



## Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD)

### LRI based Watershed Management - REWARD Program for PIA/DWCO Officers, WALMI, Aurangabad

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**Centre of Excellence on Watershed Management  
University of Agricultural Sciences, Bangalore**

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## **1. An overview of scientific approaches followed in REWARD program**

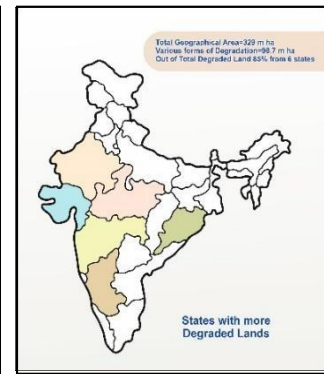
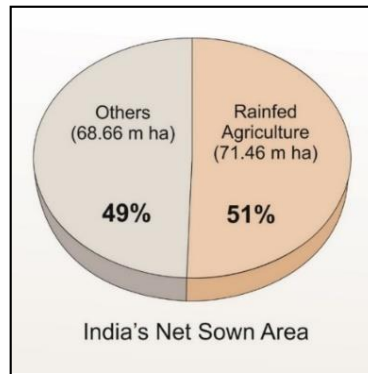
The finite land resources of our country are under severe strain due to the needs of the growing population and competing demands of land uses. Due to this about 96 million hectares of land area (MoEF 2021), representing 30 percent of the total geographical area, is degraded mostly due to erosion, salinity and alkalinity has become a serious problem in the command and arid areas, deficiency of secondary and micronutrients is widespread in the cultivated areas, ground water exploitation has become critical in most parts of the country and declining factor productivity observed in majority of the crops. Among the various forms of degradation soil erosion is the major cause for the declining factor productivity followed by salinity and alkalinity. The situation is getting aggravated year after year and as per the estimate the area critically affected by soil erosion alone has doubled from 1977 to 2007 in the country which might be even more at present (Planning Commission, 2007). As per the High-level committee on Wastelands (GoI, 1995), the uncontrolled and continuing land degradation in the form of soil erosion is a major threat to the country's economy and observed that about two-thirds of our agricultural lands are sick in one form or other and only about 48 m ha are in good health. The situation is further compounded by climate change which has emerged as the main driver of land degradation in India, with erosion of topsoil reducing the land's carbon sink ability and water storage function in the soil. The recent study carried out in Karnataka under Sujala-3 Project has highlighted the declining status of the resource base with the very poor organic carbon, low moisture retention, unremunerated and unsustainable yield levels in the vast rainfed areas of the state (The Hindu 2018, WDD 2020).

It is obvious that urgent measures are needed not only to arrest the declining health of land resources in the country but also to regenerate the degraded lands in a reasonable timeframe. Otherwise, the cost of the neglect, estimated to be about 2.5 per cent of the GDP in 2014-15, will be too high to pay in the future (TERI, 2018). Realizing this and to improve the productivity of the resources on a sustainable basis, a plethora of schemes/plans have been formulated and implemented by both state and central government in the country since independence. Even with all the budgetary provision for various schemes like Watershed Development, MGNREGA, RKVY, NFSM and others, the health of the country's resource base has not shown any perceptible change and on the other hand there is a continuing deterioration witnessed at the field level. It is obvious that there is a clear mismatch between the plans formulated and executed by various line departments and the needs or the requirements at the field/grassroots level in the country.

Hence, there is a need for adoption of advanced scientific approaches in watershed planning and management. In this regard, Karnataka has implemented Sujala-3 / Karnataka Watershed Development Project-II with the support of World Bank to generate site and location specific scientific data and continued in REWARD program. In the following paragraphs, the concept of Watershed Development and approaches followed in Sujala-3 and REWARD are described.

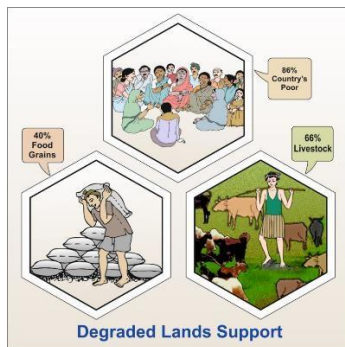
## A. Watershed Development and its importance

1. India ranks first globally in area and value of production from rainfed agriculture. It occupies about 51 per cent of country's net sown area of 140.13m ha. Out of the total geographic area of 329 m. ha, more than 30 per cent is affected by various forms of land degradation and out of this,



rained areas account for more than 85 per cent of degraded lands in the country, mostly occurring in Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Odisha and Rajasthan.

- 2.



The degraded land is the home to 86% of the country's poor, produce 40% of the food grains, and support 66% of the livestock population. Among the various forms of degradation, soil erosion is the major cause for the declining factor of productivity followed by salinity and alkalinity. The situation is getting aggravated year after year and as per the estimate, the area critically affected by soil erosion alone has doubled in 30 years from 1977 to 2007 in the country. The solution is integrated watershed management/development.

3. A watershed, is as an area in which all water flowing into it goes to a common outlet. All lands on earth are part of one watershed or the other. Watershed Development (WSD) is the preservation, renewal, and wise use of all natural resources, particularly those related to the land, the water, the vegetation, and the animals, as well as human development within the watershed.

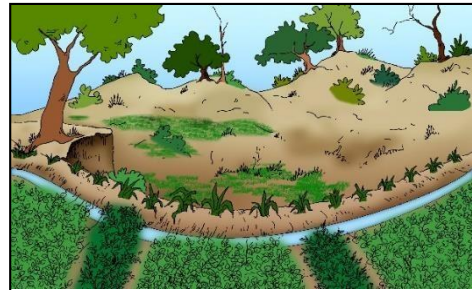
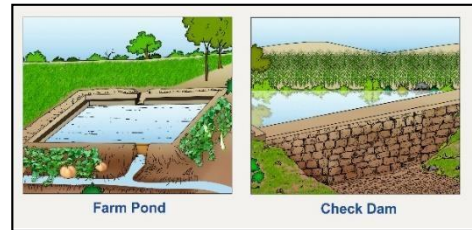


- 4.



Watershed Development in India has been a part of the national approach to improve agricultural production and alleviate poverty in rainfed regions since 1970s. Watershed development programs aim to restore degraded watersheds in rainfed regions to increase their capacity to capture and store rainwater, reduce soil erosion, and improve soil nutrient and carbon content so that they can produce greater agricultural yields and other benefits.

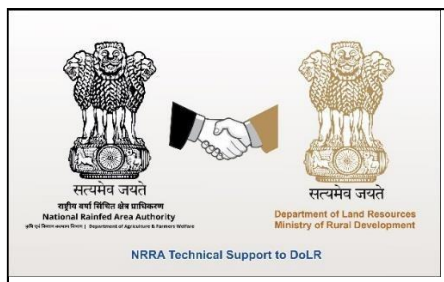
5. The objective of watershed development is maximizing the productivity and income per unit area, per unit time and per unit of water thereby improving the socio-economic status of the farmers. The objective of watershed development can be achieved through implementation of a series of systematic approaches, (a) preserving as much water as possible at the place it falls to avoid gully formation and putting checks at suitable intervals to control soil erosion, (b) harvesting and storing excess runoff by draining out excess water with a safe velocity and diverting it to farm ponds, check dams and nala bunds, (c) promotion of alternate land use system to improve vegetation by intensifying horticulture, agro forestry, silvi-pasture etc., (d) improving crop production systems by effective crop and nutrient management, increased cropping intensity, and land equivalent ratio through intercropping and sequence cropping and (e) development of livelihood support systems by promoting appropriate bio mass based income generating activities for the vulnerable sections of the community.



6.

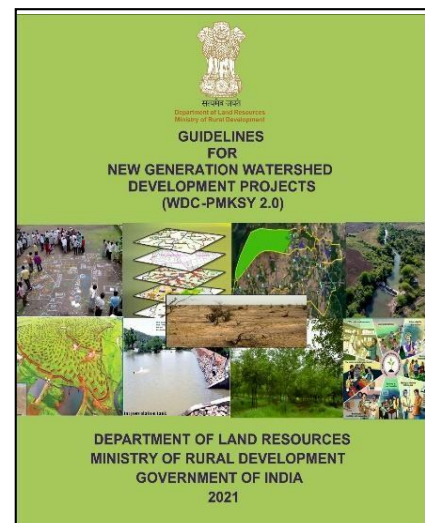


In 1970's Soil and water conservation was taken up with a focus on engineering structures mainly for protecting dams. In 1983, the Operation Research Projects (ORPs) were established in 47 watersheds spread over 16 states covering an area of 35739 ha under the technical guidance of Indian Council of Agricultural Research. The ORPs aimed at arresting the deterioration of environment and building up permanent assets in the form of water, sustainable vegetation and improved productivity of croppeland. During 1990's emphasis was given on participatory watershed development where the community was involved in planning implementation and management.

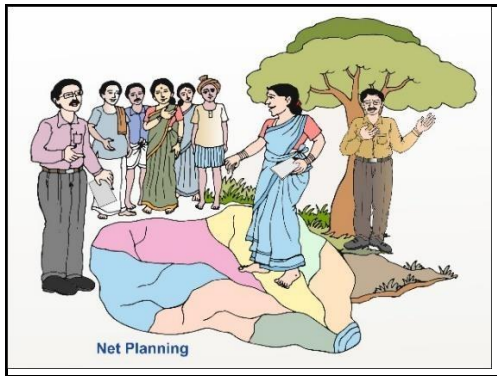


In 2006 National Rainfed Area Authority (NRRA) by the Planning Commission was established to provide technical support to Department of Land Resources (DoLR), GoI, and issued common guidelines for all watershed development programmes for the development of rainfed farming in India.

7. The Guidelines for new Generation Watershed Development Projects (WDC-PMKSY 2.0) issued by DoLR in 2021, emphasizes shifts in approaches from mechanical to agricultural engineering structures, effective use of rain water by relying more on water productivity, crop systems diversification for risk management, promotion of water use efficient crops, integrated farming systems for adaptation and mitigation of adverse impacts of climate variability, establishing FPOs to promote agri-business and nurturing of community groups. The DoLR Guidelines issued during 2021, under WDC-PMKSY 2.0, also emphasizes the use of GIS and RS technologies for scientific planning and monitoring the performance of watershed development projects.



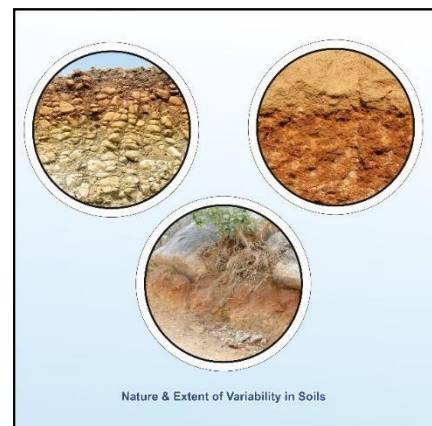
8.



The common approach followed in watershed planning in earlier watershed development programmes was, net-planning which is an eyesight-based planning for each survey number. The designs of drainage line structure were standardized ones and do not take into account the run-off available at the site. Indiscriminately, water harvesting structures were built.

## B. Emergence of Sujala-3 project

9. It is a recognized fact that the factors and processes affecting degradation, productivity and sustainability are very site and location specific. For any meaningful intervention needed for the restoration and management of degradation, necessitates site-specific land resource information which is not available at present for major part of the country. As the land resources are not uniform, generation of location specific information pertaining to the nature and extent of variability in soil, water availability, topography and land use is a prerequisite for successful planning and implementation of development programs by agriculture, horticulture, watershed, forestry, irrigation, and other programs in any area. Non availability or lack of such site-specific land resource information is responsible for the failure of many development programmes implemented in the past by Development Departments in the Country.



10. Realizing the importance of site-specific soil and other information for taking up targeted interventions, the World Bank supported Karnataka watershed Development Project- KWDP II, popularly known as Sujala-3 project, implemented from 2013 to 2019 in about

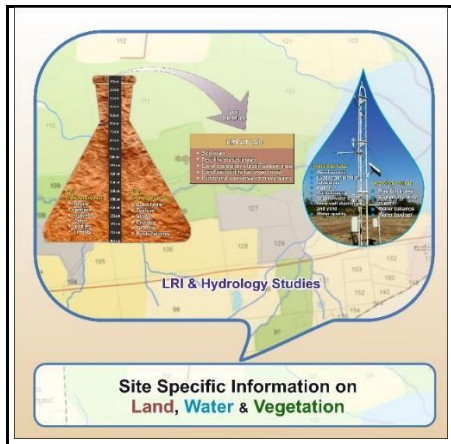


14 lakh ha spread over in 11 Districts of Karnataka. Sujala-3 has clearly demonstrated the importance of cadastral level database, thematic maps and digital tools in planning, implementation, and monitoring of various interventions at the field level. This approach has significantly reduced the watershed development cycle to four years. The advanced approaches in Sujala-3 have helped to take up site-specific soil and water conservation interventions, selection of crops as per their suitability, nutrient management as per the fertility status and crop requirement,

construction of water harvesting structures as per the available excess runoff from the area, allocation of water to different sectors as per the balance and water budgeting as per the present and future demands.

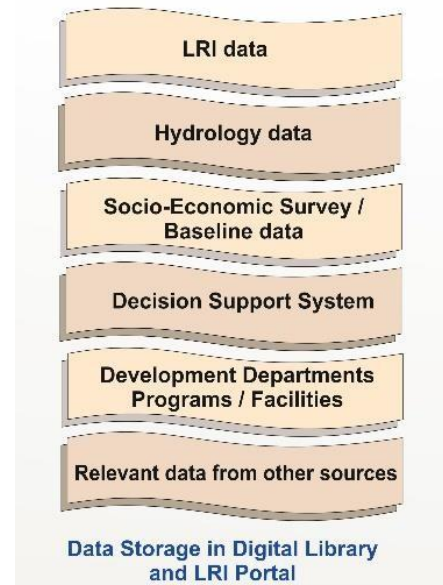
11. The uniqueness Sujala-3 project was adoption of more advanced scientific approaches for capturing the data on status of land, water, and other resources at cadastral level through land resource inventory (LRI) and hydrological assessments for preparation of scientific Detailed Project Reports (DPR) for watershed development. Sujala-3 has clearly demonstrated the importance of cadastral level database, thematic maps and digital tools in planning, implementation, and monitoring of various interventions at the field level. This approach has significantly reduced the watershed development cycle to four years.

12.



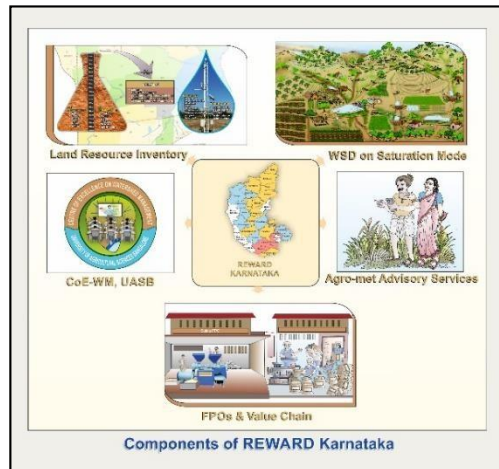
The advanced approaches in Sujala-3 have helped to take up site-specific soil and water conservation interventions, selection of crops as per their suitability, nutrient management as per the fertility status and crop requirement, construction of water harvesting structures as per the available excess runoff from the area, allocation of water to different sectors as per the balance and water budgeting as per the present and future demands.

