
Soil Fertility/ Nutrient Availability (f)	Texture	Class	sicl, cl, sc, sic, c	scl, l, sil	sl, ls	fs, ms	cs, vcs
	pH	####	5.5-6.5	5.0-5.4	4.5-4.9	4.0-4.5	<4.0
			6.6-7.3	7.4-7.8	7.9-8.4	8.5-8.9	>9.0
	CEC/Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	65-80; >80	50-65	35-50	20-35	<20
	OC	%	>0.75	0.50-0.75	0.25-0.50	<0.25	--

Root zone condition s/ Soil Physical Limitation (s)	Effective soil depth	cm	>100	75-100	50-75	25-50	<25
	CaCO ₃ in	%	<5	5-10	10-15	>15	--
	root zone						
	Coarse fragments	Vol %	<15	15-35	35-60	60-80	>80
Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	<2	2-4	4-8	8-12	>12
	Sodicity (ESP)	%	<10	10-20	20-30	30-40	>40

• Upland Paddy

Table 11-6: Crop Suitability Criteria for Upland Paddy (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highly suitable	Moderately suitable	Marginaly suitable	Currently Not suitable	Permanently Not Suitable (N2)
			(S1)	(S2)	(S3)	(N)	
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	31-34	35-38	39-41	42-45	>45
			26-30	21-29	16-20	Oct-15	<10
	Mean RH in growing season	%	60-75	50-60	30-40	25-30	<25
				40-50			
	Total rainfall	mm	1250-1500	1000-1250	850-1000	750-850	<750
Land quality-Soil-site characteristic							

Erosion hazard (t)	Slope	%	0-5	5-10	10-15	15-25	>25	
Moisture availability (w)	Length of growing period	Days	180-210	150-180	120-150	<120	--	
			>210					
	AWC	mm/m	150-175	125-150	100-125	<100	--	
Oxygen availability to roots (w)	Soil drainage	Class	Poor	Mod. Well	Well	SW Excessive	Excessive	
			SW Poor					
	Free from flooding duration	Months	>4	3-4	2-3	<2	<1	
Soil Fertility/ Nutrient Availability (f)	Texture	Class	sicl, cl, sc, sic, c	scl, l, sil	sl, ls	fs, ms	cs, vcs	
	pH	####	5.5-6.5	5.0-5.4	4.5-4.9	4.0-4.5	<4.0	
			6.6-7.3	7.4-7.8	7.9-8.4	>8.5	--	
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--	
	Base Saturation	%	65-80; >80	50-65	35-50	20-35	<20	
	OC	%	>0.75	0.50-0.75	0.25-0.50	<0.25	--	
Root zone conditions/ Soil Physical Limitation (s)	Effective soil depth	cm	>100	50-75	25-50	<25	--	
			75-100					
	CaCO ₃ in	%	Nil	1-5	5-10	10-15	>15	
	root zone							
	Coarse fragments	Vol %	<15	15-35	35-60	60-80	>80	

Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	<2	2-4	4-8	8-12	>12	
	Sodicity (ESP)	%	<10	10-20	20-30	30-40	>40	

- Maize

Table 11-7: Crop Suitability Criteria for Maize (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highly suitable	Moderate ly suitable	Marginal ly suitable	Current ly Not suitable	Permanen tly Not Suitable (N2)
			(S1)	(S2)	(S3)	(N)	
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperatu re in growing season	°C	25-32	33-38	38-40	>40	>42
			20-25		16-20	<15	<12
	Mean RH in growing season	%	50-80	45-50	35-40	30-35	<30
	Total rainfall	mm	1250-1500	1000-1250	750-1000	500-750	<500
					>1500		
	Land quality-Soil-site characteristic						
Erosion hazard (t)	Slope	%	0-3	5-10	10-15	25-33	>33
			3-5		15-25		
Moisture availabilit y (w)	Length of growing period	Days	180-210	120-150	100-120	<100	--
			150-180				
		AWC	mm/m	150-175	125-150	100-125	<100

Oxygen availability to roots (w)	Soil drainage	Class	Well/ SW Excessive	SW Poor/ Mod. Well	Poor	Very Poor	--
	Free from flooding duration	Months	>8 6-8	4-6	3-4	2-3	<2
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sil, cl, scl, sicl	sic, sc, sl	ls, c (< 60%v)	fs, ms, c (>60%v)	--
	pH	#####	6.0-6.5	5.5-5.9	5.0-5.4	4.5-4.9	<4.5
			6.6-7.8	7.9-8.4	8.4-8.9	>9.0	>9.0
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	65-80; >80	50-65	35-50	20-35	<20
	OC	%	>0.80	0.60-0.80	0.40-0.60	0.30-0.40	<0.30
Root zone condition s/ Soil Physical Limitation (s)	Effective soil depth	cm	>75	50-75	25-50	<25	--
	CaCO ₃ in	%	0-5	5-10	10-15	15-25	>25
	root zone						
	Coarse fragments	Vol %	<15	15-35	35-60	60-80	>80
Soil toxicity/ Salinity/ Sodicty (n)	Salinity (ECe)	ds/m	<2	2-4	4-8	8-12	>12
	Sodicty (ESP)	%	0-8	15-20	20-25	25-30	>30
			10-15				

- **Pearl Millet**

Table 11-8: Crop Suitability Criteria for Pearl Millet (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highly suitable	Moderately suitable	Marginally suitable	Currently Not suitable	Permanently Not Suitable
			(S1)	(S2)	(S3)	(N)	(N2)
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	24-28	37-39	40-42	42-44	>45
			32-36	19-23	16-18	13-15	<12
	Mean RH in growing season	%	40-60	30-40	25-30	<20-25	<20
				65-70	70-75	75-80	>85
	Total rainfall	mm	550-750	450-550	350-450	250-350	<250
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-3	5-10	15-25	25-33	>33
			3-5	10-15			
Moisture availability (w)	Length of growing period	Days	90-120	70-90	60-70	<60	--
			>120				
	AWC	mm/m	125-150	100-125	75-100	50-75	<50
Oxygen availability to roots (w)	Soil drainage	Class	Well/	SW Poor	Poor but drainable	Very Poor/	Not drainable
			Mod. Well			Ext. poor	
	Free from flooding duration	Months	>8	6-8	4-6	3-4	<3
Soil Fertility/	Texture	Class		sc,sic, sl, c	ls, fs	cs, ms,	fragmental ,

Nutrient Availability (f)			l, sil, cl, scl, silcl		c (<60%v)	c (>60%v)	skeletal
	pH	####	6.0-6.5	5.5-5.9	5.0-5.4	4.6-4.9	<4.5
			6.6-7.5	7.6-8.2	8.2-8.5	8.6-8.9	>9.0
	CEC/Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	50-70	40-60	30-40	20-30	<20
	OC	%	0.50-0.75	0.40-0.50	0.30-0.40	0.20-0.30	<0.20
Root zone conditions / Soil Physical Limitation (s)	Effective soil depth	cm	75-100	50-75	25-50	<25	--
			>100				
	CaCO ₃ in	%	0-10	10-20	20-30	30-40	>40
	root zone						
Soil toxicity/ Salinity/ Sodicity (n)	Coarse fragments	Vol %	15-35	35-60	>60		
	Salinity (ECe)	ds/m	0-4	4-8	8-12	12-16	>16
	Sodicity (ESP)	%	0-8	15-20	20-25	25-30	>30
			8-15				

- Finger Millet**

Table 11-9: Crop Suitability Criteria for Finger Millet (Source: NBSS & LUP, Kolkata)

Land use requirement		Rating				
Soil –site characteristics	Unit	Highly suitable	Moderately suitable	Marginally suitable	Currently Not suitable	Permanently Not Suitable
		(S1)	(S2)	(S3)	(N)	(N2)

Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	27-30	35-38	38-41	41-45	>45
			31-35	24-26	20-23	18-20	<18
	Mean RH in growing season	%	40-60	30-40	25-30	<20-25	<20
				65-70	70-75	75-80	>85
	Total rainfall	mm	750-900	600-750	500-600	400-500	<400
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-3	5-10	15-25	25-33	>33
			3-5	10-15			
Moisture availability (w)	Length of growing period	Days	90-120	70-90	60-70	<60	--
			>120				
	AWC	mm/m	125-150	100-125	75-100	50-75	<50
Oxygen availability to roots (w)	Soil drainage	Class	Well/	SW Poor	Poor but drainable	Very Poor/	Not drainable
			Mod. Well			Ext. poor	
	Free from flooding duration	Months	>8	6-8	4-6	3-4	<3
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sil, cl, scl, sicl	sc,sic, sl, c	ls, fs	cs, ms,	fragmental ,
					c (<60%v)	c (>60%v)	skeletal
	pH	####	6.0-6.5	5.5-5.9	5.0-5.4	4.6-4.9	<4.5
			6.6-7.5	7.6-8.2	8.2-8.5	8.6-8.9	>9.0
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	50-70	40-60	30-40	20-30	<20

	OC	%	0.50-0.80	0.40-0.50	0.30-0.40	0.20-0.30	<0.20
Root zone conditions / Soil Physical Limitation (s)	Effective soil depth	cm	75-100	50-75	25-50	<25	--
			>100				
	CaCO ₃ in root zone	%	0-10	10-20	20-30	30-40	>40
	Coarse fragments						
		Vol %	<15	15-35	35-60	60-80	>80
Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	0-4	4-8	8-12	12-16	>16
	Sodicity (ESP)	%	0-8 8-15	15-20	20-25	25-30	>30

- **Greengram**

Table 11-10: Crop Suitability Criteria for Green gram (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highly suitable	Moderate ly suitable	Marginal ly suitable	Current ly Not suitable	Permanent ly Not Suitable
			(S1)	(S2)	(S3)	(N)	(N2)
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	25-28	34-36	37-39	39-40	>40
			31-33	21-24	18-20	<18	<15
	Mean RH in growing season	%	60-75	50-60	40-50	35-40	<35
	Total rainfall	mm	900-1000	750-900	600-750	500-600	<500

			1000-1250	1250-1500			
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-3	3-5	5-10	10-15	>15
Moisture availability (w)	Length of growing period	Days	180-210	150-180	120-150	100-120	<100
	AWC	mm/m	140-160	120-140	100-120	80-100	<80
Oxygen availability to roots (w)	Soil drainage	Class	Well/ SW Excessive	Mod. Well	SW Poor/ Poor	Very Poor	Not drainable
				Imperfect			
	Free from flooding duration	Months	6-8	4-6	3-4	2-3	<2
			>8				
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sil, cl, scl, sicl	sc, sic,	sl, ls,	vfs, fs, ms,	cs, skeletal
					c (<60%v)	c (>60%v)	
	pH	####	6.0-6.5	5.5-5.9	5.0-5.4	4.6-4.9	<4.5
			6.6-7.8	7.9-8.4	8.5-8.9	9.0-9.4	>9.5
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	60-75	50-60	40-50	30-40	<30
Root zone conditions/ Soil Physical Limitations (s)	Effective soil depth	cm	100-125	75-100	50-75	25-50	<25
			>125				
	CaCO ₃ in	%	0-5	5-10	10-15	15-20	>15
	root zone						
	Coarse fragments	Vol %	0-10	10-15	15-35	35-60	>60

Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	<2	2-4	4-8	8-10	>10
	Sodicity (ESP)	%	<10	10-15	15-20	20-30	>30

- **Blackgram**

Table 11-11: Crop Suitability Criteria for Blackgram (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highly suitable	Moderately suitable	Marginally suitable	Currently Not suitable	Permanently Not Suitable (N2)
			(S1)	(S2)	(S3)	(N)	
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	25-28	34-36	37-39	39-40	>40
			31-33	21-24	18-20	<18	<15
	Mean RH in growing season	%	60-75	50-60	40-50	35-40	<35
	Total rainfall	mm	900-1000	750-900	600-750	500-600	<500
			1000-1250	1250-1500			
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-3	3-5	5-10	10-15	>15
Moisture availability (w)	Length of growing period	Days	180-210	150-180	120-150	100-120	<100

	AWC	mm/m	150-175	125-150	100-125	90-100	<90	
Oxygen availability to roots (w)	Soil drainage	Class	Well/	Imperfect	Poor	Very Poor	Not drainable	
			Mod. Well					
	Free from flooding duration	Months	6-8	4-6	3-4	2-3	<2	
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sil, cl, scl, sicl	sc, sic,	sl, ls,	vfs, fs, ms,	cs, skeletal	
					c (<60%v)	c (>60%v)		
	pH	#####	6.0-6.5	5.5-5.9	5.0-5.4	4.6-4.9	<4.5	
			6.6-7.8	7.9-8.4	8.5-8.9	9.0-9.4	>9.5	
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--	
	Base Saturation	%	60-75	50-60	40-50	30-40	<30	
	OC	%	0.60-0.80	0.50-0.60	0.40-0.50	0.30-0.40	<0.30	
Root zone conditions/ Soil Physical Limitation (s)	Effective soil depth	cm	>100	75-100	50-75	25-50	<25	
	CaCO ₃ in root zone	%	Nil	5-10	10-15	15-20	>15	
	Coarse fragments	Vol %	0-10	10-15	15-35	35-60	>60	
Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	<2	2-4	4-8	8-10	>10	
	Sodicity (ESP)	%	0-5	5-10	10-15	15-20	>20	

- Cowpea**

Table 11-12: Crop Suitability Criteria for Cowpea (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highl y suitabl e	Moderate ly suitable	Marginal ly suitable	Currentl y Not suitable	Permanent ly Not Suitable (N2)
			(S1)	(S2)	(S3)	(N)	
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperatu re in growing season	°C	25-29	22-24	20-22	18-20	<18
			30-33	34-36	35-39	>40	>42
	Mean RH in growing season	%	60-80	50-60	50-60	40-50	<40
				80-90	>90	>90	>90
	Total rainfall	mm	700-900	600-700	500-600	400-500	<400
			900-1000	1000-1250			
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-3	3-5	5-10	15-25	>25
					10-15		
Moisture availability (w)	Length of growing period	Days	150-180	120-150	100-120	80-100	<80
			180-210				
	AWC	mm/m	150-160	125-150	100-125	80-100	<80
Oxygen availability to roots (w)	Soil drainage	Class	Well	Imperfect / Mod. well	Poor	Very Poor	Not drainable
	Free from flooding duration	Months	6-8	4-6	3-4	2-3	<2
			>8				
	Texture	Class		sl, sc, sic	ls, vfs, fs	ms,	

Soil Fertility/ Nutrient Availability (f)			l, sil, cl, scl, sicl		c (<60%v)	c (>60%v)	cs, skeletal
	pH	####	6.6-7.5	6.0-6.5 7.6-7.8	5.5-5.9 7.9-8.4	5.0-5.4 8.5-8.9	<4.9 >9.0
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	65-80	50-65	40-50	30-40	<30
	OC	%	0.60-0.80	0.50-0.60	0.40-0.50	0.30-0.40	<0.30
Root zone conditions / Soil Physical Limitation (s)	Effective soil depth	cm	>100	75-100	50-75	25-50	<25
	CaCO ₃ in root zone	%	Nil	0-5	5-10	10-15	>15
	Coarse fragments	Vol %	0-10	10-15	15-35	35-60	>60
Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	<1	1-2	2-4	4-8	>8
	Sodicity (ESP)	%	0-5	5-10	10-15	15-20	>20

- Mustard

Table 11-13: Crop Suitability Criteria for Mustard (Source: NBSS & LUP, Kolkata)

Land use requirement		Rating				
Soil –site characteristics	Unit	Highly suitable	Moderately suitable	Marginal ly suitable	Currentl y Not suitable	Permanent ly Not Suitable (N2)
		(S1)	(S2)	(S3)	(N)	
Productivity		(85-100%)	(60-85%)	(40-60%)	(25-40%)	--