13. To carryout LRI and hydrological studies under Sujala-3 project, 15 scientific consortium partners were involved. Development of Decision Support System (DSS), to improve watershed planning, by integrating the data base generated with decision criteria, models and algorithms is one of the noteworthy outcomes of the project. A web-based portal was created for easy access to data sets for multiple purposes in targeted watersheds

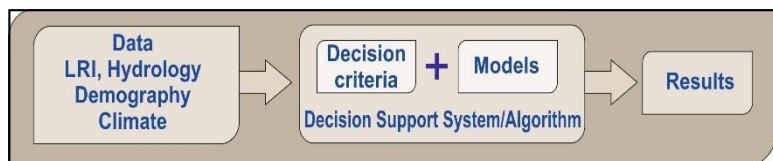




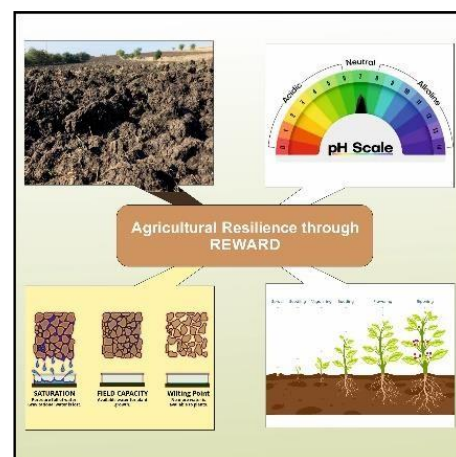
17. The major Components of REWARD program are (a) Land resource inventory (LRI) in 19 lakh ha of rainfed watershed areas spread over in 21 districts, (b) watershed development on Saturation mode covering an area of one lakh ha in 20 sub watersheds based on LRI & Hydrology recommendations, (c) FPO and Value chain development through 25 FPOs, (d) providing improved agro-met advisory services to farmers, (e) anchoring Centre of Excellence on Science based Watershed Management at UAS Bangalore.



18. Salient features of REWARD are (a) generation of cadastral level land resource information using RS, GIS and other advanced scientific tools and technologies, (b) development of criteria, models, algorithms and guidelines, (c) understanding hydrological dynamics vis-a-vis hydro-geology & climatic variability and develop tools to measure them (d) developing protocol for demystifying the science to community through consultation process and thus reducing watershed development cycle, (e) evidence based monitoring and impact evaluation of the project interventions, (f) consortium approach in achieving objectives - Scientific research institutes associate as project stakeholders, (g) establishing CoE on WM plays a critical role in building capacity of all the States on LRI and operationalization of future generation PMKSY- WDC programs in the country.



19. To achieve agricultural resilience, the science-based approaches are being adopted in assessing the status of natural resources and improving them through comprehensive approaches in the watershed management program, to improve soil organic carbon, improvement in soil pH, improvement in soil moisture retention and improvement in length of growing period.



20. The REWARD program's Development Objective is to strengthen capacities of National and State institutions to adopt improved watershed management for increasing farmers' resilience and support value chains in selected watersheds of participating States.

21. The committees for smooth implementation of the REWARD program

- a. National Level Steering Committee (NLSC): Headed by Secretary, DoLR, Senior Officers from: DoLR, NRAA & relevant national departments and research organizations; and State Watershed Departments of Karnataka and Odisha

Responsibilities of NLSC: (a) To improve convergence between agriculture, watershed, water resources, rural development and other related ministries and (b) provide high level oversight and guidance for the implementation of the Program



- b. National Level Technical Committee (NLTC): The committee will be constituted by DoLR.

Responsibilities of NLTC: (a) review and standardize scientific protocols; (b) develop national technical standards; (c) strengthen the national web-based portal; and (d) provide high level support to the National Level Steering Committee



- c. National Program Management Unit: Chaired by the Joint Secretary of DoLR, Program Director supported by an additional Program Director, watershed management expert, hydrologist/water resource expert, institution and capacity building expert, monitoring and evaluation expert, financial management expert, and procurement expert



- d. Karnataka State Level Nodal Agency: Chaired by the Commissioner & Program Director of Karnataka's Watershed Development Department, and include senior officers of the rank of Joint Director, Deputy Directors and consultants, for covering subjects related to soil and water conservation (including land resource inventory), agronomy, horticulture, forestry, animal husbandry, hydrology, social development, capacity building, RS/GIS, value chains (FPOs), procurement, monitoring and evaluation, and others



- e. District and Block Level (PIA): Officers of Karnataka's DoA will supervise the implementation of the Program Implementing Agency's Respective Part of the Program at the District and Block levels

- f. WCs and GPs: Program Implementing Agency shall support WC and GPs to actively participate in the implementation of Program, including operation and maintenance, reporting.

22.

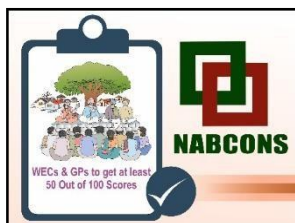


The REWARD program in Karnataka, covers 21 Districts with a budget outlay of Rs 600 Crores. Out of the total budget, the World Bank share is 70% and GoKs share is 30%. The duration of the program is for five years. The major Components of REWARD program are (a) Land resource inventory (LRI) in 19 lakh ha of rainfed watershed areas spread over in 21 districts, (b) watershed development on Saturation mode covering an area of one lakh ha in 20 sub watersheds based on LRI & Hydrology recommendations, (c) FPO and Value chain development through 25 FPOs, (d) providing improved agro-met advisory services to farmers, (e) anchoring Centre of Excellence on Science based Watershed Management at UAS Bangalore.

23. The World Bank financing for the REWARD program is “P for R” (Program for Results) mode and disbursement of funds by the World Bank is based on achievements of the results (a) strengthened institutions and supportive policy for watershed development and (b) scientific watershed development and enhanced livelihoods. A set of Disbursement Linked Indicators (DLI) are identified for the components of REWARD program. The NABCONS (NABARD Consultancy Services) has been entrusted for verification of the indicators at different phases of the project cycle.

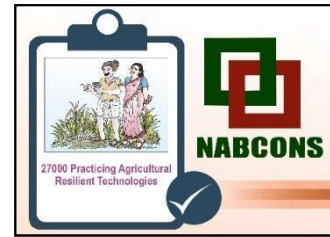


24. Disbursement of funds based on achievements of the results. For this purpose, Disbursement Linked Indicators are set for important components. The NABCONS (NABARD Consultancy Services) has been entrusted for verification of the indicators.



According to the first indicator, the WCs & GPs demonstrate satisfactory watershed management as measured through a performance rating system-30% WCs and GPs get more than 50% score on the indicators at three stages of project cycle-preparatory, works and operation and maintenance.

According to the second indicator, the land area in 200 MWS should be treated as per the scientific recommendations (LRI and Hydrology). It is also called watershed development on saturation mode.



According to the third indicator, 27000 farmers to adopt and practice resilient agriculture technologies.

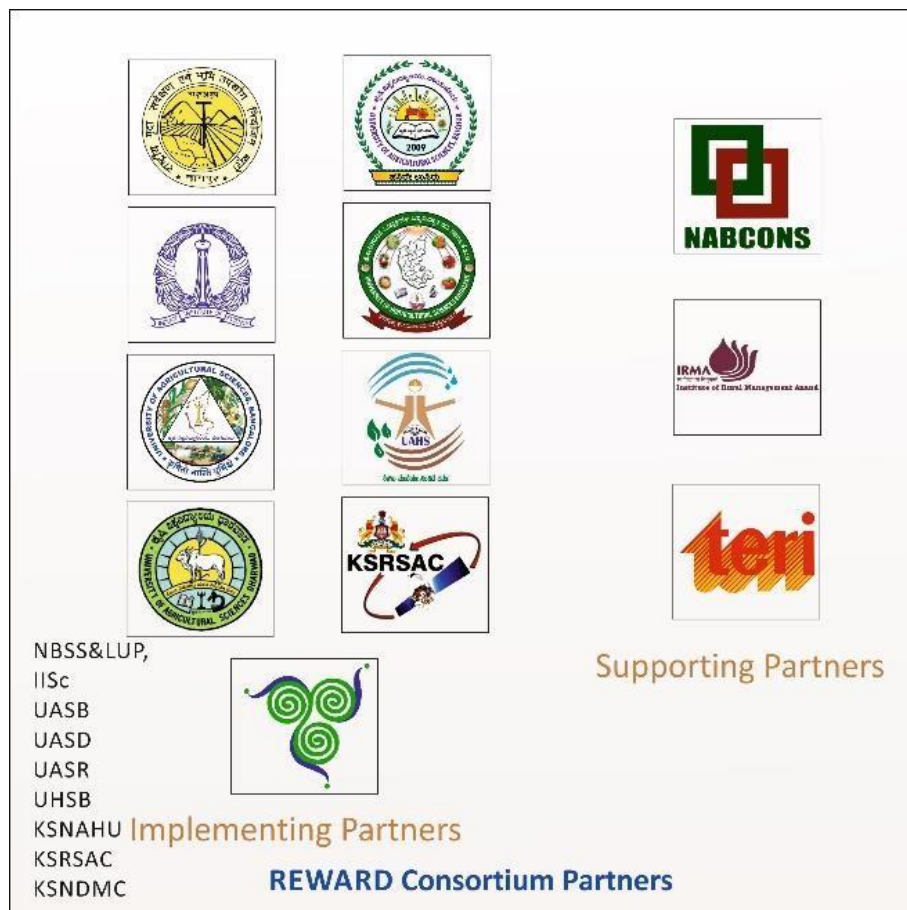
According to fourth indicator, there should be 25 per cent increase in business turnover relative to baseline among existing FPOs and additional 15 FPOs should be started.



According to fifth indicator, certified training to 1125 professionals on improved watershed management by the Centre on Excellence on Watershed Management.

25. The REWARD program is distinctly different from other watershed development programs initiated in the country. Its distinctness is attributed to seven in built salient features of the program namely, (a) generation of cadastral level land resource information using RS, GIS and other advanced scientific tools and technologies, (b) development of criteria, models, algorithms and guidelines, (c) understanding hydrological dynamics vis-a-vis hydro-geology & climatic variability and develop tools to measure them (d) developing protocol for demystifying the science to community through consultation process and thus reducing watershed development cycle, (e) evidence-based monitoring and impact evaluation of the project interventions, (f) consortium approach in achieving objectives - Scientific research institutes associate as project stakeholders, (g) establishing CoE on WM plays a critical role in building capacity of all the States on LRI and operationalization of future generation PMKSY-WDC programs in the country.

26. The REWARD program creates an opportunity for establishment of a consortium of scientific partners/user agencies with defined roles & responsibilities, which will form a template to take forward science-based watershed development approach. Two types of consortium partners are involved namely implementing partners and supporting partners. Implementing Partners include (a) National Bureau of Soil Survey & Land Use Planning (ICAR-NBSS&LUP)-lead institute for LRI, (b) Indian Institute of Science (IISc), Bengaluru- lead institute for hydrology, (c) Five State Agricultural Universities (UAS-B/D/R/UHS-B/ KSN&HU-S)- for LRI and hydrology, (d) Karnataka State Remote Sensing and Application Centre (KSRSAC)-providing maps and satellite imageries, (e) Karnataka State Natural Disaster Monitoring Centre (KSNDMC)- for metrological data.



The Supporting partner institutes under REWARD program are (a) NABARD Consultancy Services (NABCONS)- as an Independent Verification Agency (IVA) for verifying disbursement linked indicators (DLI) achievement and reporting to the World Bank, (b) Centre of Excellence for Watershed Management, UAS Bangalore for upscaling LRI, (c) Institute of Rural Management, Anand (IRMA) as a consulting Research Agency (CRA) for impact evaluation, and (d) The Energy and Resources Institute (TERI) as a Process Monitoring Agency (PMA) for process monitoring.

## 2. Land Resources Inventory for watershed planning and management

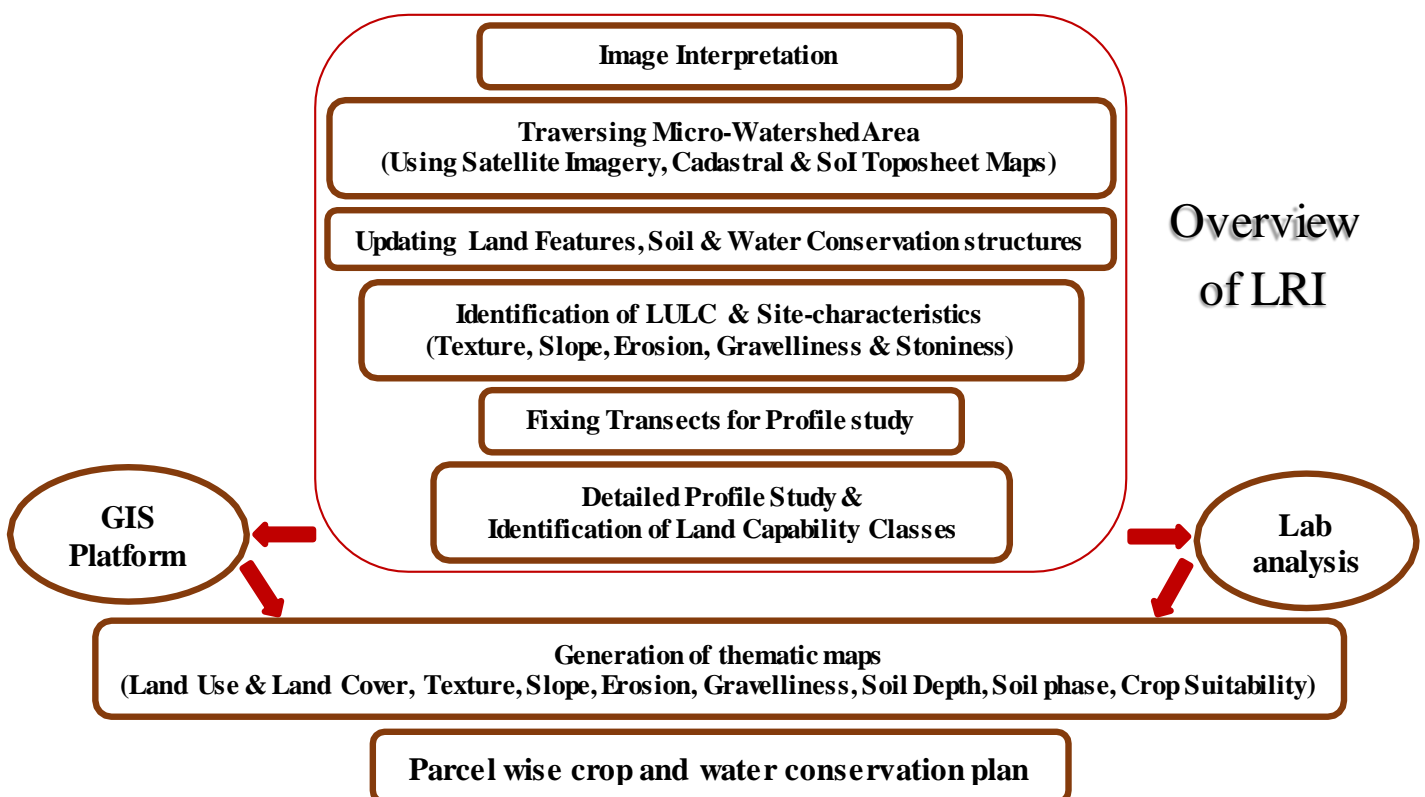
The Land Resource Inventory (LRI) is an assessment of the status and changing condition of soil, water and related resources at the field level. The LRI database is generated on a geo-referenced cadastral map, superimposed on satellite imagery. The land parcels are grouped into management units based on similarity in soil and site characteristics.