Climatic regime (c)	Mean temperature in growing season	°C	26–30	31-35	36-38	38-40	>40
			22-25	21-24	18-20	16-18	<16
	Mean RH in growing season	%	60-75	50-60	40-50	>90	--
				75-80	80-90	<40	
	Total rainfall	mm	1000-1250	900-1000	650-750	500-650	<500
			>1250	750-900			
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-1	3-5	5-10	10-15	>15
			1-3				
Moisture availability (w)	Length of growing period	Days	180-210	150-180	120-150	100-120	<100
	AWC	mm/m	150-175	125-150	100-125	90-100	<90
Oxygen availability to roots (w)	Soil drainage	Class	Well	Mod. Well	Imperfect	Poor	Very Poor
	Free from flooding duration	Months	6-8	4-6	3-4	<3	<3
			>8				
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sl, scl, ls, sil	sc, cl, sicl	sic, vfs, fs	ms	cs, vcs,
					c (<60% v)	c (>60% v)	fragmental
	pH	#####	6.0-6.5	5.6-5.9	5.0-5.5	4.6-4.9	<4.5
			6.6-7.5	7.5-7.8	7.9-8.4	8.5-8.9	>9.0
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	65-80	50-65	40-50	30-40	<30
	OC	%	0.60-0.80	0.50-0.60	0.40-0.50	0.30-0.40	<0.30

Root zone conditions / Soil Physical Limitation (s)	Effective soil depth	cm	>100	75-100	50-75	25-50	<25
	CaCO ₃ in root zone	%	Nil	0-5	5-10	10-15	>15
	Coarse fragments						
		Vol %	0-10	10-15	15-35	35-60	>60
Soil toxicity/ Salinity/ Sodicty (n)	Salinity (ECe)	ds/m	<1	1-2	2-4	4-8	>8
	Sodicty (ESP)	%	0-5	5-10	10-15	15-20	>20

- **Groundnut**

Table 11-14: Crop Suitability Criteria for Groundnut (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highly suitable	Moderately suitable	Marginally suitable	Currently Not suitable	Permanently Not Suitable
			(S1)	(S2)	(S3)	(N)	(N2)
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	24–29	22–24;	20–22;	18-20	<18
			30-34	35–38	39-41	42-44	>45
	Mean RH in growing season	%	60-75	50-60	40-50	>90	--
				75-80	80-90	<40	
	Total rainfall	mm	900-1200	700-900	600-700	500-600	<500
				1200-1500			
Land quality-Soil-site characteristic							

Erosion hazard (t)	Slope	%	0-5	5-10	10-15	15-25	>25
Moisture availability (w)	Length of growing period	Days	180-210	150-180	120-150	100-120	<100
	AWC	mm/m	140-160	120-140	100-120	80-100	<80
Oxygen availability to roots (w)	Soil drainage	Class	Well	Mod. Well	Imperfect	Poor	Very Poor
	Free from flooding duration	Months	6-8	4-6	3-4	<3	<3
			>8				
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sl, scl, ls, sil	sc, cl, sicl	sic, vfs, fs	ms	cs, vcs,
					c (<60% v)	c (>60% v)	fragmental
	pH	####	6.0-6.5	5.6-5.9	5.2-5.6	5.1-5.2	<5.0
			6.6-7.5	7.5-7.8	7.9-8.2	8.2-8.4	>8.5
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	65-80	50-65	40-50	30-40	<30
Root zone conditions / Soil Physical Limitation (s)	Effective soil depth	cm	>100	50-75	25-50	<25	--
			75-100				
	CaCO ₃ in root zone	%	0-15	15-25	25-35	35-50	>50
	Coarse fragments						
Soil toxicity/ Salinity/	Salinity (ECe)	ds/m	<2	2-4	4-8	8-12	>12

Sodicity (n)	Sodicity (ESP)	%	0-5	5-10	10-15	15-20	>20
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- Sesame**

Table 11-15: Crop Suitability Criteria for Sesame (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highly suitable	Moderately suitable	Marginally suitable	Currently Not suitable	Permanently Not Suitable
			(S1)	(S2)	(S3)	(N)	(N2)
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	26–29	23–25;	20–22;	18-20	<18
			30-34	35–38	39-41	42-44	>45
	Mean RH in growing season	%	60-75	50-60	40-50	>90	--
				75-80	80-90	<40	
	Total rainfall	mm	700-900	700-900	600-700	500-600	<500
			900-1000	1000-1200			
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-1	3-5	5-10	10-15	>15
			1-3				
Moisture availability (w)	Length of growing period	Days	150-180	120-150	100-120	90-100	<90
			180-210				
	AWC	mm/m	140-160	120-140	100-120	80-100	<80
Oxygen availability	Soil drainage	Class	Well	Mod. Well	Imperfect	Poor	Very Poor

y to roots (w)	Free from flooding duration	Month s	6-8	4-6	3-4	<3	<3
			>8				
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sl, scl, ls, sil	sc, cl, sicl	sic, vfs, fs	ms	cs, vcs,
					c (<60% v)	c (>60% v)	fragmental
	pH	####	6.0- 6.5	5.6-5.9	5.2-5.6	5.1-5.2	<5.0
			6.6- 7.5	7.5-7.8	7.9-8.2	8.2-8.4	>8.5
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	65-80	50-65	40-50	30-40	<30
Root zone conditions / Soil Physical Limitation (s)	Effective soil depth	cm	>100	50-75	25-50	<25	--
			75- 100				
	CaCO ₃ in root zone	%	--	--	--	--	--
	Coarse fragments	Vol %	0-10	10-15	15-35	35-60	>60
Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	<1.0	1.0-2.0	2.0-4.0	4.0-8.0	>8.0
	Sodicity (ESP)	%	<5	5-10	10-15	>15	>20

- **Cashewnut**

Table 11-16: Crop Suitability Criteria for Cashewnut (Source: NBSS & LUP, Kolkata)

Land use requirement	Rating
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Soil –site characteristics		Unit	Highly suitable (S1)	Moderately suitable (S2)	Marginally suitable (S3)	Currently Not suitable (N)	Permanently Not Suitable (N2)
Productivity			(85-100%)	(60-85%)	(40-60%)	(25-40%)	--
Climatic regime (c)	Mean temperature in growing season	°C	25–30	22–25	20–22	38-40	>40
			30–32	32–36	36-38	<20	
	Mean RH in growing season	%	60-80	50-60	40-50	35-40	<35
	Total rainfall	mm	1500-1800	1250-1500	1000-1250	750-1000	<750
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-5 5-10	10-15 15-25	25-33	33-50	>50
Moisture availability (w)	Length of growing period	Days	180-210 >210	150-180	120-150	100-120	<100
	AWC	mm/m	140-160	120-140	100-120	90-100	<90
Oxygen availability to roots (w)	Soil drainage	Class	Well	Mod. Well	Imperfect	Poor	Very Poor
	Dry months (P<0.5PE T)	Months	2-4	4-5	5-6	6-7	>7
Soil Fertility/ Nutrient Availability (f)	Texture	Class	sl, l, scl, sil, sicl, cl	sc, sic, c (<60% v)	ls, vfs, fs, c (>60% v)	ms, cs, vcs, c (>60% v)	skeletal/ fragmental
	pH	####	5.4-5.9	5.1-5.3	4.6-4.9	<4.5	<4.5
			6.0-7.5	7.6-7.8	7.9-8.2	8.2-8.5	>8.5
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--

	Base Saturation	%	40-55	56-65	65-75	<35	--
	OC	%	1.00-1.20	0.80-1.00	0.60-0.80	0.50-0.60	<0.50
Root zone conditions / Soil Physical Limitation (s)	Effective soil depth	cm	100-150	75-100	50-75	25-50	<25
			>150				
	CaCO ₃ in root zone	%	Nil	<5	5-10	>10	--
	Coarse fragments						
Soil toxicity/ Salinity/ Sodicity (n)	Salinity (ECe)	ds/m	<2	2-4	4-8	8-10	>10
	Sodicity (ESP)	%	<5	5-10	10-15	15-20	>20

- Mango**

Table 11-17: Crop Suitability Criteria for Mango (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highl y suitabl e	Moderate ly suitable	Marginal ly suitable	Currentl y Not suitable	Permanent ly Not Suitable (N2)
			(S1)	(S2)	(S3)	(N)	
Productivity			(85- 100%)	(60-85%)	(40-60%)	(25- 40%)	--
Climatic regime (c)	Mean temperatu re in growing season	°C	27-30	24-26	38-40	>40	>40
			31-34	35-37	22-24	20-22	<20

	Mean Min. temp. before flowering	°C	10-15	15-22	>22	--	--
	Mean RH in growing season	%	60-80	50-60	40-50	30-40	<30
			>80				
	Total rainfall	mm	1600-2000	1200-1600	1000-1200	900-1000	<900
Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-3	3-5	5-10 10-15	>15	--
Moisture availability (w)	Length of growing period	Days	180-210 >210	150-180	120-150	100-120	<100
	AWC	mm/m	160-200	125-150	110-125	100-110	<100
Oxygen availability to roots (w)	Soil drainage	Class	Well	Mod. Well	Imperfect	Poor	Very Poor
	Dry months (P<0.5PET)	Months	1-4	4-5	6-7	7-8	>8
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, scl, sil, sicl, cl	sc, sic	sl, ls, c (<60% v)	vfs, fs, ms c (>60% v)	cs, vcs, skeletal
	pH	#####	5.4-5.9 6.0-7.5	5.1-5.3 7.6-7.8	4.6-4.9 7.9-8.4	4.1-4.5 8.5-8.9	<4.0 >9.0
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	60-80	50-60	40-50	30-40	<30
	OC	%	1.00-1.20	0.80-1.00	0.60-0.80	0.50-0.60	<0.50
Root zone conditions	Effective soil depth	cm	>150	100-150	75-100	50-75	<50

/ Soil Physical Limitation (s)	CaCO ₃ in	%	Nil	<5	5-10	>10	--
	root zone						
	Coarse fragments	Vol %	Nil	0-5	5-10	10-15	>15
Soil toxicity/ Salinity/ Sodicty (n)	Salinity (ECe)	ds/m	<2	2-4	4-8	8-10	>10
	Sodicty (ESP)	%	<5	5-10	10-15	15-20	>20

- Citrus**

Table 11-18: Crop Suitability Criteria for Citrus (Source: NBSS & LUP, Kolkata)

Land use requirement			Rating				
Soil –site characteristics		Unit	Highl y suitabl e	Moderate ly suitable	Marginal ly suitable	Currentl y Not suitable	Permanent ly Not Suitable (N2)
			(S1)	(S2)	(S3)	(N)	
Productivity			(85- 100%)	(60-85%)	(40-60%)	(25- 40%)	--
Climatic regime (c)	Mean temperatu re in growing season	°C	28-30	31-35	36-38	38-40	>40
			22-25	23-26	20-22	18-20	<18
	Mean Min. temp. before flowering	°C	15-18	13-15	10-13	<10	--
	Mean RH in growing season	%	65-80	50-65	45-50	40-45	<40
						80-90	>90
	Total rainfall	mm	1400- 1800	1200- 1400	1000- 1200	<1000	--

Land quality-Soil-site characteristic							
Erosion hazard (t)	Slope	%	0-5	5-10 10-15	15-25	25-33	>33
Moisture availability (w)	Length of growing period	Days	180-210	150-180	120-150	100-120	<100
	AWC	mm/m	>210				
Oxygen availability to roots (w)	Soil drainage	Class	Well	Mod. Well	Imperfect	Poor	Very Poor
	Dry months (P<0.5PET)	Months	--	--	--	--	--
Soil Fertility/ Nutrient Availability (f)	Texture	Class	l, sil, silcl, cl, scl	sc, sic	sl, ls, c (<60% v)	vfs, fs, ms, c (>60% v)	cs, vcs, skeletal
	pH	####	5.6-5.9	5.0-5.5	4.6-4.9	4.1-4.6	<4.0
			6.0-7.5	7.6-7.8	7.9-8.2	8.2-8.4	>8.5
	CEC/ Clay	:	>0.24	0.16-0.24	<0.16	--	--
	Base Saturation	%	50-70	45-50	35-45	<35	--
Root zone conditions / Soil Physical Limitation (s)	OC	%	1.00-1.50	0.80-1.00	0.60-0.80	0.50-0.60	<0.50
	Effective soil depth	cm	>150	100-150	75-100	50-75	<50
	CaCO ₃ in root zone	%	Nil	1-5	5-10	10-15	>15
Soil toxicity/ Salinity/	Coarse fragments	Vol %	Nil	0-5	5-10	10-15	>15
	Salinity (ECe)	ds/m	<1	1-2	2-4	4-8	>8

Sodicity (n)	Sodicity (ESP)	%	<5	5-10	10-15	15-20	>20
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Table 11-19: Criteria table of soil depth (Source: NBSS & LUP, Kolkata)

Soil Depth	Description
<25 cm	Very shallow
25-50 cm	Shallow
50-75 cm	Moderately shallow
75-100 cm	Moderately deep
100-150 cm	Deep
>150 cm	Very deep

Table 11-20: Representation Code of Soil Texture (Source: NBSS & LUP, Kolkata)

Soil Texture Code	Soil Texture
a	Sandy
b	Loamy sand
c	Sandy loam
d	Loam
e	Silt loam
f	Clay loam
g	Silty clay loam
h	Sandy clay loam
i	Sandy clay
k	Silty clay
m	Clay

Table 11-21: Criteria table of soil drainage (Source: NBSS & LUP, Kolkata)

Soil Drainage	Description
Very poor	Entire profile is mottled or gleyed, water table < 15 cm
Poor	Mottles throughout the profile, gleyed from upper B, water table < 25 cm
Somewhat Poor	Mottles in upper B horizon, lower B is often gleyed, water table between 25-75 cm
Moderately Well	Mottles in lower B horizon, water table between 75-100 cm
Well	Mottles in C or BC horizon, water table at or nearer to 100 cm
Somewhat Excessive	No mottles in profile, fine textured soils, water table > 100 cm

Soil Drainage	Description
Excessive	No mottles in profile, rapid removal of water from soil

Table 11-22: Criteria table of soil slope (Source: NBSS & LUP, Kolkata)

Code	Soil Slope	Range
A	Nearly level	0 – 1 %
B	Very gently sloping	1 – 3 %
C	Gently sloping	3 – 5 %
D	Moderately sloping	5 – 10 %
E	Strongly sloping	10 – 15 %
F	Very Strongly sloping	15 – 25 %
G	Moderately Steeply Sloping	25 – 33 %
H	Steeply Sloping	33 – 50 %
I	Very Steeply Sloping	> 50 %

Table 11-23: Description of particle size class (Source: NBSS & LUP, Kolkata)

Particle Size Class	Descriptions
Very-fine	≥ 60% clay (weight)
Fine	35-60% clay (weight)
Clayey	≥ 35% clay (weight), shallow family, lithic sub group
Fine-loamy	> 15% sand (weight), 18-35% clay (weight)
Fine-silty	< 15% sand (weight), 18-35% clay (weight)
Coarse-silty	< 15% sand (weight), < 18% clay (weight)
Coarse-loamy	> 15% sand (weight), < 18% clay (weight)
Loamy	Very fine sand, loam, less than 35 percent clay (weight)
Sandy	Coarse sand, sand, fine sand, loamy sand
Clayey skeletal	Rock fragments ≥ 35% (volume); ≥ 35% clay (weight)
Loamy skeletal	Rock fragments ≥ 35% (volume); < 35% clay (weight)
Sandy skeletal	Rock fragments ≥ 35% (volume); sandy or loamy sand texture
Very-fine	≥ 60% clay (weight)
Fine	35-60% clay (weight)
Clayey	≥ 35% clay (weight), shallow family, lithic sub group
Fine-loamy	> 15% sand (weight), 18-35% clay (weight)

11.9 Steps for the execution of crop suitability DSS module in the portal

1. After successfully logging into the portal, the user shall select the DSS tab located on the right side of the web page.

2. Once the user clicks on the DSS tab, then two options, “DSS” and “Layers” will be displayed on the left of the web page.
3. The user will select the DSS tab.
4. There will be three options, and the user needs to select the LRI option; a list of DSS modules will then drop down under the LRI tab.
5. The user shall select the DSS module named **Crop Suitability** from the list. After selecting the module, a dialogue box will appear on the right side of the web page.
6. The dialogue box will have two options to select Micro Watershed, “From List” and “From Map”. The “From List” option allows the user to select District, Block, Cluster, Micro Watershed, Village, Plot, Season, Crop Type and Crop. The details of the input fields in the Web page are as mentioned in the section. The “From Map” option will allow the user to select on the map, which will auto-fill the District, Block, Cluster, Micro Watershed, Village, and Plot. Then the user needs to select Season, Crop Type and Crop.