### Significance of LRI

- Identification of land resources
- Provides scientific database for adopting suitable soil and water conservation measures
- Helps in developing site-specific agricultural technologies
- Helps in increasing productivity
- Helps in enhancing farmers income and increasing the socio-economic status of the farmer

### Maps inputs needed for LRI

- Village cadastral maps at a particular scale
- Satellite imagery like Cartosat/Quick Bird images at a convenient scale
- Seamless image for micro watersheds and sub watersheds
- Overlay of seamless cadastral maps on micro watershed, sub watersheds
- Survey of India Topographical sheets of 1: 50,000 or larger if available
- Geology map of the Taluk/District sheets on 1:50,000 scale or larger
- Overlay of 1:50,000 scale geology map on 1: 50,000 scale imagery
- Geomorphology map, wherever available
- Land use/Land cover map
- Drainage and water bodies map



## LRI approach - data generation process

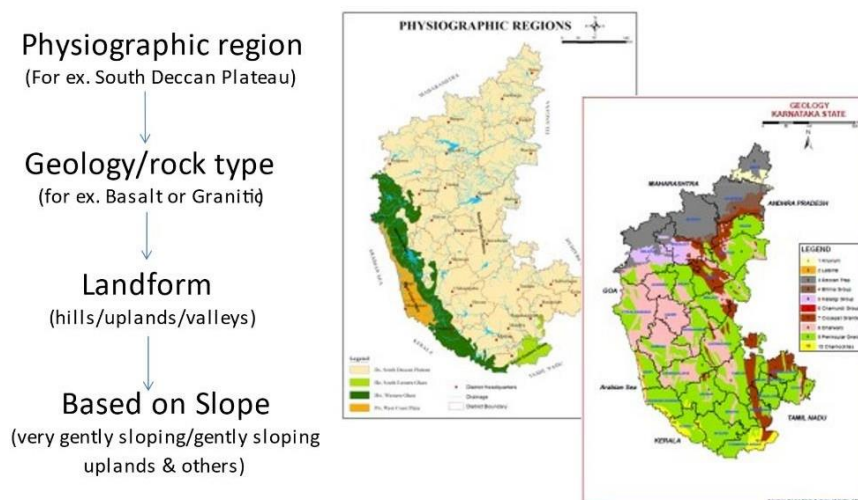
### Pre-field activities: Image interpretation for various physiographic units and identification of transect for profile studies

This is the most important pre-field activity, carried out to identify and delineate different physiographic regions, rock types, landscapes, landforms and their subdivisions at different levels-from district, taluk, watershed and village before the start of the field work in the survey area. At the time of interpretation itself transects representing the variations observed on the imagery to be selected and marked on the base map.

### Interpretation at Sub watershed level:

At SWS level, interpretation is done to identify major physiographic regions/units, geology or rock types, different landforms occurring within the geological formations and landform units based on land use, slope, image characteristics and other converging evidence.

### Sub watershed level



Then within the physiographic region/unit, any variation in geology/rock formations is identified and separated on the imagery and within each geological area landforms like hills, mounds and ridges, inselbergs, uplands, valleys, lowlands, *etc.* are delineated based on contour intervals as observed from the contour map/toposheet and image characteristics. This will result in the generation of physiography-landform map with the legend at the SWS level. During the interpretation itself few transects representing major landforms selected and marked on the imagery.

### Interpretation at MWS level:

At MWS level, the landform units identified at SWS level is further subdivided based on change in slope, land use and other surface features as evidenced through the image characteristics and other converging evidence of the area.

For example, the hills identified at sub-watershed level and not subdivided due to the scale limitation can be further subdivided into summits, escarpments, side slopes (upper, middle, and lower side slopes) and foot slopes at the MWS level based on their extent and slope. Similarly,

the uplands can be subdivided into rolling, undulating, gently sloping, very gently sloping and nearly level lands based on their extent and slope at the MWS level.



**Red sand stone**



**Basalt Rock**



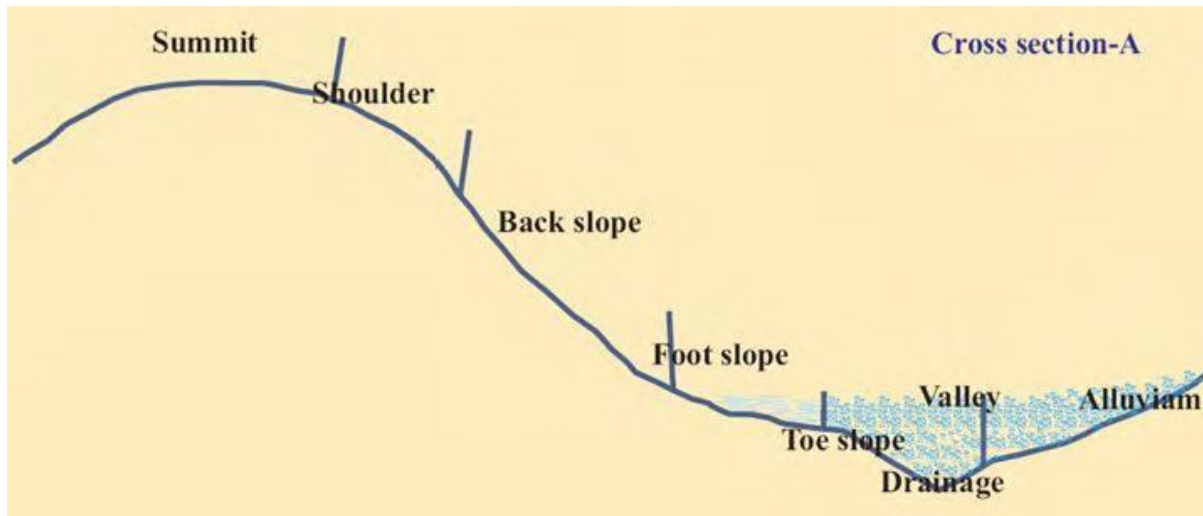
**Granite**



**Laterite**

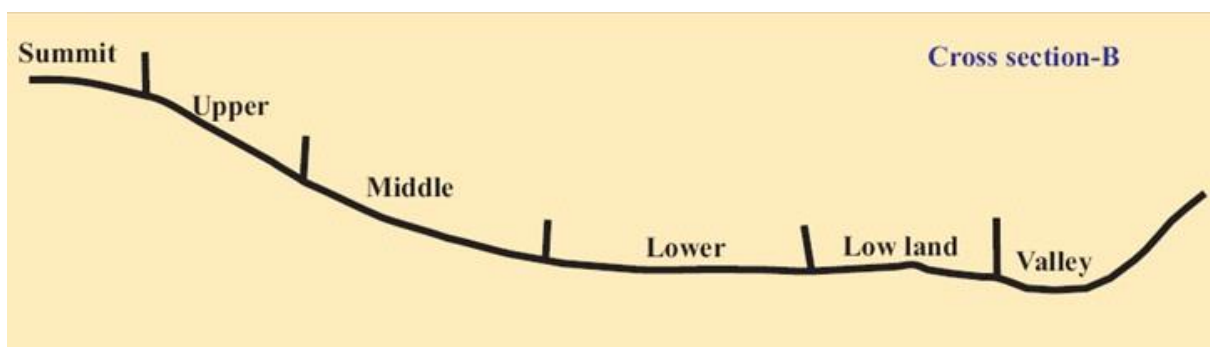


**Schist**



### **Different slope elements as seen in hills landform in a micro watershed**

In the next level, the landform units can be further subdivided based on variations like erosion, presence of gravel/stones/boulders, rock outcrops, drainage, salinity *etc.*, as evidenced further through the image characteristics and other converging evidence of the area.



### **Different slope elements as seen in uplands landform in a micro watershed**

For example, within the undulating or gently sloping area of the upland if there are any variations observed in the tonal characteristics of the imagery and such variations are mappable, then such areas are to be delineated on the imagery. The variations at this level could be due to the severity of erosion in some areas of the unit or the presence of gravel or stones *etc.* Many times, the reasons for these variations could not be ascertained clearly on the imagery at this level and in such situations, the delineated unit can be checked in the field later and corrected accordingly.

In lowland areas, slope will not be a critical factor, instead soil texture, colour, drainage, flooding, salinity and sodicity *etc.*, will be critical for management. If there is any significant change in one of these properties as seen on the imagery, then it needs to be identified and delineated based on the tonal characteristics.

## Image Interpretation Legend for Physiography

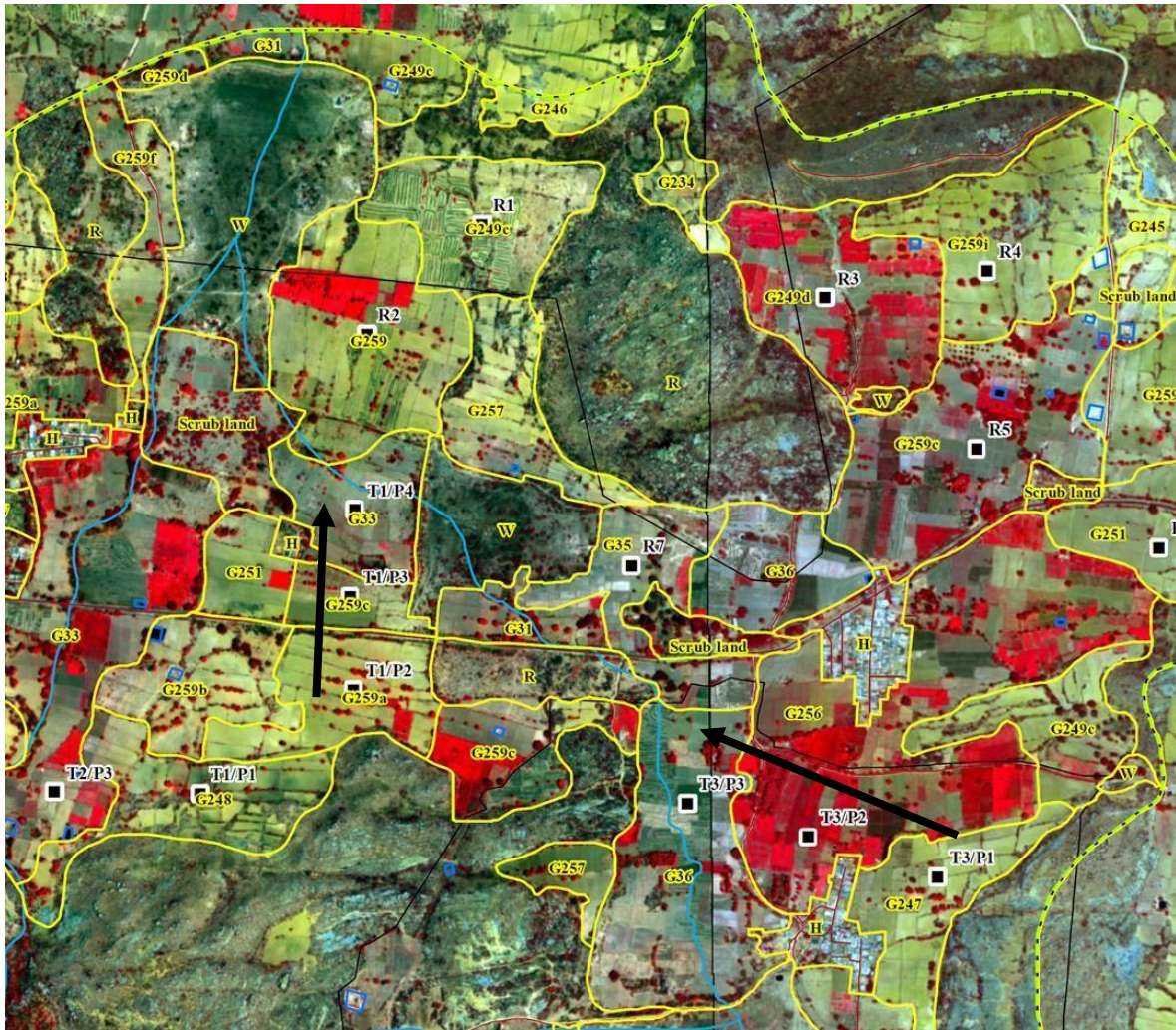
- D Deccan Plateau**
- DS South Deccan Plateau**
- G Granite and Granite Gneiss Landscape**
  - G1 Hills/Ridges/ Mounds**
    - G11 Summits
    - G12 Hill/Side Slopes
      - G121 Side slopes with dark grey tones
    - G13 Isolated hillocks
  - G2 Uplands**
    - G21 Summits/ Nearly Level Lands
    - G22 Very gently sloping uplands
      - G221 Very gently sloping uplands, yellowish green
      - G222 Very gently sloping uplands, medium green and pink
      - G223 Very gently sloping uplands, pink and green (scrub land)
      - G224 Very gently sloping uplands, medium greenish grey
      - G225 Very gently sloping uplands, yellowish white (eroded)
      - G236 Very gently sloping uplands, dark green
      - G237 Very gently sloping uplands, medium pink (coconut garden)
    - G23 Gently sloping uplands
      - G231 Gently sloping uplands, yellowish green (eroded)
      - G232 Gently sloping uplands, yellowish white (severely eroded)
    - G24 Undulating uplands
  - G3 Valleys**
    - G31 Interhill Valley
    - G32 Valley /Lowlands
- A Alluvial landscape**
  - A1 Nearly level Uplands
  - A2 Very gently sloping lands

### Identification of transect for profile studies:

After the interpretation of maps for physiographic units, transects can be fixed tentatively based on variations observed in the map. Transects can be marked on different landform units falling adjacent and along the slope.

Criteria's for transect identification:

- ✓ Should represent large area and lengthy slope
- ✓ Should be along the slope
- ✓ Preferably in odd numbers
- ✓ Should not cross river, drainages and water bodies
- ✓ Each profile point in a transect should represent different landform units



**Transects and randoms marked for profile study**

### Field activities: Traversing and validation of interpreted map

#### a) At Sub watershed level:

The physiography-landform map is to be checked for the accuracy of the delineation and their description in the field by taking up rapid traverse of the sub watershed area and corrected wherever necessary. During the traverse available road/well cuts, excavations, and profiles in few transects are examined, and variations observed in soil-site characteristics recorded. Based on the information collected a tentative map with legend of the SWS is prepared along with identifying characteristics for the major soils observed. This preliminary legend forms the basis for detailed field investigations at MWS level.

#### Differentiating Characteristics for identifying Soils at SWS level

| Sl. No.                           | Soil Series   | Depth (cm) | Colour                    | Texture | Gravel (%) | Horizon  | Others |
|-----------------------------------|---------------|------------|---------------------------|---------|------------|----------|--------|
| Soils of Granite gneiss Landscape |               |            |                           |         |            |          |        |
| 1                                 | Devihal (Dvh) | <25        | 2.5YR2.5/4<br>5YR3/4 ,4/6 | cl      | <15        | Ap-Cr    |        |
| 2                                 | Harve (Hrv)   | 25-50      | 2.5YR3/6<br>5YR4/4        | cl      | >35        | Ap-Bt-Cr |        |

#### b) At Micro watershed level:

The delineated units are checked and corrected and extent of habitations, permanent features, rock outcrops, gullies and ravines, quarried areas, fishponds, check dams *etc.*, are marked on the map which eliminates areas that are not to be surveyed.

#### Study of site characteristics (phases):

During the traverse any variations observed in slope, erosion, texture, presence of stones, boulders, rock outcrops, drainage, salinity *etc.*, are recorded on the map (preferably cadastral map) and in the proforma (if required). Then profiles are opened in the selected transects and their morphological and physical characteristics will be recorded.

Based on field observations and profile study, the initial legend prepared earlier at the SWS level is updated at the MWS level. After finalizing the soil series and updating the map legend, the soils series identified can be linked to the delineations along with site characteristics recorded earlier. This process results in the conversion of the interpreted map into a soil map for the MWS area. The delineated mapping units are shown on the map in the form of symbols.

For example, in the map unit **GHTcB2**

**GHT** - indicates the name of the soil series

**c** - indicates the texture of the surface soil

**B** - indicates the slope of the land

**2** - indicates the degree of erosion

Any other feature observed in the field (like salinity, gravel *etc.*) can be shown by using appropriate symbols on the map. It is not possible to depict all the variations observed in the field on the map itself. The legend accompanying the map provides detailed description of the

properties (like depth, texture, gravel, slope, salinity *etc.*) and their variations for each mapping unit.

**Codification of soil samples (in master profiles):**

Soil samples are collected from a representative pedon for each series for laboratory analysis. For labelling, the codification given below may be followed

For example - **Gg-Sht-Rtr-T1-P1 -P1/1, P1/2, P1/3, P1/n**

Gg - indicates the name of the district, Gadag

Sht - indicates the name of the taluk, Shirahatti

Rtr - indicates the name of the village, Ranatur

T1 - Transect No.1 in Ranatur village

P1 - profile No.1 in transect No.1 in Ranatur village

P1/1 (0-11 cm) - soil sample No.1 from Profile No.1

P1/2 (11-33 cm) - soil sample No. 2 from profile No.1

or

R1 Random profile No.1 from Ranatur village

R1/1 (0-18 cm) - soil sample No.1 from Random profile No. R1

R1/2 (18-42 cm) - soil sample No. 2 from Random profile No. R1

**Grid soil sampling:**

Composite soil samples are to be collected from grids drawn on the cadastral map at every 320 m interval (10.24 ha) for rainfed/dry land areas and 160 m interval (2.56 ha) for irrigated/command areas respectively. On an average, about 50 to 70 soil samples are collected for an area of about 500 ha. The codification indicated below may be followed on the sample bag.