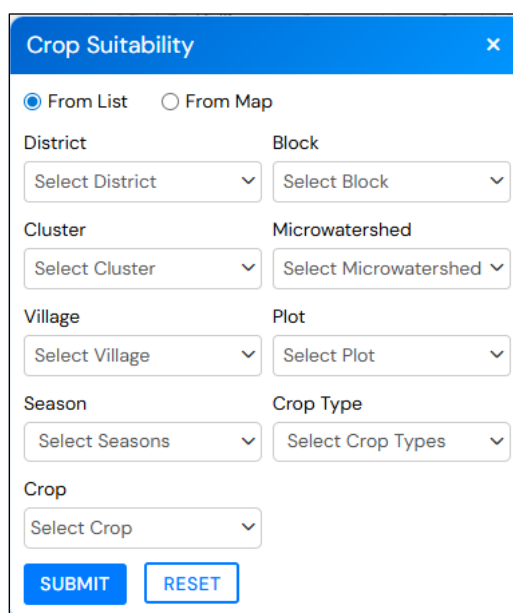


Figure 11-2: Dialogue box for selection of input fields

7. The user will select the District, Block, Cluster, Micro Watershed, Village, Plot, Season, Crop Type and Crop.
8. After the selection of the crop, click on the “Submit” tab
9. A database query will be executed to retrieve the following parameters of the selected plot.
 - Mean temperature in the growing season (°C)
 - Total Annual Rainfall (mm)
 - Slope (%)
 - Soil drainage
 - Texture
 - pH

- OC (%)
 - Effective Soil Depth (cm)
10. Once the data for the required parameters are fetched from the database for the selected plot, derive the crop suitability (S1/S2/S3/N) for each parameter based on the crop-specific criteria table.
 11. Following classification, compute the frequency of suitability classes (S1/S2/S3). The final suitability category for the crop corresponds to the class with the maximum count. For example, if the selected crop has 2 parameters classified as S1, 4 as S2, and 2 as S3, then the overall suitability class of the crop will be S2.
 12. When more than one crop is selected, determine the suitability class (S1/S2/S3/N) for each parameter of every crop and prioritize the crops according to the total number of S1 classifications obtained.
 13. The crop will be excluded from suitability assessment if any of its evaluated parameters fall under the 'N' (Not Suitable) class.
 14. Execute a database query to retrieve the farmer's name from the LRI table corresponding to the selected plot number.
 15. Display the results in a tabular format using the fields listed below.
 - Micro Watershed Name
 - Micro Watershed Code
 - Plot no.
 - Total Area in Hectare (ha)
 - Crop Name
 - Suitability
 - Season

District:Sambalpur Block:Jajmura Cluster:Jajmura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dist120801786							
EXPORT TO EXCEL		DOWNLOAD REPORT		Search:			
Sl No.	Micro Watershed	Micro Watershed Code	Plot	Total Area in Hectare	Crop Name	Suitability	Season
1	Bhadimura	040701020740201	Dist120801786	3.6	Maize	Permanently Not Suitable	Kharif
2	Bhadimura	040701020740201	Dist120801786	3.6	Redgram	Permanently Not Suitable	Kharif
3	Bhadimura	040701020740201	Dist120801786	3.6	Blackgram	Currently Not suitable	Kharif
4	Bhadimura	040701020740201	Dist120801786	3.6	Greengram	Permanently Not Suitable	Kharif
5	Bhadimura	040701020740201	Dist120801786	3.6	Groundnut	Permanently Not Suitable	Kharif
6	Bhadimura	040701020740201	Dist120801786	3.6	Mustard	Permanently Not Suitable	Rabi
7	Bhadimura	040701020740201	Dist120801786	3.6	Sesame	Permanently Not Suitable	Kharif
8	Bhadimura	040701020740201	Dist120801786	3.6	Mustard	Permanently Not Suitable	Rabi
9	Bhadimura	040701020740201	Dist120801786	3.6	Cowpea	Permanently Not Suitable	Rabi
10	Bhadimura	040701020740201	Dist120801786	3.6	French Bean	Permanently Not Suitable	Rabi

Figure 11-3: Sample Output View of Crop Suitability DSS

16. The user can export the table to an Excel sheet using the 'EXPORT TO EXCEL' option and can also download the generated report using the "DOWNLOAD REPORT" as shown in Figure 11-3.

The process flow for execution of the DSS for Crop Suitability in the portal is given in Figure 11-4.

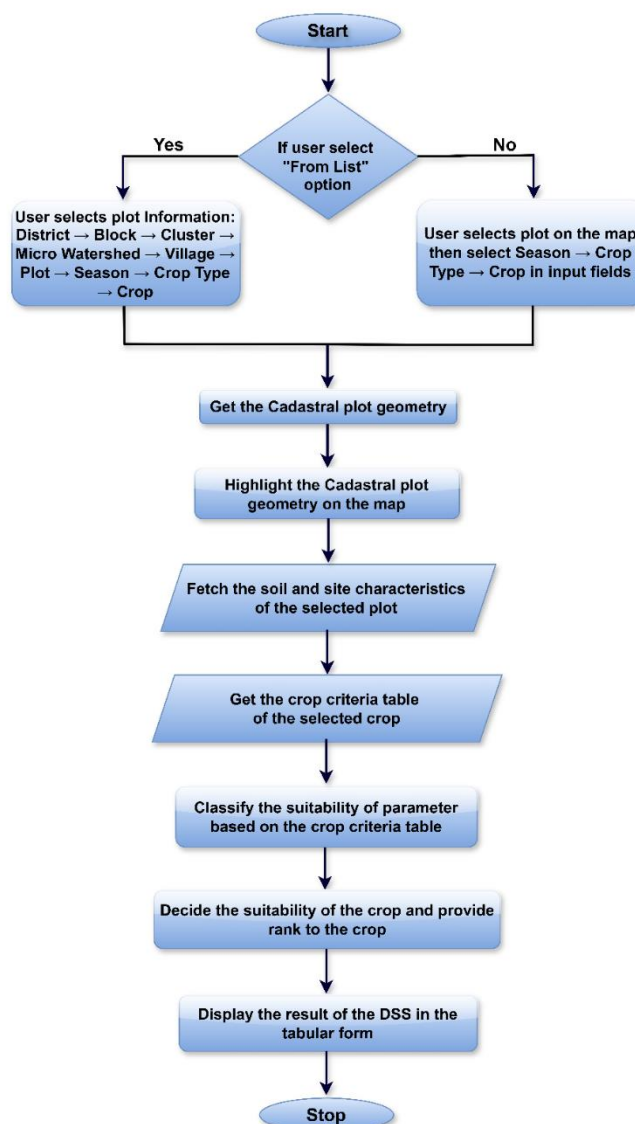


Figure 11-4: Flow diagram for the execution of DSS on the crop suitability in the portal

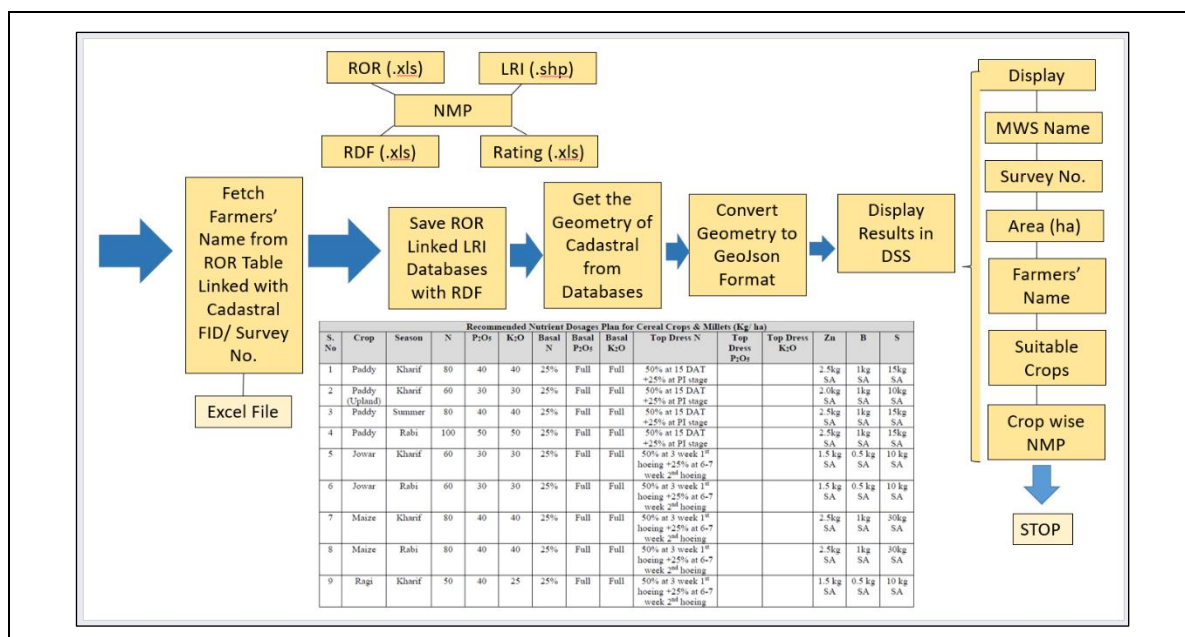


Figure 12-1: Flow Chart of the DSS for Nutrient Management Plan (Source: NBSS & LUP, Kolkata)

12.4 Input Data Required

To determine the recommended fertilizer dosage for a selected crop, the Nutrient Management Plan requires information on the essential macronutrients along with crop and fertilizer specifications. These inputs are used to compute nutrient requirements and adjust fertilizer dosage based on the soil nutrient status. The list of required input data is provided in Table 12-1.

Table 12-1: List of Input parameters used in the DSS

S. No.	Data
1	Nitrogen
2	Phosphorus
3	Potassium
4	Crop Name
5	NPK Recommendation
6	Fertilizer Name
7	Nutrient Adjustment Factor

12.5 Steps involved in the Nutrient Management Plan

Table 12-2: Description of steps involved in the Nutrient Management Plan

S. No.	Description of the steps involved
1.	Select the plot number
2.	A database query will be executed to retrieve the soil fertility data (N, P, and K values) of the selected plot.

S. No.	Description of the steps involved
3.	A query will be executed to identify the soil fertility class of the selected plot.
4.	The user will select the crop name along with its corresponding season
5.	A query will be executed to retrieve the nutrient recommendations for the selected crop based on its soil fertility class.
6.	Estimate the amount of nutrients required for the selected crop corresponding to the recommended fertilizers.
7.	Estimate the adjusted recommended dose of nutrients for the selected crop corresponding to the recommended fertilizers.
8.	Display the amount of nutrients required for the selected crop corresponding to the recommended fertilizers.

12.6 Classification of Soil Fertility based on the Nutrient Contents

Soil fertility classification is an essential step in determining the nutrient status of agricultural land and assessing the requirement of fertilizers for crop production. This classification is carried out by analyzing the concentration of primary nutrients such as Nitrogen (N), Phosphorus (P), and Potassium (K) in the soil. Based on the nutrient content, soil is categorized into fertility classes such as Low, Medium, and High.

Table 12-3: Soil fertility classes based on nutrients content (Source: NBSS & LUP, Kolkata)

Nutrient	Low	Medium	High
Available N (Kgha ⁻¹)	< 250	250-500	> 500
Available P (Kgha ⁻¹)	< 14	14-40	> 40
Available K (Kgha ⁻¹)	< 118	118-280	> 280

12.7 Recommendation of NPK based on the class of Nutrient content

The fertilizer recommendation for a crop is determined based on its soil nutrient class (N–P–K rating). Once the soil's nutrient status is classified as High (H), Medium (M), or Low (L), the corresponding recommended nutrient dose is derived from the Table 12-4 for the respective crop. When the soil exhibits different fertility combinations such as MHH, MHL, or MHM, the recommended quantity of nutrients will change accordingly. These recommendations ensure balanced nutrient supply, avoid over-fertilization, and support optimal crop growth and yield.

Table 12-4: NPK Recommendation as per the nutrient class (Source: NBSS & LUP, Kolkata)

CROPS	PADDY			BLACKGRAM			REDGRAM			MUSTURD		
RATINGS_N_P_K	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP
HHH	93	58	45	6	58	22	6	58	22	58	36	28
HHL	93	58	89	6	58	44	6	58	44	58	36	28
HHM	93	58	67	6	58	33	6	58	33	58	36	42
HLH	93	116	45	6	116	22	6	116	22	58	72	28
HLL	93	116	89	6	116	44	6	116	44	58	72	28
HLM	93	116	67	6	116	33	6	116	33	58	72	42
HMH	93	87	45	6	87	22	6	87	22	58	54	28
HML	93	87	89	6	87	44	6	87	44	58	54	28
HMM	93	87	67	6	87	33	6	87	33	58	54	42
LHH	124	58	45	12	58	22	12	58	22	116	36	28
LHL	124	58	89	12	58	44	12	58	44	116	36	28
LHM	124	58	67	12	58	33	12	58	33	116	36	42
LLH	185	116	45	12	116	22	12	116	22	116	72	28
LLL	185	116	89	12	116	44	12	116	44	116	72	28
LLM	185	116	67	12	116	33	12	116	33	116	72	42
LMH	185	87	45	12	87	22	12	87	22	116	54	28
LML	185	87	89	12	87	44	12	87	44	116	54	28
LMM	185	87	67	12	87	33	12	87	33	116	54	42
MHH	139	58	45	9	58	22	9	58	22	87	36	28
MHL	139	58	89	9	58	44	9	58	44	87	36	28
MHM	139	58	67	9	58	33	9	58	33	87	36	42
MLH	139	116	45	9	116	22	9	116	22	87	72	28
MLL	139	116	89	9	116	44	9	116	44	87	72	28
MLM	139	116	67	9	116	33	9	116	33	87	72	42

CROPS	PADDY			BLACKGRAM			REDGRAM			MUSTURD		
RATINGS_N_P_K	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP
MMH	139	87	45	9	87	22	9	87	22	87	54	28
MML	139	87	89	9	87	44	9	87	44	87	54	28
MMM	139	87	67	9	87	33	9	87	33	87	54	42

CROPS	RAGI			MAIZE			GREENGRAM			GROUNDNUT		
RATINGS_N_P_K	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP
HHH	50	58	28	93	58	45	6	58	22	6	58	44
HHL	50	58	56	93	58	45	6	58	44	6	58	88
HHM	50	58	42	93	58	67	6	58	33	6	58	66
HLH	50	116	28	93	116	45	6	116	22	6	116	44
HLL	50	116	56	93	116	45	6	116	44	6	116	88
HLM	50	116	42	93	116	67	6	116	33	6	116	66
HMH	50	87	28	93	87	45	6	87	22	6	87	44
HML	50	87	56	93	87	45	6	87	44	6	87	88
HMM	50	87	42	93	87	67	6	87	33	6	87	66
LHH	98	58	28	185	58	45	12	58	22	12	58	44
LHL	98	58	56	185	58	45	12	58	44	12	58	88
LHM	98	58	42	185	58	67	12	58	33	12	58	66
LLH	98	116	28	185	116	45	12	116	22	12	116	44
LLL	98	116	56	185	116	45	12	116	44	12	116	88
LLM	98	116	42	185	116	67	12	116	33	12	116	66
LMH	98	87	28	185	87	45	12	87	22	12	87	44
LML	98	87	56	185	87	45	12	87	44	12	87	88
LMM	98	87	42	185	87	67	12	87	33	12	87	66
MHH	74	58	28	139	58	45	9	58	22	9	58	44

CROPS	RAGI			MAIZE			GREENGRAM			GROUNDNUT		
RATINGS_N_P_K	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP	UREA	DAP	MOP
MHL	74	58	56	139	58	45	9	58	44	9	58	88
MHM	74	58	42	139	58	67	9	58	33	9	58	66
MLH	74	116	28	139	116	45	9	116	22	9	116	44
MLL	74	116	56	139	116	45	9	116	44	9	116	88
MLM	74	116	42	139	116	67	9	116	33	9	116	66
MMH	74	87	28	139	87	45	9	87	22	9	87	44
MML	74	87	56	139	87	45	9	87	44	9	87	88
MMM	74	87	42	139	87	67	9	87	33	9	87	66