For example - **Kp/Gn/Kav/F1**

Kp - indicates the name of the district, Koppal District

Gn - indicates the name of the taluk, Gangavati Taluk

Kav - indicates the name of the village, Kavalur village

F1 - indicates the surface soil sampled at Grid Point No.1

**Well Inventory:**

The number of wells, both open and bore wells, tube wells with their exact locations to be collected along with water samples in the project area

**Socio- economic data:**

Socio-economic data on demography, land holdings, land use, cropping pattern, source of irrigation, cattle population *etc.*, are to be collected from Census reports, village records and

Directorate of Statistics either during or even prior to the start of the LRI. If the available data is not complete or insufficient, then efforts can be made to collect the required additional data for the area.

**Land use particulars (land use and land cover):**

During the execution of the LRI, the land cover and land use particulars are to be collected. Apart from this, data on cropping pattern, inputs and level of management followed, yields obtained for different crops and other information pertaining to land use are to be collected wherever possible. For this, first broad land use areas like arable and non-arable lands, forest areas, community, and wastelands *etc.*, are identified, and then within each land use area, like arable lands, major crops or combination of crops that are under cultivation are identified and marked for each survey number. Similarly, the tree species, shrubs and other vegetation types observed in non-arable, forest, community and wasteland areas are identified during the survey and land use map prepared for the watershed.

**Identification of existing structures:**

All the existing soil and water conservation and harvesting structures are to be identified and marked on the map

## Profile study

### **Description of Site characteristics:**

Soils are formed by the influence of various soil forming factors like climate, biota, topography, parent material and time. Since these factors are not uniform in any landscape, the soils formed will be different from place to place. To understand their variability and to map the distribution of soils, we need to have not only a detailed study and description of the soils but also the landform or site characteristics of the area. This chapter provides the guidelines needed for describing soil-site characteristics observed in the field.

The standard format to describe the soil-site characteristics is attached at the end of the chapter in which the first page lists the site characteristics to be recorded and soil characteristics on the back side. The field team should be familiar with the list of soil site characteristics that are to be studied and described in the standard proforma.

**Field investigation** Tick in the appropriate box

**Author and date** - Give the name of the Officer in- charge of the field party and date/time of observation

Example: Date/Month/Year (02/12/2022)

**Series name** - This box to be filled at the end of the soil profile study by comparing the pedon description with the series identification table provided for the survey area.

**Map unit symbol** - Indicate two or three letter symbols for the series, followed by the phase symbols

**Soil classification** - This box to be filled at the end of the soil profile study as per Soil Taxonomy

**Observation No** - Follow codification as described in previous section Codification of soil samples (in master profiles)

The list of districts with their symbols in the state, name of taluks and their symbols from each district and list of villages and their symbols in each taluk will be provided to the field parties before the start of LRI. This observation number will be unique for each site and to be followed both on the site description proforma as well as in the collection of soil samples for analysis from the site.

**Toposheet**, imagery, base map and cadastral sheet particulars are self-explanatory

**Location** - Indicate the exact location of the profile on the cadastral map within the survey number and describe the location of the profile with reference to some nearby fixed features. Precise GPS reading of the location is to be taken and entered in the box provided for latitude and longitude. The other locational details like plot number, village, hobli, taluk *etc.*, are to be entered in their respective spaces.

**Physiographic region** - Based on geology, relief and land use, the state is divided broadly into four physiographic regions *viz.*, South Deccan Plateau, Western Ghats, Eastern Ghats and West Coast. Enter the appropriate physiographic region of area in the provided box.

**Geology** - The major geological formations are Granite Gneiss (GG), Granite (G), Charnockite (C), Basalt (B), Schist (S), Limestone (LS), Sandstone (SS), Laterite (L), Quartzite (QZ) and Alluvium (A). Indicate the type of rock types observed in the area. Geology maps provided to the field parties can be used as a reference.

**Parent material** - The loose unconsolidated mineral material formed by weathering of rocks, from which the soils form is known as the parent material of the soil. The parent material is designated as C horizon in the soil profile and can be grouped into those formed in place through the disintegration and decomposition of rocks and those that have been transported from the place of their origin by various agents like water, wind and gravity *etc.*

**Topography of the surrounding country** - The surrounding area of the profile will normally have complex slopes and the terms used to describe the topography are indicated below. This contrasts with the simple slopes (soil slopes) used to describe the location of the profile in the pedon description form. This indicates the general variation in slope of the landform from its summit to its lowest one. Tick the one which is appropriate for the area after checking the slope with the counter map or with the help of Abney level or Clinometer.

|              |                         |
|--------------|-------------------------|
| Level        | 0-1 % slope 1-3 % slope |
| Nearly Level | 3-8 % slope             |
| Undulating   | 8-16 % slope            |
| Rolling      | 16-30 % slope           |
| Hilly        | 30-60 % slope           |
| Steep        | >60 % slope             |
| Very steep   | 0-1 % slope 1-3 % slope |

**Landform** - Based on geology, elevation, location and other features, the four major physiographic regions of the state are further subdivided broadly into nine landscape areas.

For example, the South Deccan Plateau region is subdivided broadly into Granite and granite gneiss landscape, basalt landscape, schistose landscape and lateritic landscape. Similarly, the Western Ghats region is divided into Northern and Southern Ghats, coastal plains into coastal uplands and marine plains. Since there is not much variation in the landscape features of the Eastern Ghats region, it is not subdivided further and retained as such as one landscape area. Enter the appropriate landscape name in the proforma.

Any physical, recognizable feature of a landscape, having a characteristic shape and mappable area at the scale of survey is to be recorded

| <i>Major landscape areas</i> | <i>Landforms identified</i>  |
|------------------------------|--|
| Basalt landscape             | Plateau, Mesas, butte, summits, escarpments, side slopes, sloping uplands, plains, valleys |

|                               |   |
|-------------------------------|---|
| Granite and gneiss landscape  | Hills (high hills, low hills), summits, escarpments, hill slopes, ridges, tors, inselbergs, foot slopes, sloping uplands, valleys |
| Schistose landscape           | Hills (high hills, low hills), summits, escarpments, hill slopes, ridges, foot slopes, sloping uplands, valleys                   |
| Lateritic landscape           | Hills, ridges, mounds, summits, side slopes, sloping uplands, valleys   |
| Western Ghats-northern region | Hills (high hills, low hills), summits, escarpments, hill slopes, ridges, tors, inselbergs, foot slopes, sloping uplands, valleys |
| Western Ghats-southern region | Hills (high hills, low hills), summits, escarpments, hill slopes, ridges, tors, inselbergs, foot slopes, sloping uplands, Valleys |
| Eastern Ghats landscape       | Hills (high hills, low hills), summits, escarpments, hill slopes, ridges, tors, inselbergs, foot slopes, sloping uplands, Valleys |
| Coastal uplands landscape     | Mounds, ridges, summits, side slopes, foot slopes, uplands, lowlands, valleys   |
| Coastal plains landscape      | Beach, dunes, plains, salt pans, swamps, marshes, island  |



**Gently sloping severely eroded uplands**

**Elongated plateau in basalt landscape**

**Conical residual hillock**



**Gently sloping uplands**

**Steeply sloping low hills**

**Level (< 1 %) lowlands**

**Typical landform units of granite gneiss and basalt landscape**

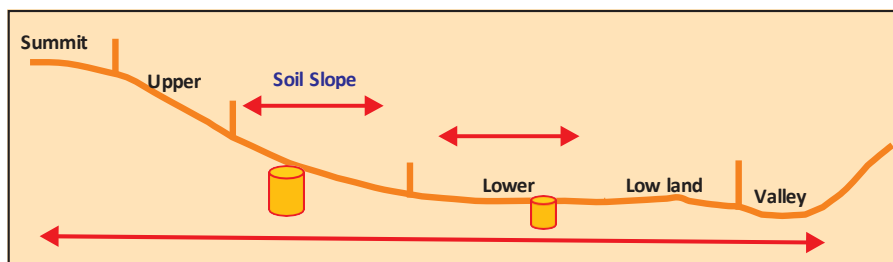
**Micro-features** - Any discrete, natural or artificial surface feature, occupying very small area on the land surface, which cannot be delineated at the scale of mapping are known as micro features. These small features individually cover less than 100 m<sup>2</sup> area and the height difference will be within few metres from the ground level. For example, small gullies or sand dunes if

they occur in a very small extent in the survey area are described as micro features and if the same occupy large areas, then they are delineated and described as a mapping unit.

The other examples of micro features are ridge-and-furrow, erosion rills, ant hills, channel, depression, hillock, interdune, intermittent stream, minor scarp, mound, hummocks, dune, gilgai, cracks, pond, pool, ripple mark, shoreline, tank, contour terracing, levees and land slip features. Describe the nature and frequency of occurrence of such micro features in the survey area and the relationship of the profile site to such features in the proforma.

**Profile position** - In a hilly area the profile position can be indicated as summit, shoulder, backslope, footslope or toeslope as the case may be. In uplands, the profile position can be indicated as summits, upper, middle and lower part of the upland and lowlands or valleys.

**Soil slope** - Soil slope refers specifically to the slope of the land immediately surrounding the profile (*i.e.* within 100 m of the profile pit) or representative section of the landform from which the profile is described. Since soil slope is generally in one direction, it is considered as simple slope. Slope has gradient, complexity, length, form and aspect.



**Slope gradient** is the inclination of the surface of the soil from the horizontal. The difference in elevation between two points is expressed as a percentage of the distance between those points. If the difference in elevation is 1 meter over a horizontal distance of 100 meters, then slope gradient is 1 per cent.

The slope gradient is measured at the profile site by using Abney Level and ranging rods or Clinometer. The Abney Level readings, degrees of inclination or declination can be converted into slope percentages and slope classes. The equivalence between percentage gradient, degree of slope angle and class of slope to be used in the field are as follows:

| Class of slope | Range of slope % | Abney Level reading                      |
|----------------|------------------|--|
| A              | 0-1              | 0 to 35 min                              |
| B              | 1-3              | 35 min to 1 degree 44 min                |
| C              | 3-5              | 1 degree 44 min to 2 degrees 52 min      |
| D              | 5-10             | 2 degrees 52 min to 5 degrees 43 min     |
| E              | 10-15            | 5 degrees 43 min to 8 degrees 32 min     |
| F              | 15-25            | 8 degrees 32 mins to 14 degrees 03 mins  |
| G              | 25-33            | 14 degrees 03 mins to 18 degrees 16 mins |
| H              | 33-50            | 18 degrees 16 mins to 26 degrees 34 mins |

**Slope length** - Indicates the distance up to which there is no break in the slope. For example, if the length of B slope is 100 m, then this indicates that the distance between the starting point

of the slope and the point where it breaks is about 100 m. Record the gradient and length in the proforma.

**Erosion** - The detachment and movement of soil materials from one place to another is known as soil erosion. Sheet, rill and gully erosion is common in the state.

- a) **Sheet erosion** is responsible for almost uniform removal of soil from an area without leaving any significant marks at the surface.
- b) **Rill erosion** is the removal of soil through many small incipient channels or rills.
- c) **Gully erosion** is the consequence of water that cuts down into the soil along the line of flow.



**Moderately eroded (e2), > 50 % surface soil eroded due to sheet erosion**



**Very severely eroded (e4), due to deep and wide gully erosion**

**Erosion classes** - The erosion classes are estimated in the field based on the proportion of upper horizons/layers that have been removed. Since these horizons may range widely in their thickness, estimating the absolute amount of erosion in the field is not possible. The erosion classes indicated below are applicable for both water and wind erosion.

| <i>Erosion Class</i> | <i>Estimated % loss of the surface soil (A horizon)</i> |
|----------------------|---|
| 1                    | Up to 25%   |
| 2                    | 25 to 75%   |
| 3                    | 75 to 100%  |
| 4                    | >75 % and total removal of surface or even subsoil      |

**Class 1 (slight erosion)** - This consists of soils that have lost some, but on the average less than 25 per cent of the surface soil (A horizon). Evidence for class 1 erosion includes

1. a few rills
2. an accumulation of sediment at the base of slopes or in depressions
3. scattered small areas where the plough layer contains material from below
4. evidence of the formation of widely spaced deep rills.

**Class 2 (moderate erosion)** - This class consists of soils that have lost, on the average, 25 to 75 per cent of the surface soil (A horizon). In cultivated areas, the surface layer consists of a

mixture of the original A and/or horizons and material from below. Some areas may have intricate patterns, ranging from uneroded small areas to severely eroded small areas.

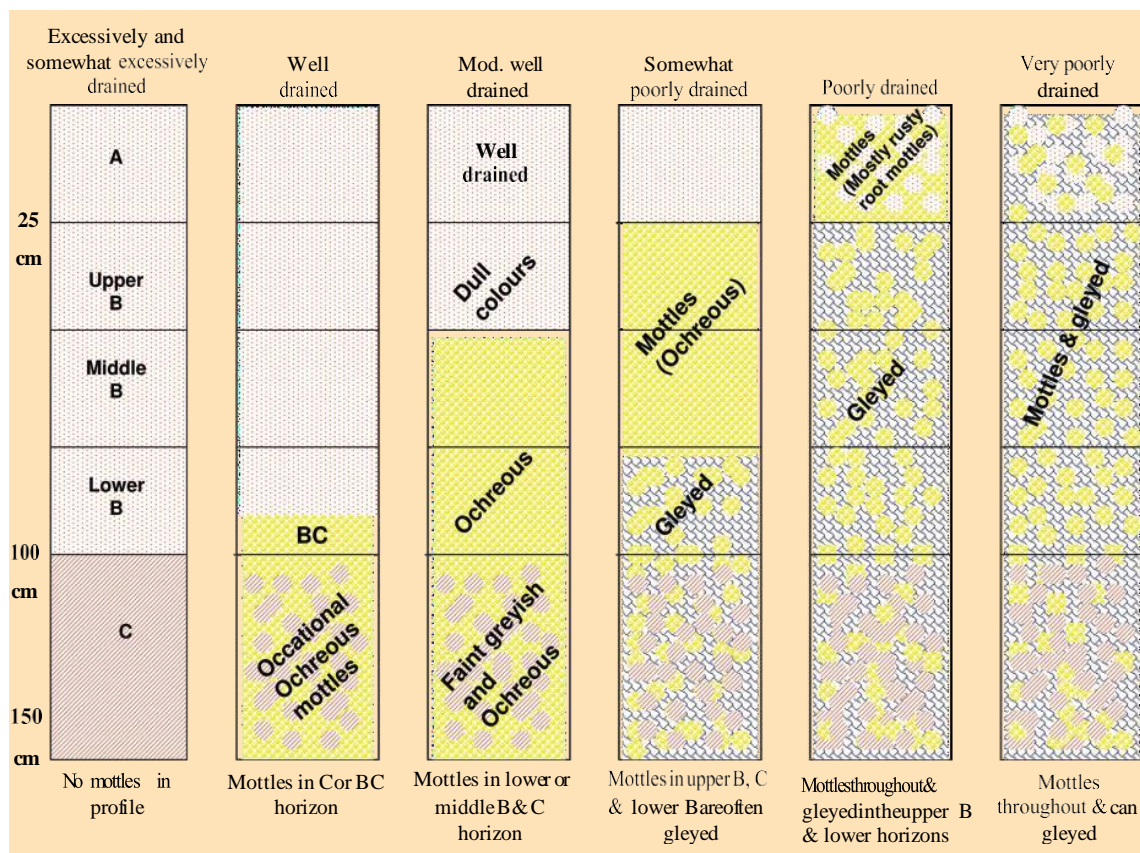
**Class 3 (severe erosion)** - This class consists of soils that have lost, on the average, 75 per cent or more of the original A horizon. In class 3 erosion, material below the A horizon is exposed at the surface in cultivated areas and some mixing with underlying material is also observed.