CROPS	COWPEA (kg/ha)			MANGO (kg/plant)		
RATINGS_N_P_K	UREA	DAP	MOP	UREA	DAP	MOP
HHH	9	81	32	2.41	0.64	1.47
HHL	9	81	53	2.41	0.64	2.44
HHM	9	81	43	2.41	0.64	1.95
HLH	0	136	32	2.34	1.06	1.47
HLL	0	136	53	2.34	1.06	2.44
HLM	0	136	43	2.34	1.06	1.95
HMH	0	109	32	2.37	0.85	1.47
HML	0	109	53	2.37	0.85	2.44
HMM	0	109	43	2.37	0.85	1.95
LHH	36	81	32	4.10	0.64	1.47
LHL	36	81	53	4.10	0.64	2.44
LHM	36	81	43	4.10	0.64	1.95
LLH	15	136	32	4.02	1.06	1.47
LLL	15	136	53	4.02	1.06	2.44

CROPS	COWPEA (kg/ha)			MANGO (kg/plant)		
RATINGS_N_P_K	UREA	DAP	MOP	UREA	DAP	MOP
LLM	15	136	43	4.02	1.06	1.95
LMH	25	109	32	4.06	0.85	1.47
LML	25	109	53	4.06	0.85	2.44
LMM	25	109	43	4.06	0.85	1.95
MHH	23	81	32	3.25	0.64	1.47
MHL	23	81	53	3.25	0.64	2.44
MHM	23	81	43	3.25	0.64	1.95
MLH	2	136	32	3.18	1.06	1.47
MLL	2	136	53	3.18	1.06	2.44
MLM	2	136	43	3.22	0.85	1.95
MMH	12	109	32	3.22	0.85	1.47
MML	12	109	53	3.22	0.85	2.44
MMM	12	109	43	3.22	0.85	1.95

12.8 Adjustment Factor for the Recommended Dose of Fertilizer

To optimize fertilizer application based on soil nutrient status, a correction factor known as the Adjustment Factor (AF) is applied to the recommended nutrient dose. This factor ensures a balanced nutrient supply by increasing the amount of fertilizer in nutrient-deficient soils and reducing it in nutrient-rich soils.

Table 12-5: Soil fertility criteria for adjusting the recommended fertilizer doses for macro nutrient application (NPK) (Source: NBSS & LUP, Kolkata)

Nutrient	Very Low	Low	Medium	High	Very High
Nitrogen	Recommended dose x 1.67	Recommended dose x 1.33	Recommended dose x 1.00	Recommended dose x 0.67	Recommended dose x 0.33
P ₂ O ₅	Recommended dose x 1.67	Recommended dose x 1.33	Recommended dose x 1.00	Recommended dose x 0.67	Recommended dose x 0.33
K ₂ O	Recommended dose x 1.67	Recommended dose x 1.33	Recommended dose x 1.00	Recommended dose x 0.67	Recommended dose x 0.33

12.9 List of Fertilizers

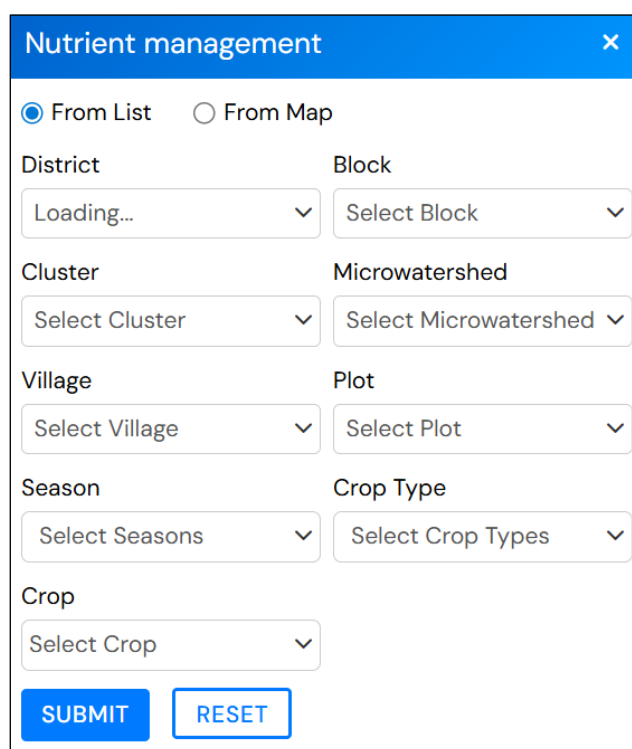
Fertilizers are chemical or organic substances that supply essential nutrients required for healthy crop growth. They are applied to soil or crops to replenish nutrient deficiencies and to improve soil fertility. The major fertilizers commonly used in agriculture are classified based on the nutrients they supply, such as Nitrogenous, Phosphatic, Potassic.

Table 12-6: Name of fertilizers (Source: NBSS & LUP, Kolkata)

S. No	Name of Fertilizers
1	Diammonium Phosphate (18-46-0)
2	Urea (46% N) in different forms like Super granulated, granular and neem-coated urea.
3	Ammonium Phosphate (20-20-0)
4	Potassium Chloride (Muriate of Potash)- powder and granular form
5	N.P ₂ O ₅ K ₂ O (10-26-26)
6	Single Super Phosphate (16% P ₂ O ₅)
7	Diammonium Phosphate (18-46-0), Urea, Single Super Phosphate (16% P ₂ O ₅), Potassium Chloride (Muriate of Potash)
8	Ammonium Phosphate (20-20-0), Urea, Single Super Phosphate (16% P ₂ O ₅), Potassium Chloride (Muriate of Potash)
9	N.P ₂ O ₅ K ₂ O(10-26-26), Urea, Single Super Phosphate (16% P ₂ O ₅), Potassium Chloride (Muriate of Potash)
10	Urea, Single Super Phosphate (16% P ₂ O ₅), Potassium Chloride (Muriate of Potash)

12.10 Steps for the execution of Nutrient Management Plan DSS

1. After successfully logging into the portal, the user shall select the DSS tab located on the right side of the web page.
2. Once the user clicks on the DSS tab, then two options, "DSS" and "Layers" will be displayed on the left of the web page.
3. The user will select the DSS tab.
4. There will be three options, and the user needs to select the LRI option; a list of DSS modules will then drop down under the LRI tab.
5. The user shall select the DSS module named **Nutrient Management** from the list. After selecting the module, a dialogue box will appear on the right side of the web page.
6. The dialogue box will have two options to select Micro Watershed, "From List" and "From Map". The "From List" option allows the user to select District, Block, Cluster, Micro Watershed, Village, Plot, Season, Crop Type and Crop. The details of the input fields in the Web page are as mentioned in the section. The "From Map" option will allow the user to select on the map, which will auto-fill the District, Block, Cluster, Micro Watershed, Village, and Plot. Then the user needs to select Season, Crop Type and Crop.



The dialog box titled "Nutrient management" contains the following fields and controls:

- Radio buttons: ☒ From List, ☐ From Map
- Dropdowns: District (Loading...), Block (Select Block), Cluster (Select Cluster), Microwatershed (Select Microwatershed), Village (Select Village), Plot (Select Plot), Season (Select Seasons), Crop Type (Select Crop Types), and Crop (Select Crop).
- Buttons: SUBMIT and RESET.

Figure 12-2: Dialogue box for the selection of input fields

1. The user will select the District, Block, Cluster, Micro Watershed, Village, Plot, Season, Crop Type and Crop.
2. After the selection of the crop, click on the "Submit" tab.
3. A database query will be executed to retrieve the soil fertility data (N, P, and K values) of the selected plot.
4. A database query will be executed to determine the soil fertility class (i.e., Low, Medium, High) for each nutrient (N, P, and K) corresponding to the selected plot.
5. A query will be executed to retrieve the recommended nutrient dose for the selected crop based on the class-code of the nutrient for the selected crop.