**Class 4 (very severe erosion)** - This class consists of soils that have lost all the A horizon and in addition includes some or all the deeper horizons in most of the area. Indicate the kind or degree and class of erosion observed at the profile site in the proforma.

**Surface Runoff** - Surface runoff or external soil drainage refers to the loss of water from an area by flow over the land surface. Six classes are used to describe the runoff of an area.

- a) **Ponded** - None of the water added to the soil as precipitation or by flow from surrounding areas escapes as runoff. This condition occurs normally in depressed areas.
- b) **Very slow** - Surface water flows away **very slowly** that free water lies on the surface for long periods or enters immediately into the soil. In very slow condition, most of the water either passes through the soil or evaporates into the air. This condition is observed normally in level to nearly level areas or in very porous sandy soils.
- c) **Slow** - Surface water flows away **slowly** that free water lies on the surface for significant periods or enters rapidly into the soil. This condition is observed normally in nearly level or very gently sloping areas or in sandy soils.
- d) **Medium** - Surface water flows away at such a rate that a moderate proportion of the water enters the soil and free water lies on the surface for only short periods.
- e) **Rapid** - A large part of the rainfall moves rapidly over the surface of the soil and a small part moves through the soil profile. In this condition, water runs off nearly as fast as it is added and occur in moderately steep to steep areas and in soils with low infiltration capacity.
- f) **Very rapid** - A very large part of the rainfall moves rapidly over the surface of the soil and a very small part moves through the soil profile. In this condition, water runs off as fast as it is added and are observed in steep to very steep areas and in soils with low infiltration capacity.

**Drainage Classes** - Natural drainage class refers to the frequency and duration of wet periods under conditions like those under which the soil developed. After completing the profile study, go through the description provided in the table and compare the soil colour and occurrence of mottles with the chart to find out the drainage class.



**Morphological changes due to prolonged wetness and poor drainage**

**Description of various drainage classes of soil**

| <i>Drainage class</i>        | <i>Characteristics</i>  | <i>Water table (cm)</i> | <i>Mottles/gleying &amp; other features</i>                         |
|------------------------------|---|-------------------------|---|
| Excessively drained          | Water is removed from the soil very rapidly   | >100                    | None in profile   |
| Somewhat Excessively drained | Similar to excessively drained, but water table may not be as deep, and the soil may be slightly fine textured  | >100                    | None in profile   |
| Well drained                 | Water is removed from the soil readily but not rapidly.   | at or nearer to 100     | Mottles in C or BC horizon  |
| Moderately well drained      | Water is removed from the soil somewhat slowly. Soil is wet for a short time have a slowly pervious layer within one metre, periodically receive high rainfall, or both | 75 – 100                | Mottles in lower or middle B horizon and in C horizon               |
| Somewhat poorly drained      | The soil is wet at a shallow depth for significant periods and commonly have a pervious layer, high-water table, and/or nearly continuous rainfall                      | 25-75                   | Mottles in upper B horizon; C and lower B horizons are often gleyed |

|                     |   |                    |   |
|---------------------|---|--------------------|---|
| Poorly drained      | The soil is wet at shallow depths or remains wet for long periods. Needs proper drainage for cultivation.         | < 25               | Mottles throughout the profile; soil is in the upper B and lower horizons |
| Very poorly drained | Similar to poorly drained soils except that the soils occur on level or depressed areas and are frequently ponded | At surface or < 15 | Entire profile has mottles and soil may be gleyed                         |

**Ground water depth** - Indicate the depth of the water table and seasonal fluctuations of the profile site area. The water table measurements can be taken from the nearest open or bore wells or by enquiring with the farmers of the area.

**Flooding** - Wherever records are available they can be collected, and the frequency can be indicated and in other areas, it can be estimated based on the site characteristics and other converging evidence.

| <i>Frequency</i> | <i>Classes Criteria</i>                                 |
|------------------|---|
| None             | No possibility of flooding in the area                  |
| Rare             | 1 to 5 times in 100 years                               |
| Occasional       | 5 to 50 times in 100 years                              |
| Frequent         | >50 times in 100 years, <i>ie</i> , once in two years   |
| Very frequent    | Every month > 15 day in a year, used for tidal flooding |

**Salt / alkali (per cent surface coverage)** - The presence of salinity or alkalinity can be identified based on the occurrence of barren areas, presence of salt tolerant crops like prosopis and very poor or stunted growth of plants. Presence of white encrustation on the surface of the soil is an indication of salinity and smooth or fluffy feel to the feet indicates alkalinity in the field. Observe the extent of the area covered by the saline or alkali areas and indicate the per cent surface cover in the column provided.

**Soil Reaction (pH)** - In the field, pH is estimated by using pH indicator papers and portable pH meter. After estimation, tick the appropriate pH values given in the column.

**Electrical Conductivity (EC)** - It is a measure of the concentration of water-soluble salts in soils. The occurrence of bare spots, salt tolerant crops like prosopis and uneven crop growth are indicators of salinity in the field. Portable field EC meters are used to estimate the salt content.

**Surface fragments** - This refers to the presence of coarse fragments (>2 mm in size) on the soil surface. The classes used are pebbles, cobbles, stones, and boulders based on their size. Gravel is a collection of pebbles that have diameters ranging from 2 to 75 mm. The size of the cobbles ranges from 75 to 250 mm (3 to 10 inches), stones from 250 to 600 mm (10 to 24 inches) and boulders above 600 mm (>24 inches). Assessment for the surface fragments is done separately for the gravel and for stones and boulders. Indicate the size of the fragments observed in the field. The gravelliness and stoniness classes used are indicated below

| <i>Gravelliness class</i>     | <i>% of area covered</i> |
|-------------------------------|--------------------------|
| Non gravelly                  | < 15 per cent            |
| Gravelly                      | 15 to 35 per cent        |
| Very gravelly                 | 35 to 60 per cent        |
| Extremely gravelly            | 60 to 80 per cent        |
| Considered as part of the top | >80 per cent             |

| <i>Stoniness class</i>    | <i>Percentage of surface covered</i> |
|---------------------------|--------------------------------------|
| Stony (class 1)           | 0.01 to 0.1 per cent of the surface  |
| Very stony (class 2)      | 0.1 to 3 per cent of the surface     |
| Extremely stony (class 3) | 3 to 15 per cent of the surface      |
| Rubbly (class 4)          | 15 to 50 per cent of the surface     |
| Very rubbly (class 5)     | >50 per cent of the surface          |

**Rock outcrops** - The distance between the rock outcrops and their percentage coverage in the field is to be recorded as indicated below

| <b>Per cent coverage</b> | <b>Description</b>   |
|--------------------------|--|
| < 2                      | No rocks or very few rocks to interfere with tillage   |
| 2 to 10                  | Fairly rocky, sufficient to interfere with tillage but not to make inter-tilled crops impracticable. Exposures are roughly 35 to 100 m apart |
| 10 to 25                 | Rocky, sufficient to interfere with tillage of inter-tilled crops impracticable. Exposures are roughly 10 to 35 m apart.                     |
| 25 to 50                 | Very rocky, sufficient to make all use of machinery impracticable, except for light machinery. Exposures are roughly 3.5 to 10 m apart       |
| 50 to 90                 | Extremely rocky, sufficient rock outcrops to make all use of machinery impracticable. Exposures are about 3.5 m apart or less                |
| Over 90                  | Rock outcrops  |

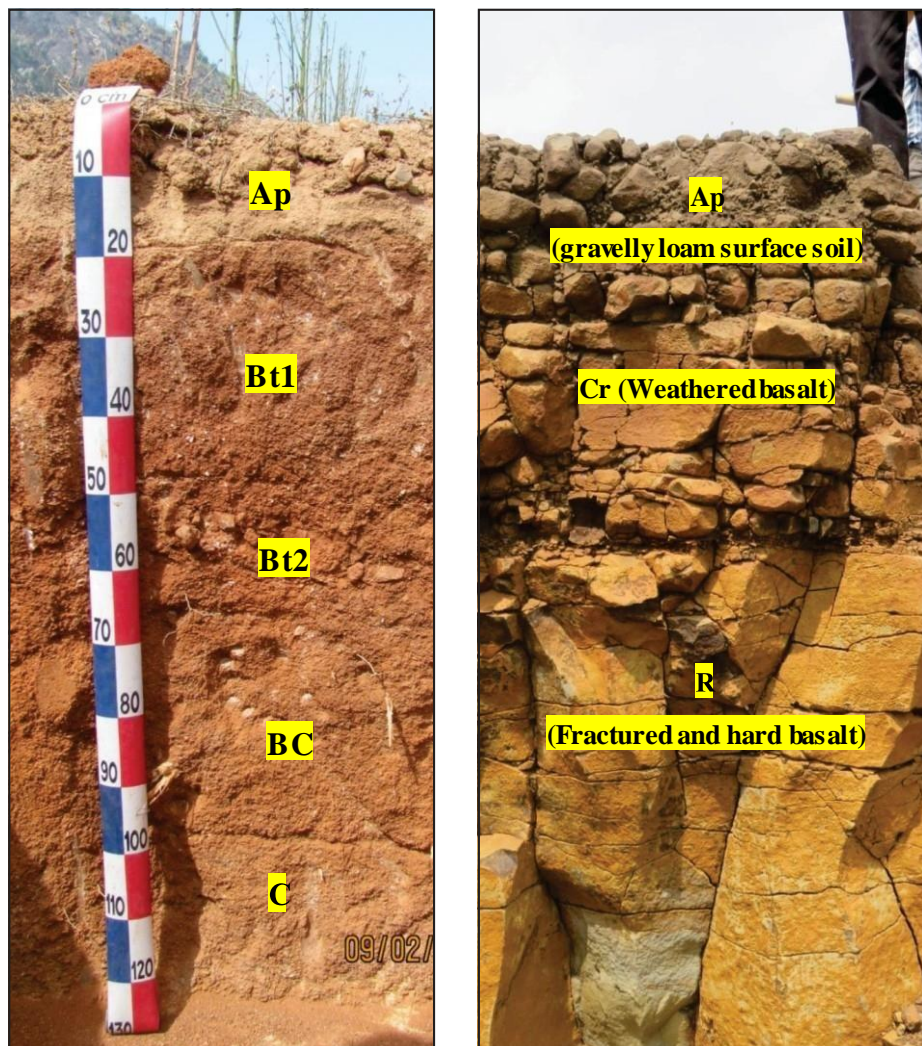
**Elevation** - Elevation refers to the height of a point on the earth's surface, relative to mean sea level. It can be determined from the contour maps or by using Global Positioning System (GPS). The elevation of the area is to be noted in the box based on the GPS measurement.

**Land Use** - Indicate the name of the crop or combination of crops (common names like bajra, ragi *etc.*, are preferred) cultivated in the season and crops cultivated in the previous season and major and minor crops if it is a mixed one.

**Vegetation** - The type of natural vegetation to be described with their common names.

### Soil characters

Study and description of soils is important to understand their formation and mapping. Soil properties are studied by opening a profile of 2 m length, 1m width and 2 m depth in a representative area. The profile is cleaned and examined carefully from the surface to identify any change in the morphology or other properties of the soil. Based on the changes observed, layers/horizons are identified and marked. Immediately after marking the layers photographs of the profile and surrounding features are to be completed, followed by estimation of the volume of coarse fragments and any other features that may be destroyed later during the study of the soils. Apart from profile study, road/well cuts, quarries or other fresh cuts can be used to describe the soils of the survey area.



Typical horizon designations used to describe profile development

**Soil depth** - Soil depth indicates the depth of the solum, which includes A and B horizons, occurring above the parent material or hard rock. Depth is measured from the soil surface. For soils with a cover of 80 per cent or more rock fragments on the surface, the depth is measured from the surface of the rock fragments. Generally, all the four faces of the pit will not be uniform, and care is necessary to select the typical or representative face of the pit for the study of the profile. The depth classes are

|                    |            |
|--------------------|------------|
| Very shallow       | 25 cm      |
| Shallow            | 25-50 cm   |
| Moderately shallow | 50-75 cm   |
| Moderately deep    | 75-100 cm  |
| Deep               | 100-150 cm |
| Very deep          | > 150 cm   |

**Horizon** - Horizon development indicates the extent and degree of soil formation. It will be weak in the early stages and exhibit distinct characteristics in well-developed soils.

**a. Designations for horizons** - Layers and horizons of different kinds are identified by symbols. Capital letters (O, A, E, B, C, R and W) are used to designate the master horizons. Lower case letters are used as suffixes to indicate specific characteristics of master horizons. Arabic numerals are used both as suffixes to indicate vertical subdivisions within a horizon or layer and as a prefix to indicate discontinuities.

**b. Master Horizons and Layers**

**O horizons or layers** - This layer is dominated by organic material and consist of undecomposed or partially decomposed litter, deposited on the surface of either mineral or organic soils.

**A horizons** - It is a mineral horizon formed at the surface or below O horizon. They exhibit obliteration of all or much of the original rock structure and show an accumulation of humified organic matter intimately mixed with the mineral fraction.

**E horizons** - Mineral horizon in which the main feature is loss of silicate clay, iron, aluminium, or some combination of these, leaving a concentration of sand and silt particles. This horizon is usually lighter in colour than B and A horizons. The organic matter is normally less than A horizon and occurs commonly near the surface.

**B horizons** - Horizons that formed below an A, E, or O horizon and are dominated by obliteration of all or much of the original rock structure and show one or more the following:

1. illuvial concentration of silicate clay, iron, aluminium, humus, carbonates, gypsum, or silica, alone / in combination
2. evidence of removal of carbonates
3. residual concentration of sesquioxides
4. coatings of oxides that makes the horizons lower in value, higher in chroma, or redder in hue than overlying and underlying horizons
5. alteration that forms silicate clay or liberates oxides or both and that forms granular, blocky or prismatic structure
6. brittleness or gleying

**C horizons** - Horizons, excluding hard bedrock, that are little affected by pedogenic processes and lack properties of O, A, E, or B horizons. The material of C layers may be either like or

unlike that from which the solum presumably formed. The C horizon may have been modified even if there is no evidence of pedogenesis.

**R layers: Hard Bedrock** - The R layer is coherent when moist to make hand digging with a spade impractical, although it may be chipped or scrapped.

**Transitional horizons** - Horizons dominated by properties of one master horizon but having subordinate properties of another. Two capital letter symbols are used to designate the transitional horizons (AB, EB, BE, BC, CB). The master horizon symbol that is given first designates the kind of horizons whose properties dominate the transitional horizon.

**Combination horizons** - Horizons in which distinct parts have recognizable properties of the two kinds of master horizons indicated by the capital letters. The two capital letters are separated by a slash as A/B, E/B, B/E, B/C.

**Subordinate distinctions within master horizons** - Lower case letters are used as suffixes to designate kinds of master horizons and some of the symbols used commonly are indicated below

| <i>Horizon suffix</i> | <i>Criteria</i>                                       |
|-----------------------|---|
| A                     | Highly decomposed organic matter. Used with O horizon |
| C                     | Concretions or nodules                                |
| E                     | Moderately decomposed org. matter                     |
| G                     | Strong gley   |
| K                     | Accumulation of (pedogenic) carbonates                |
| N                     | Pedogenic, exchangeable sodium accumulation           |
| P                     | Plough layer or other artificial disturbance          |
| R                     | Weathered or soft bedrock                             |
| Ss                    | Presence of slickensides                              |
| T                     | Illuvial accumulation of silicate clay                |
| V                     | Presence of plinthite                                 |
| W                     | Weak color or structure within B (used only with B)   |

### Conventions for using letter suffixes

- Master horizon symbol (capital letter) should be followed by one or more lower case letters.
- Normally up to two suffixes are used and more than three suffixes are rarely used.
- B horizon with accumulation of clay and also showing evidence of colour or structure, or both, is designated as Bt and not as Btw or Bts or Btws (t has precedence over w, s, and h).