For example: If the user selects a plot where the soil nutrient classes are identified as: Nitrogen (High – H), Phosphorus (Medium – M), and Potassium (Low – L), then the corresponding nutrient class-code will be **"HML."**

6. Estimate the amount of recommended dose of nutrients for the respective fertilizers.

For example: If the recommended dose of nutrients for a crop is:

- Nitrogen (N) = 56 kg/ha
- Phosphorus (P_2O_5) = 26 kg/ha
- Potassium (K_2O) = 20 kg/ha

And the selected fertilizer for supplying nitrogen is Urea (46–0–0), which contains 46% Nitrogen, then the required amount of Urea is calculated as,

$$\text{Nitrogen (N)} = 56 * 0.46 = 25.76 \text{ kg/ha}$$

$$\text{Phosphorus (P)} = 26 * 0 = 0 \text{ kg/ha}$$

$$\text{Potassium (K)} = 20 * 0 = 0 \text{ kg/ha}$$

7. Estimate the adjusted recommended dose of nutrients for the selected crop based on the corresponding soil nutrient class.
8. Display the results in a tabular format using the fields listed below.
 - Micro Watershed Name
 - Micro Watershed Code
 - Plot no.
 - Total Area in Hectare (ha)
 - Crop Name
 - NPK Recommendation as per soil test value
 - Fertilizer Name
 - Nutrient Required (kg/ha) (N, P, K)

District:Sambalpur Block:Jumumura Cluster:Jumumura-1 Micro Watershed:Bhadimura Village:Dantari Plot:Dnt1208017186

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SR No.	Micro Watershed	Micro Watershed Code	Plot	Total Area in Ha(Hectare)	Crop Name	NPK Recommendation as per soil test value	Fertilizer name	Total Nutrient Required (kg/Ha)
1	Bhadimura	0407010207140201	Dnt1208017186	3.6	Paddy	N=246 P2O5=87 K2O=67	Diammonium Phosphate	84.31
2	Bhadimura	0407010207140201	Dnt1208017186	3.6	Paddy	N=246 P2O5=87 K2O=67	Potassium Chloride	138.43
3	Bhadimura	0407010207140201	Dnt1208017186	3.6	Blackgram	N=16 P2O5=87 K2O=33	Diammonium Phosphate	42.89
4	Bhadimura	0407010207140201	Dnt1208017186	3.6	Blackgram	N=16 P2O5=87 K2O=33	Potassium Chloride	76.61
5	Bhadimura	0407010207140201	Dnt1208017186	3.6	Redgram	N=16 P2O5=87 K2O=33	Diammonium Phosphate	42.89
6	Bhadimura	0407010207140201	Dnt1208017186	3.6	Redgram	N=16 P2O5=87 K2O=33	Potassium Chloride	76.61
7	Bhadimura	0407010207140201	Dnt1208017186	3.6	Maize	N=246 P2O5=87 K2O=67	Diammonium Phosphate	84.31
8	Bhadimura	0407010207140201	Dnt1208017186	3.6	Maize	N=246 P2O5=87 K2O=67	Potassium Chloride	138.43
9	Bhadimura	0407010207140201	Dnt1208017186	3.6	Groundnut	N=16 P2O5=87 K2O=66	Diammonium Phosphate	42.89
10	Bhadimura	0407010207140201	Dnt1208017186	3.6	Groundnut	N=16 P2O5=87 K2O=66	Potassium Chloride	96.41

Showing 1 to 10 of 16 entries Previous 1 2 Next

Figure 12-3: Output View of Nutrient Management Plan DSS

9. The user can export the table to an Excel sheet using the 'EXPORT TO EXCEL' option and can also download the generated report using the "DOWNLOAD REPORT"

The process flow for execution of the DSS for Nutrient Management in the portal is given in Figure 12-4.

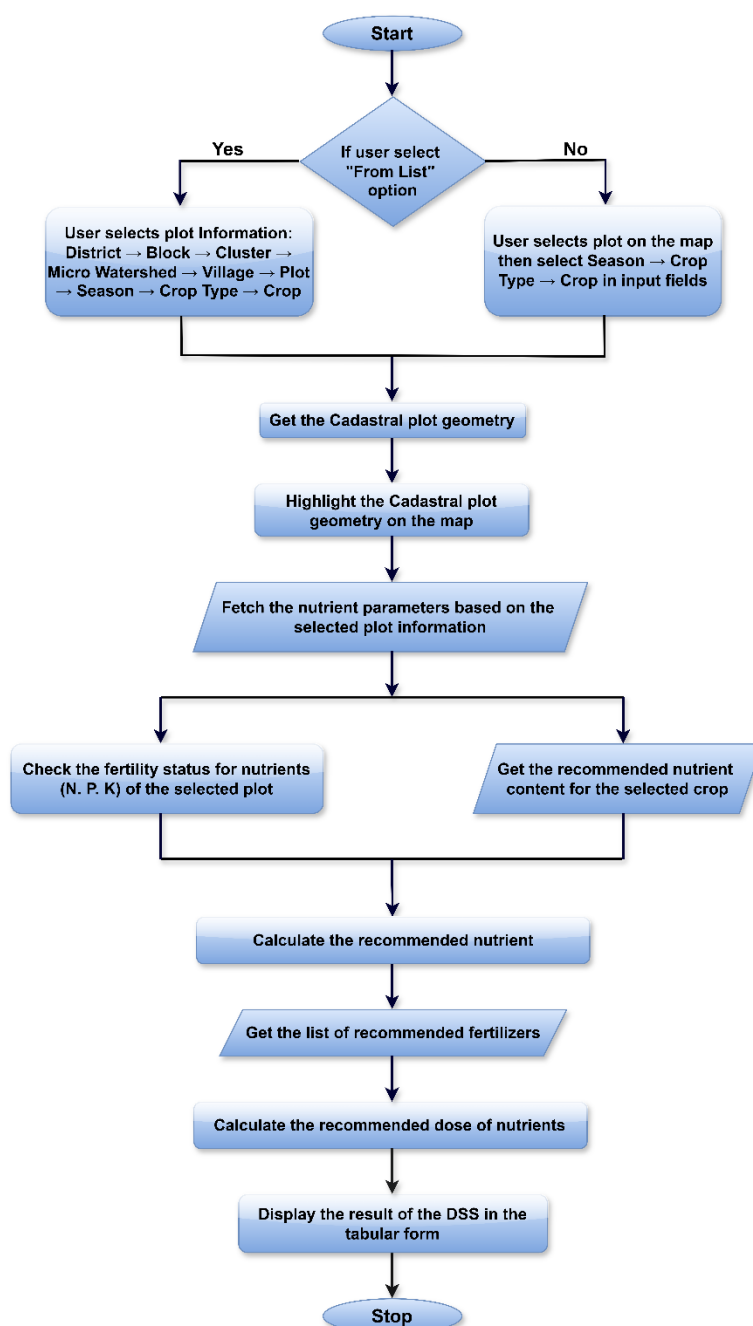


Figure 12-4: Flow diagram for the execution of DSS on nutrient management in the portal

13 List of datasets used in the DSS

Category	Parameter
Climate and Meteorological Data	Precipitation
	Maximum Temperature
	Minimum Temperature
	Annual Rainfall
	1-hour Maximum Rainfall
	Temperature
	Mean Temperature in Growing Season
	Solar Radiation
Topographical / Terrain Data	Digital Elevation Model (DEM)
	Slope
	Elevation
	Drainage Density
	Lineament Density
	Catchment Area
	Stream Order
	Land Slope (%)
Geological Data	Lithology
	Geomorphology
	Surface Soil Texture
	Subsurface Soil
Soil Moisture & Physical Properties	Daily Soil Moisture (SM)
	Field Capacity (FC)
	Permanent Wilting Point (PWP)
	Soil Infiltration
	Infiltration & Crop Condition
	Soil Type
	Hydrological Soil Group
	Hydrological Condition
	Soil Drainage
	Texture
	Effective Soil Depth
Soil Chemical Properties	pH, EC, OC, N, P, K, Zn, Fe, Cu, B, S
Land Use / Crop Data	LULC
	Arable / Non-Arable
	Area of Crop
Hydrological and Water Balance Data	Percolation Loss
	Water Level of Previous Day
	Soil Moisture of Previous Day
	Soil Moisture of Current Day

Category	Parameter
	Surface Water
	Groundwater
Structural / Engineering Design Data	Free Board (%)
	Settlement Height (%)
	Effective Length
	Height
	Top Width
	Bottom Width
	Foundation Depth
	Upstream/Downstream Slope
	Length/Width
	Filling Material / Pattern
	Pole Spacing
	Gabion Box Parameters
	Retaining Head Wall
	Bund Parameters
Cost & Labor Parameters	Cost of Stones
	Earthwork Labor Cost
	Stone Filling Labor Cost
	Stone Carriage Labor Cost
	Wire Netting Labor Cost
	Gabion Wire Cost
	Earthwork Rate
	Labor Category
	Labor Rates
	Man days per ha
	Rate per Man-day
	Skilled Labor
Socio-Economic & Demand Data	Domestic Population
	Livestock Population
	Domestic Water Demand
	Livestock Water Demand



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