**Vertical subdivision** - The subdivision of a horizon or layer designated by a single letter, or a combination of letters is indicated at the end using arabic numerals. For example, the subdivision of B horizon can be shown as Bt1-Bt2-Btk1-Btk2 and not as Bt1-Bt2-Btk3-Btk4.

**Discontinuities** - Arabic numerals are used as prefixes (preceding A, E, B, C, and R) to indicate discontinuities in mineral soils. Discontinuity is indicated by significant or abrupt change in texture, age or mineralogy between the layers or horizons. Examples: A-Bt-C-2R, Ap-Bt1-2Bt2-2Bt3-2BC-C.

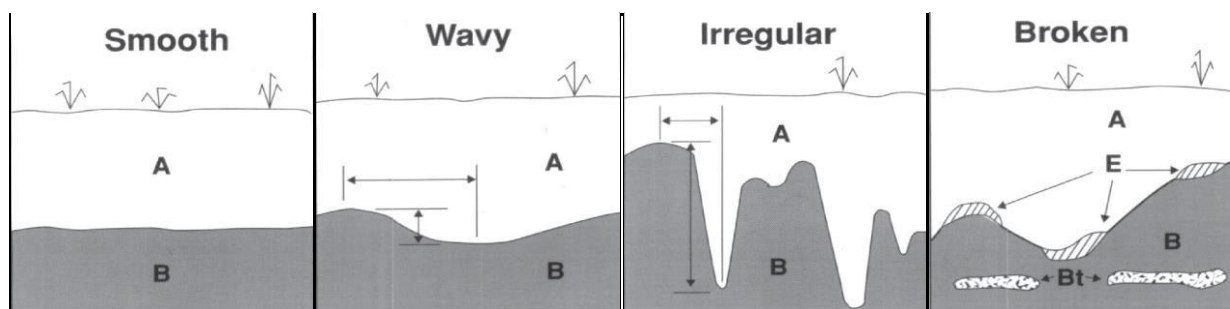
**Boundaries of horizons and layers** - A transitional area or layer present between two adjoining horizons or layers is known as the boundary. Boundaries vary in **distinctness** (contrast) and in **topography**.

**Distinctness** - Distinctness is the distance through which one horizon grades into another. It refers to the thickness of the zone within which the boundary can be located. The distinctness depends on the degree of contrast between the layers and thickness of the transitional zone. Distinctness is defined in terms of thickness of the transitional zone.

| <i>Distinctness class</i> | <i>Criteria: transitional zone thickness</i> |
|---------------------------|--|
| Very Abrupt or sharp      | Less than 0.5 cm                             |
| Abrupt                    | 0.5 to < 2 cm                                |
| Clear                     | 2 to < 5 cm                                  |
| Gradual                   | 5 to 15 cm                                   |
| Diffuse                   | > 15 cm                                      |

**Topography** - Topography is the lateral undulation and continuity of the boundary between horizons. Topography refers to the irregularities of the surface that divides the horizons

|           |  |
|-----------|--|
| Smooth    | The boundary is a plane one with few or no irregularities                            |
| Wavy      | The boundary has undulations in which the width of undulation is more than the Depth |
| Irregular | Similar to wavy in which the depth of undulation is more than the width              |
| Broken    | Discontinuous horizons; discrete but intermingled, or irregular pockets              |



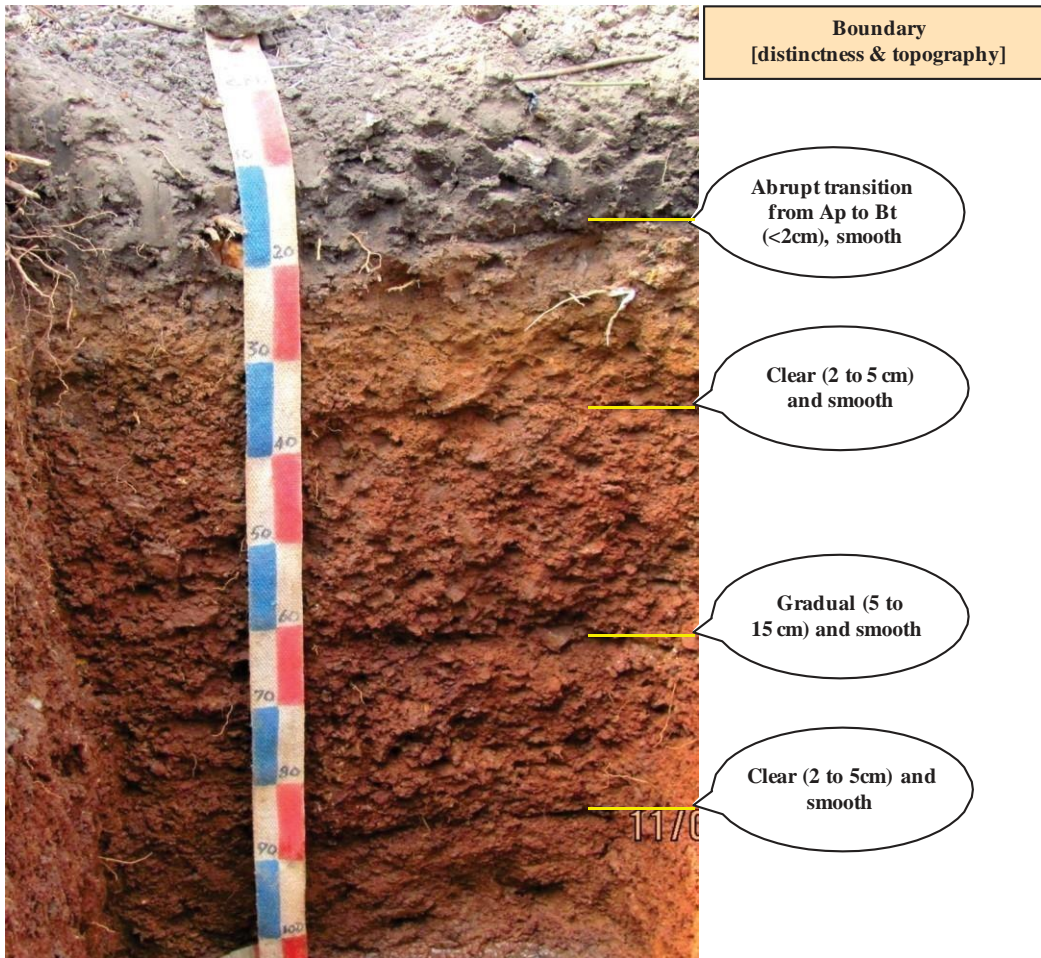
**Topography of the soil boundaries as seen in the field**

**Soil colour** - Soil colour is measured by comparing peds with Munsell Colour Chart. The notation is recorded in the form of hue, value and chroma - for example, 5YR 5/3.

- Hue** is a measure of the chromatic composition of light that reaches the eye.
- Value** indicates the degree of lightness or darkness of a colour in relation to a neutral grey scale. The value is a measure of the amount of light that reaches the eye under standard lighting conditions. **Grey** is perceived as about halfway between black and white and has a value notation of 5/.
- Chroma** is the relative purity or strength of the spectral colour. The scales of Chroma for soils extend from /0 for neutral colours to a chroma of /8 as the strongest expression of

colour used for soils.

**Distinctness (contrast between two layers) and topography of red soil profile**



**Typical soil colours in red (5YR 4/6) and black soils (10YR 3/1)**

**Conditions for measuring soil colour** - Measurement of soil colour is affected by the quality and intensity of light, moisture content and roughness of the sample selected. Determination done either early in the morning or late in the evening will not be accurate. Also, when the sun is low or the atmosphere is smoky, the light reaching the sample and the light reflected will be more towards redder colour. Colours also appear different in the subdued light of a cloudy day

than in bright sunlight. Hence, determination of soil colour is undertaken in shade by utilising the shadow of the person holding the colour chart.

**Mottling** - Mottles are spots of different colours which are different from colour variation associated with ped surfaces, worm holes, concretions, nodules, *etc.* Mottles are described by quantity, size, contrast, colour, and shape in that order.

**Quantity** - Indicates the per cent of horizon area covered by mottles

|        |                           |
|--------|---------------------------|
| Few    | < 2 % of surface area     |
| Common | 2 to 20 % of surface area |
| Many   | > 20 % of surface are     |

**Mottling size** - Refers to dimensions as seen on a plane surface. It is measured along the greatest dimension except in linear forms. The size classes used are

|             |              |
|-------------|--------------|
| Fine        | < 2 mm       |
| Medium      | 2 to < 5 mm  |
| Coarse      | 5 to < 20 mm |
| Very Coarse | > 20 mm      |

**Mottling Contrast** - Refers to the degree of visual distinction that is evident between associated colours. Record the colour difference between the mottle and the dominant matrix colour and express the contrast as indicated below

|           |  |
|-----------|--|
| Faint     | Evident only on close examination. Faint mottles commonly have the same hue as the colour to which they are compared and differ by no more than 1 unit of chroma or 2 units of value |
| Distinct  | Readily seen but contrast only moderately with the colour to which they are compared   |
| Prominent | Contrast strongly with the colour to which they are compared   |

**Soil texture** - Soil texture refers to the relative proportion (per cent by weight) of sand, silt and clay present in a soil. Texture is estimated in the field by feel method. The texture classes range from sand to clay and some of the commonly occurring texture classes are briefly described below. Normally, sand particles feel gritty, and the grains can be seen with the naked eye. Silt has a smooth feel to the fingers both in dry and wet conditions. Clayey soils exhibit sticky and plastic characteristics. Guidelines for the assessment of soil texture in the field are indicated in the table below

**Modifiers used for describing soil texture** - If the soil (fine earth) contains various rock fragments, their quantity and size are recorded and used as a modifier in describing the texture of the soil.

| <i>Rock fragments<br/>% byvolume</i> | <i>Modifier used for texture description</i>         |
|--------------------------------------|--|
| < 15                                 | No texture adjective is used (noun only; e.g., loam) |
| 15 to < 35                           | Use adjective for appropriate size; e.g., gravelly   |

|            |  |
|------------|--|
| 35 to < 60 | Use “very” with the appropriate size adjective; e.g., very Gravelly  |
| 60 to < 90 | Use “extremely” with the appropriate size adjective; e.g., extremely gravelly  |
| > 90       | No adjective or modifier, If the soil contains < 10 % fine earth, use the appropriate noun for the dominant size class; e.g., gravel (used in lieu of texture) |

**Guide for assessment of soil texture in the field**

| <i>Sl. No.</i> | <i>Texture class</i> | <i>Feel</i>                         | <i>Coherence at sticky point</i> | <i>Ribbon Length [mm]</i> | <i>Other features</i>                             | <i>Clay %</i>    |
|----------------|----------------------|-------------------------------------|----------------------------------|---------------------------|---|------------------|
| 1              | Sand                 | Very gritty                         | Nil                              | Nil                       | Single sand grains adhere to fingers              | <5               |
| 2              | Loamy sand           | Very gritty                         | Slight                           | 5                         | Discolor fingers with an organic stain            | 5-10             |
| 3              | Sandy loam           | Gritty                              | Just coherent                    | 15-25                     | Medium sand readily visible                       | 10-20            |
| 4              | Loam                 | Neither very gritty nor very smooth | Coherent                         | about 25                  | No obvious sandiness                              | 25               |
| 5              | Silt loam            | Smooth or buttery                   | Coherent                         | about 25                  | Silky; very smooth                                | 25 (>25 silt)    |
| 6              | Sandy clay loam      | Moderately gritty                   | Strong                           | 25-40                     | Medium sand in fine matrix                        | 20-30            |
| 7              | Clay loam            | Slightly Gritty                     | Strong                           | 40-50                     | No obvious sand grains                            | 30-35            |
| 8              | Silty clay loam      | Very smooth                         | Coherent                         | 40-50                     | Silky feeling                                     | 30-35 (>25 silt) |
| 9              | Sandy clay           | Sticky                              | Coherent                         | 50-75                     | Fine to medium                                    | 35-40            |
| 10             | Silty clay           | Sticky                              | Coherent                         | 50-75                     | Smooth and Silky                                  | 35-40 (>25 silt) |
| 11             | Clay                 | Sticky                              | Coherent                         | >75                       | Smooth with slight to fair resistance to shearing | 35-50            |
| 12             | Heavy Clay           | Very sticky                         | Coherent                         | >75                       | Firm resistance to shearing                       | >50              |

**Rock fragments** (described earlier as coarse fragments) - The discrete unattached pieces of rock having more than 2 mm in diameter are described by their size as indicated below.

|                    |          |
|--------------------|----------|
| 2 - 75 mm diameter | Pebbles  |
| 75 – 250 mm        | Cobbles  |
| 250 – 600 mm       | Stones   |
| > 600 mm           | Boulders |

**Soil Structure** - The arrangement of primary soil particles into aggregates is known as structure in soils. Clods and fragments in the soil are not considered as structural units. Soils

lacking structure are considered as structure less soils and described as single grain or massive. The structure is described based on the shape (type), size and grade of the structural units observed in the soil.

**Based on shape (type)**

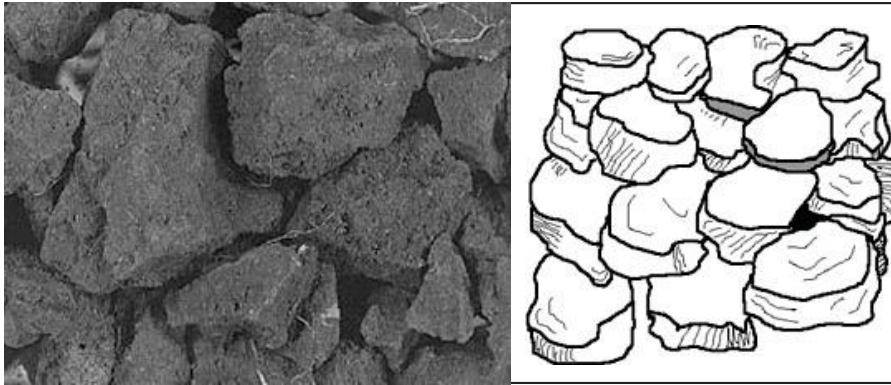
|           |  |
|-----------|--|
| Platy     | The units are flat and plate like and horizontally oriented  |
| Prismatic | Vertically elongated units with flat tops, the individual units are bounded by flat to rounded vertical faces  |
| Columnar  | The units are like prisms and are bounded by flat or slightly rounded vertical faces and the top of columns are rounded  |
| Blocky    | The units are like blocks and considered as angular blocky if the faces intersect at sharp angles; sub angular blocky if the faces are a mixture of rounded and plane faces and the corners are mostly rounded |
| Granular  | The units are approximately spherical or polyhedral and are bounded by curved or very irregular faces  |

**Size** - Based on size, the structural units are described as very fine, fine, medium, coarse and very coarse.

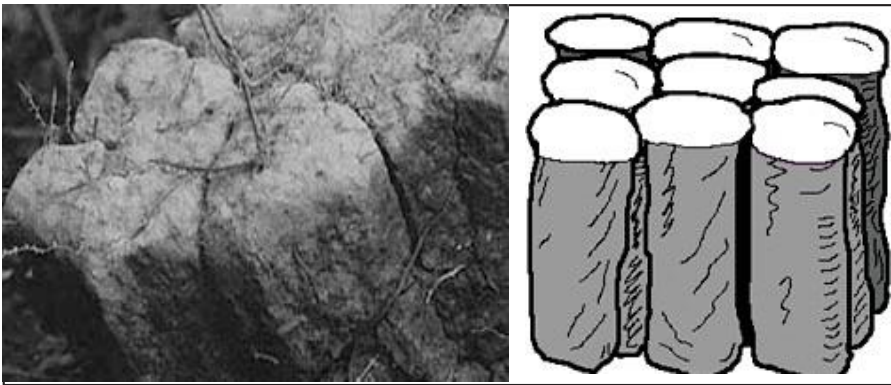
| <i>Size classes</i> | <i>Grannular, Platy (mm)</i> | <i>Prismatic &amp; Columnar (mm)</i> | <i>Blocky (mm)</i> |
|---------------------|------------------------------|--------------------------------------|--------------------|
| Very fine           | < 1                          | < 10                                 | < 5                |
| Fine                | 1-2                          | 10-20                                | 5-10               |
| Medium              | 2-5                          | 20-50                                | 10-20              |
| Coarse              | 5-10                         | 50-100                               | 20-50              |
| Very Coarse         | > 10                         | > 100                                | > 50               |

**Grade** - Grades describe the degree of ped development in the soil. It is distinguished in the field by the portion of the soil appearing as peds and the ease with which the soil separates into peds and their durability. Three classes are used to describe the grade

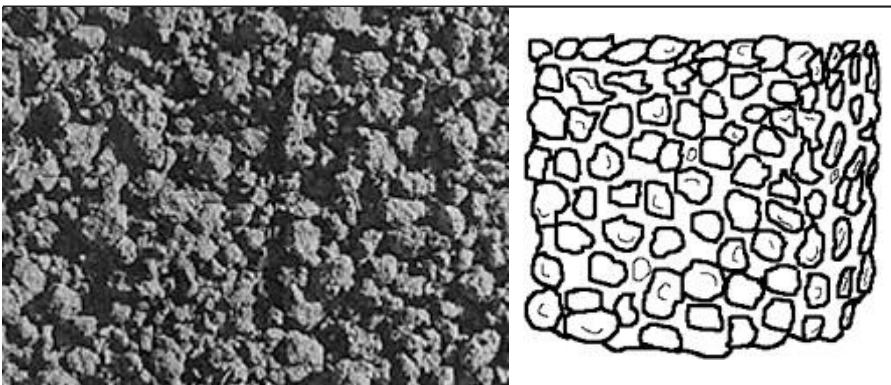
|                   |  |
|-------------------|--|
| Structureless (0) | No discrete units observable in place or in hand sample                            |
| Weak (1)          | Units are barely observable in place or in a hand sample                           |
| Moderate (2)      | Units well-formed and evident in place or in a hand sample                         |
| Strong (3)        | Units are distinct in place (undisturbed soil) and separate cleanly when Disturbed |



**Blocky** - Irregular blocks that are usually 1.5 - 5.0 cm in diameter



**Columnar** - Vertical columns found in arid climate



**Granular** - Resembles crumbs and seen in surface horizons

**Consistence** - It refers to the degree and kind of cohesion and adhesion and/or the resistance of soil to deformation or rupture when stress is applied. Every soil has this property, irrespective of their nature and moisture status. In the field, consistence is assessed based on resistance of soil material to rupture, resistance to penetration, plasticity, toughness, and stickiness of puddled soil material, and the way the soil material behaves when subject to compression. Consistence is highly dependent on the soil-water state, and it is observed for dry and moist soil in the field separately.

| <i>Dry Class</i> | <i>Moist Class</i> | <i>Specimen fails under</i>                    |
|------------------|--------------------|--|
| Loose            | Loose              | Intact specimen not available                  |
| Soft             | Very friable       | Very slight force between fingers              |
| Slightly hard    | Friable            | Slight force between fingers                   |
| Moderately Hard  | Firm               | Moderate force between fingers                 |
| Hard             | Very firm          | Strong force between fingers                   |
| Very hard        | Extremely firm     | Moderate force between hands                   |
| Extremely hard   | Slightly rigid     | Foot pressure by full body weight              |
| Rigid            | Rigid              | Cannot be failed underfoot by full body weight |

**Plasticity** is the degree to which puddled or reworked soil can be permanently deformed without rupturing. The evaluation is made by forming a roll (wire) of soil at a water content where the maximum plasticity is expressed

|                        |   |
|------------------------|---|
| Non plastic (po)       | Will not form a roll 6 mm in diameter, or if a roll is formed, it can't support itself if held on end |
| Slightly Plastic (ps)  | 6 mm diameter roll supports itself  |
| Moderately Plastic (p) | 4 mm diameter roll supports itself; 2 mm diameter roll does not                                       |
| Very Plastic (vp)      | 2 mm diameter roll supports its weight  |

**Stickiness** - refers to the capacity of a soil to adhere to other objects. The determination is made on puddled soil material at the water content at which the material is stickiest. The sample is crushed in the hand, water is applied while manipulation is continued between thumb and forefinger until maximum stickiness is reached.

| <i>Stickiness Class</i> | <i>Code</i> | <i>Criteria-Description</i>   |
|-------------------------|-------------|---|
| Non-sticky              | so          | After release of pressure, practically no soil material adheres to fingers                                      |
| Slightly sticky         | ss          | Soil adheres to both fingers, after release of pressure. Soil stretches little on separation of fingers.        |
| Moderately Sticky       | ms          | Soil adheres to both fingers, after release of pressure. Soil stretches some on separation of fingers.          |
| Very Sticky             | vs          | Soil adheres firmly to both fingers, after release of pressure. Soil stretches greatly on separation of fingers |

**Redoximorphic Features (RMF)** - Mottles are already described under the section soil colour. RMF mottling is normally associated with wetness. The colour pattern of RMF, is due to depletion or concentration of pigments compared to the matrix colour and formed by oxidation/reduction of Fe and/or Mn coupled with their removal, translocation, or accrual; or a soil matrix colour controlled by the presence of Fe<sup>2+</sup>. RMF are described separately from other mottles, salt concentrations or clay films.

**RMFs include the following:**

1. **Redox Concentrations** - Localized zones of enhanced pigmentation, formed due to the accumulation of Fe-Mn minerals in the form of
  - **Masses** - Non cemented bodies of enhanced pigmentation that have a redder or blacker color than the adjacent matrix.
  - **Nodules or Concretions** - Cemented bodies of Fe-Mn oxides.
2. **Redox Depletions** - Localized zones of “decreased” pigmentation that are greyer, lighter, or less red than the adjacent matrix. Redox depletions (chroma  $\leq 2$ ) are used to define aquic conditions and to infer the depth of saturation in soils. Types of redox depletions in the soil are:
  - **Iron Depletions** - Localized zones that have a yellower, greener; or bluer hue; a higher value; or a lower chroma than the matrix color. Color value is normally  $\geq 4$ . Loss of pigmentation results from the loss of Fe and/or Mn.
  - **Clay Depletions** - Localized zones that have either a yellower, greener or bluer hue, a higher value; or a lower chroma than the matrix color. Color value is normally  $\geq 4$ . Loss of pigmentation results from a loss of Fe and or Mn and clay.
3. **Reduced Matrix** - A soil horizon that has an *in-situ* matrix chroma  $\leq 2$  due to the presence of Fe<sup>2+</sup>. Color of a sample becomes redder or brighter (oxidizes) when exposed to air.

RMF are described separately from other color variations, mottles or concentrations. Record Kind, Quantity (% of area covered), Size, Contrast, Color, Shape, Location, Hardness *etc.* in the proforma

**Quantity** (% of area covered)

| <i>Class</i> | <i>Code</i> | <i>Criteria: % of surface area covered</i> |
|--------------|-------------|--|
| Few          | F           | < 2  |
| Common       | C           | 2 to < 20                                  |
| Many         | M           | $\geq 20$                                  |

**Size** (Refer size class under mottles or concentrations)

| <i>Size Class</i> | <i>Code</i> | <i>Criteria</i> |
|-------------------|-------------|-----------------|
| Fine              | 1           | < 2 mm          |
| Medium            | 2           | 2 to < 5 mm     |
| Coarse            | 3           | 5 to < 20 mm    |
| Very Coarse       | 4           | 20 to < 76 mm   |
| Extremely Coarse  | 5           | $\geq 76$ mm    |

**Contrast** - Describe the contrast as faint, distinct or prominent as provided for the mottles

**Colour** - use the Color chart to describe them

**Concentrations** - Concentrations are formed by accumulation of material during soil formation due to dissolution, precipitation, oxidation, and reduction and physical and/or biological removal, transport, and accrual. Types of concentrations include

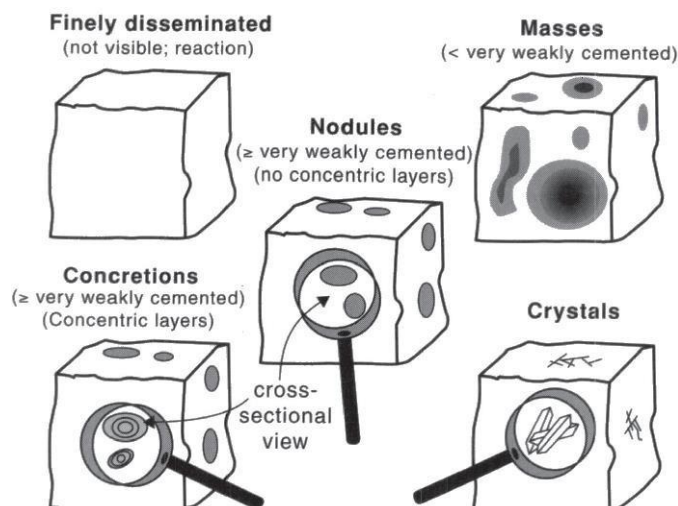
- a. **Finely Disseminated Materials** are patches of precipitates (e.g. salts, carbonates) dispersed throughout the matrix of a horizon and can be detected by a chemical reaction (e.g. effervescence of  $\text{CaCO}_3$  by HCl).
- b. **Masses** are non-cemented accumulation that cannot be removed from the soil as discrete units, and consist of calcium carbonate, fine crystals of gypsum or more soluble salts or iron and manganese oxides.
- c. **Nodules** are cemented bodies of various shapes that can be removed as discrete units from soil.
- d. **Concretions** are cemented bodies like nodules, except for the presence of visible concentric layers of material around a point line or plane.
- e. **Crystals** are crystalline forms of relatively soluble salts (e.g. halite, gypsum, carbonates) that form *in situ* by precipitation from soil solution.
- f. **Biological Concentrations** are discrete bodies accumulated by a biological process like fecal pellets, or insect casts formed or deposited in soil.
- g. **Plinthite** is iron-enriched reddish bodies that are low in organic matter and are coherent enough to be separated readily from the surrounding soil. It is firm or very firm when moist, hard, and very hard.

**Field description of concentrations** - The description of concentrations is like that of the mottles or redoximorphic features present in the soil.

- a. **Kind** - Identify the composition and the physical state of the concentration in the soil. A rough field guide to identify the materials is given below
  - Finely disseminated - Carbonates, salts
  - Masses - non-cemented Carbonates, Gypsum, Salts
  - Nodules - cemented Carbonates, Gibbsite
  - Concretions - cemented Carbonates, Gibbsite, Titanium oxide
  - Crystals - Calcite, Gypsum, Salt (NaCl, Na-Mg sulfates)
  - Biological concentrations - fecal pellets, insect casts, root sheaths, worm casts
- b. **Quantity (% area covered)** - Refers to the relative volume of a horizon or other specified unit occupied by the bodies. The classes used are the same as that used for estimating the quantity of mottles and redoximorphic in the soil.
- c. **Size** is like the classes used for describing mottles.
- d. **Contrast** is like describing Mottle or RMF present in the soil.
- e. **Colour** chart to describe the colour.

f. **Location** is described as on the matrix, ped faces, pores, cracks *etc.*

g. **Composition** of the material like carbonates, iron, manganese *etc.*



**Types of concentrations present in soil**

**Coats/Films/ Stress Features** (Internal Surface Features) - These features include coats/films, or stress features and formed by translocation and deposition, or shrink-swell processes. The kind, amount, continuity, distinctness, location, and thickness of the feature is described.

a. **Kind** - Includes carbonate coats, clay films, organic stains *etc.*

b. **Amount of ped and void surface features** - Estimate the relative per cent of the visible surface area that a ped surface feature occupies in a horizon

| Amount   | Code | Criteria: % of surface area |
|----------|------|-----------------------------|
| Very few | Vf   | <5                          |
| Few      | F    | 5 to<25                     |
| Many     | M    | 25 to<50                    |
| Common   | C    | 50 to<90                    |

c. **Continuity** - It is described as continuous if the feature covers the entire surface, discontinuous if only partially covered and patchy if in isolated patches.

d. **Distinctness** - The relative extent to which a ped surface feature visually stands out from the adjacent material is known as its distinctness. The classes used are

| Distinctness Class | Code | Criteria  |
|--------------------|------|---|
| Faint              | f    | Visible with magnification only (10X hand lens); little contrast between materials. |
| Distinct           | d    | Visible without magnification; significant contrast between materials.              |
| Prominent          | p    | Markedly visible without magnification; sharp visual contrast between materials.    |

**Roots** - Quantity, size, and location of roots in each layer are to be recorded. Describe the quantity (number) of roots for each size class. The unit area that is evaluated varies with the size class of the roots being considered. The unit area for different root size classes is: 1 sq cm

for very fine and fine roots, 1 sq dm (10 x 10 cm) for medium and coarse roots, and 1 m<sup>2</sup> for very coarse roots.

| Quantity Class | Code | Average Count (per assessed area) |
|----------------|------|-----------------------------------|
| Few            | f    | <1 per area                       |
| Common         | c    | 1 to<5 per area                   |
| Many           | m    | ≥ 5 per area                      |

### Size of Roots (and Pores)

| Size Class  | Code | Diameter    | Soil Area Assessed |
|-------------|------|-------------|--------------------|
| Very Fine   | vf   | <1 mm       | 1 cm <sup>2</sup>  |
| Fine        | f    | 1 to<2 mm   | 1 cm <sup>2</sup>  |
| Medium      | m    | 2 to<5 mm   | 1 dm <sup>2</sup>  |
| Coarse      | c    | 5 to< 10 mm | 1 dm <sup>2</sup>  |
| Very Coarse | vc   | ≥ 10 mm     | 1 m <sup>2</sup>   |

**Pores** - Pores are the air or water filled voids present in the soil. It is difficult to assess very small size pores (e.g. < 0.05 mm) in the field. So, field observations are limited to those pores that can be seen through a 10X hands lens or larger. Pores are described by their quantity and size. Quantity classes pertain to number of pores per unit area-1cm<sup>2</sup> for very fine and fine pores, 1 dm<sup>2</sup> (10 x 10 cm) for medium and coarse pores, and 1 m<sup>2</sup> for very coarse. The quantity and size classes are similar to the classes used for roots.

**Cracks** - Are fissures primarily associated with clayey soils and are most pronounced in high shrink-swell soils. Record the Relative Frequency (estimated average number per m<sup>2</sup>) and Depth.

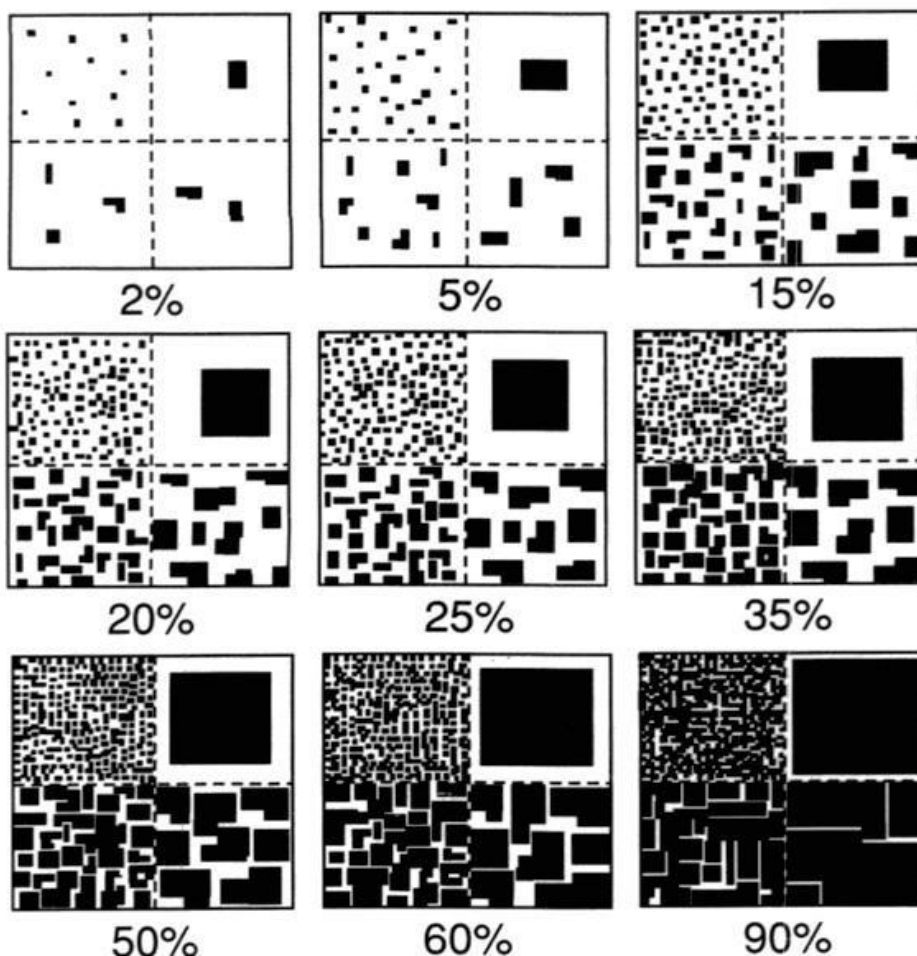
**Soil crusts** - A soil crust is a thin (e.g. <1 cm up to 10 cm thick) surface layer of soil particles bound together by living organisms and / or by minerals into a horizontal mat or small polygonal plates. Soil crusts form at the soil surface and have different physical and /or chemical characteristics than the underlying soil material. Typically soil crusts change the infiltration rate of the mineral soil and stabilize loose soil particles and aggregates. There are two general categories of soil crusts: Biological crusts, and Mineral crusts. Record the type of (kind) surface crust present in the soil.

**Soil reaction (pH)** - Both colorimetric and electrometric methods can be used for measuring pH. Colorimetric methods are simple and inexpensive. Record the pH and method of observation.

**Effervescence** - The gaseous response of soil to cold dilute (about 1:10 dilution) hydrochloric acid is used to test the presence of carbonates in the field. The amount and expression of effervescence is affected by distribution and mineralogy as well as the amount of carbonates present in the soil. The effervescence classes used are very slight, slight, strong, and violent.

**Other features** - Like presence of small animals, termite mounds, ant hills, heaps of excavated earth, the openings of burrows, paths, feeding grounds, earthworm or other castings *etc.*, as special notes to be recorded in the proforma.

**For estimation of per cent of area covered in soil**



The above graphic can be used to assess the amount or quantity of mottles, concentrations, redoximorphic features and ped and void surface features present in the soil. Within any given box above, each quadrant contains the same total area covered, but with by different sized objects.



| Observation Method: |         |                  |   | Auger       |               |       |                      | Minipit |                         |      | Roadcut |                        |         |                          |     |     |     |  |
|---------------------|---------|------------------|---|-------------|---------------|-------|----------------------|---------|-------------------------|------|---------|------------------------|---------|--------------------------|-----|-----|-----|--|
| Depth (cm)          | Horizon | Bnd <sup>1</sup> |   | Diag. Hori. | Matrix Colour |       | Texture <sup>2</sup> | % clay  | Rock Frags <sup>3</sup> |      |         | Structure <sup>4</sup> |         | Consistence <sup>5</sup> |     |     |     |  |
|                     |         | D                | T |             | Dry           | Moist |                      |         | Sz                      | Kind | Vol     | Grade                  | Sz Type | Dry                      | Mst | Stk | Pls |  |
| 1                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 2                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 3                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 4                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 5                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 6                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 7                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 8                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 9                   |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |
| 10                  |         |                  |   |             |               |       |                      |         |                         |      |         |                        |         |                          |     |     |     |  |

|    | Mottles/ Redox features <sup>6</sup> |    |    |     |        | Coats/Films/Stress Features <sup>7</sup> Amt Dst Cont |     |     |     | Concentrations <sup>8</sup> (Conca, Conir, etc.) |      |     |    | Roots <sup>9</sup> |    |     | Pores <sup>10</sup> |    | pH | Efferv <sup>11</sup> (dil Hol)-1,2,3 | Sample bag No. |     |  |  |
|----|--------------------------------------|----|----|-----|--------|---|-----|-----|-----|--|------|-----|----|--------------------|----|-----|---------------------|----|----|--------------------------------------|----------------|-----|--|--|
|    | Qty                                  | Sz | Cn | Col | Sp Loc | Kd  | Loc | Col | Amt | Dst  | Cont | Qty | Sz | Cn                 | Kd | Col | Qty                 | Sz |    |                                      |                | Shp |  |  |
| 1  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 2  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 3  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 4  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 5  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 6  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 7  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 8  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 9  |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |
| 10 |                                      |    |    |     |        |   |     |     |     |  |      |     |    |                    |    |     |                     |    |    |                                      |                |     |  |  |

- D-Distinctness:** a-abrupt, c-clear, g-gradual, d-diffuse, **T-topography:** s-smooth, w-wavy, i -irregular, b-broken
- Texture:** s-sand, ls-loamy sand, sl -sandy loam, l -loam, sil -silt loam, si-silt, scl -sandy clay loam, cl -clay loam, silc -silty clay loam, sc-sandy clay, sic-silty clay, c-clay.
- Size:** fg- fine gravel(<2cm), cg-coarse gravel(2-7.5cm), cb-cobbles(7.5-25cm), st-stones(25-60cm), b-boulders(>60cm).
- Grade:** 0-structureless, 1-weak, 2-moderate, 3-strong; **Size:** vf-very fine, f-fine, m-medium, c-coarse, vc-very coarse  
**Type:** gr-granular, cr-crumb, clr-columnar, pr-prismatic, pl-platy, abk-angular blocky, sbk-subangular blocky, sg-single grain, m-massive, c-cloddy.
- Dry:** l-loose, s-soft, sh-slightly hard, h-hard, vh-very hard, eh-extremely hard, **Moist:** l-loose, vfr-very friable, fr-friable, fi-firm, vfi-very firm, efi-extremely firm, **Stickyness:** so-non-sticky, ss-slightly sticky, ms-moderately sticky, vs-very sticky, **Plasticity:** po-non-plastic, sp-slightly plastic, mp-moderately plastic, vp-very plastic.
- Quantity(qty):** f-few(<2%), c-common(2-20%), m-many(>20%); **Size(sz):** 1-fine(<2mm), 2-medium(2-<5mm), 3-coarse (5-<20mm), 4-very coarse(>20mm); **Contrast(cn):** f-faint, d-distinct, p-prominent; **Colour(col); Shape(sp):** c-cylindrical, d-dendritic, i-irregular, p-platy, s-spherical, t-threads, r-reticulate; **Location(Loc)-matrix/ped/pores/others.**
- Amount(Amt):** vf-very few(<5%), f-few(5-<25%), c-common(25-<50%), m-many(50-<90%), vm-very many(>90%);**Distinctness(Dst):** f-faint, d-distinct, p-prominent; **Continuity(Cont):** c-continuous, d-discontinuous, p-patchy; **Kind(Kd):** Type of coating/stress features; **Location(Loc):** on bottom/top or all faces of peds; **Colour(Col):** Munsell
- Concentrations:** Quantity(qty), Size(sz), Contrast(cn) and Colour are to be described similar to that of the mottles; **Kind(Kd):** Disseminated materials, Masses, Nodules, Concretions, Crystals and Biological concentrations.
- Roots/Pores:** **Quantity:** f-few(<1 per area), c-common(1-5), m-many(>5); **Size:** vf-very fine, f-fine, m-medium, c-coarse; vc- very coarse; **Location(Loc):** between peds(p), in cracks(c), throughout(t); **Shape(Shp):** tubular/irregular/vesicular/interstitial. 11. **Effervescence:** 1-slight, 2-strong, 3-violent.

### **Soil series establishment and phase map preparation**

Grouping of similar kind of soils called soil series and it is a basic mapping unit in detailed soil survey. Soils which are similar in surface characteristics (Texture, Slope, Erosion and gravelliness) are grouped as phases.

**Following Institutes are supporting REWARD in Karnataka for generation of data required for scientific planning of watersheds**

|  |                               |
|--|-------------------------------|
| NBSS&LUP, Regional Centre, Bengaluru                             | Lead Partner for LRI          |
| University of Agricultural Sciences, Bangalore                   | Partner for LRI and hydrology |
| University of Agricultural Sciences, Dharwad                     | Partner for LRI and hydrology |
| University of Agricultural Sciences, Raichur                     | Partner for LRI and hydrology |
| University of Agricultural Sciences, Bangalore                   | Partner for LRI and hydrology |
| University of Agricultural & Horticultural. Science, Shivamogga  | Partner for LRI and hydrology |
| University of Horticultural. Science, Bagalkot                   | Partner for LRI and hydrology |
| Indian Institute of Science, Bengaluru                           | Lead Partner for Hydrology    |
| Karnataka State Remote Sensing and Application Centre, Bangalore | RS and GIS                    |
| Karnataka State Natural Disaster Management Centre, Bengaluru    | Meteorological aspects        |

**LRI outputs:** All the LRI outputs generated, compiled and reproduced in the form of Atlas and reports. The atlas contains basic information on kinds of soils, their geographic distribution, characteristics and classification. The soil map and soil based thematic maps derived from data on soil depth, soil texture, soil gravelliness, slope, erosion, land capability, land suitability for various crops and land use maps are presented. The maps on fertility status *viz.*, soil reaction, salinity (EC), organic carbon, nitrogen, phosphorus, potassium, sulphur, exchangeable calcium and magnesium, available copper, manganese, zinc, iron and boron were derived on analysis of surface soils sampled at 320 m grid spacing within the micro watershed. The atlas illustrates maps and tables that depict the soil resources of watershed and the need for their sustainable management.

The user, depending on his/her requirement, can refer this atlas first by identifying his/her field and survey number on the village soil map and by referring to the soil legend which is provided in tabular form after the soil map for details pertaining to his/her area of interest.

The atlas explains in simple terms the different kinds of soils present in the watershed, their potentials and problems through a series of thematic maps that help to develop site-specific plans as well as the need to conserve and manage this increasingly threatened natural resource through sustainable land use management. The Land Resource Atlas contains database collected at land parcel/survey number level on soils, climate, water, vegetation, crops and cropping patterns, socio-economic conditions, marketing facilities etc. helps in identifying soil and water conservation measures required, suitability for crops and other uses and finally for preparing viable and sustainable land use options for each and every land parcel. LRI also helps in grouping together areas where similar land resource exists on ground, which require the same kind of management, the same kind and intensity of conservation treatment and same kind of crops, pasture or forestry species, with similar yield potentials.

#### **Data products of LRI atlas**

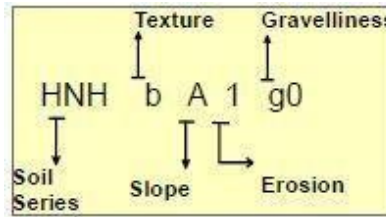
- 1. Location and extent:** Indicate the location of watershed with latitude, longitude along with total area cover and area bounded.
- 2. Agro Ecological Sub Region of watershed:** Represent the Agro Ecological Sub regions of watershed among different Agro Ecological Sub regions of India.
- 3. Agro-climatic Zone of watershed:** Indicate the Agro-climatic Zone under which the watershed falls along with the total geographical area, total cultivable area under irrigation, mean sea level (MSL), average annual rainfall, major soil types and main cropping season of that particular Agro-climatic Zone.
- 4. Base maps, satellite images and cadastral maps:** Before start of an inventory, there is a need for the data resources like base maps, satellite images and cadastral maps to study the location features and existing situation.

- a. **Base map:** A base map is the graphic representation at a specified scale of selected fundamental map information; used as a framework upon which additional data of a specialized nature may be compiled (American Society of Photogrammetry, 1980).
- b. **Satellite image:** Satellite images are images of earth collected by imaging satellites. At present for survey (inventory), we (Karnataka) are using maps in the False Colour Composite (FCC) form at 1: 8000 scale from Karnataka State Remote Sensing and Application Centre (KSRSAC), Bengaluru.
5. **Cadastral map:** Cadastral Maps are a digital form of land records that show all the boundaries of different parts of land (survey number of land parcels).

The above said satellite image and cadastral maps overlaid with and without grid are used for the survey.

6. **Rainfall trend in watershed area:** The watershed area temperature, annual rainfall, South West monsoon, North East monsoon and pre monsoon data to be recorded, which will be further useful in suggesting the crop plans and conservation measures.
7. **Geology:**
  - a. **Geology of State:** Information on the geology of the State helps to know the distribution of different types of rocks and minerals, weathering stages in soil, dominant rocks, minerals and major soil types.
  - b. **Geology of watershed area:** Study of the geology of the particular watershed area helps to know the predominant rocks and minerals, weathering stages and major soil types.
8. **Current land use map:** The information on present serve (use) of the land (*i.e.*, cultivable land, non-cultivable land (fallow land) and use for construction, *etc.*) under particular watershed will be collected and represented in the map to know the percent usage of land.
9. **Location of wells map:** The total number of wells (open wells and bore wells) existing in the particular watershed area will be indicated in the maps along with their location.
10. **Existing Structures:** Existing soil and water conservation structures (agronomical and mechanical), water harvesting structures (farm pond, gokatte, *etc.*) will be recorded.
11. **Soil characteristics:** During land resource inventory, data/observations on surface soil features like soil texture, slope, soil erosion, gravelliness and subsurface features like soil depth and profile characteristics as per pedon description form will be recorded and represented in the form of thematic maps.
12. **Mapping unit description:** Mapping units are represented in the form of surface characteristics combined with series code on map, that should be described clearly in the atlas. Also extent of area occurring in the mapping unit to be mentioned.

**Ex: HNHbA1:** Moderately shallow, non-gravelly (0-15%) loamy sand, derived from granite gneiss, occurring on nearly level land, slope 0-1 per cent and slight erosion.



**13. Soil fertility description:** It represents the status and distribution of different soil fertility parameters like pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, Sulphur, exchangeable calcium, magnesium, DTPA extractable iron, manganese, copper, zinc and hot water-soluble boron in the particular watershed area, which will be further helpful to correct the deficit nutrient through proper nutrient management techniques.

**14. Land capability classes:** Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. There are eight land capability classes

Class I- Class IV: Suitable for cultivation

Class V- Class VIII: Not suitable cultivation and suitable only for pasture and recreation.

Classification of soils based on their capability helps to know the usefulness of the land

**15. Land suitability for different crops:** Under this section we can assess the suitability of land/soils for cultivation of particular crops *viz.*, cereals (paddy, ragi, maize *etc.*), pulses (red gram, black gram, cowpea *etc.*), oilseeds (groundnut, sunflower *etc.*), plantations (tea, coffee, coconut, *etc.*) and commercial crops (sugarcane, cotton *etc.*).

**16. Land management units (LMU):** It is the grouping of different soils into single management unit based on their similar characteristic's features. It helps to propose similar management practices. The number LMUs we can get in a particular watershed area is based on the variability in management requirements of lands. If the variation in the land features is more, more the number land management units.

**Ex:** LMU-1, LMU-2, LMU-3 *etc.*

**17. Proposed crop plan based on LMU:** After grouping of soils into LMUs, suitable crops for cultivation to that particular watershed area is to be proposed which helps to exploit the yield potentials of the crops. Along with suitable crop plan, suitable interventions like cultivation on raised beds with mulches and irrigation system with suitable soil and water conservation measures and application of amendments if needed is to be proposed.

**18. Economic land evaluation of different land use types:** Economic evaluation of the land is very much important and it will be done based on benefit cost ratio (B:C ratio) and land suitability classes.

The FAO framework defines two suitability orders: 'S' (suitable if Benefit Cost Ratio (BCR) >1) and 'N' (not suitable if BCR < 1), which are divided into five economic suitability classes: 'S1' (highly suitable if BCR >3), 'S2' (moderately suitable if BCR >2 and < 3), 'S3' (marginally suitable if BCR >1 and < 2), 'N1' (not suitable for economic reasons but physically suitable), and 'N2' (not suitable for physical reasons).

**19. Runoff distribution:** Knowing runoff status of the particular watershed area is important to adopt the proper conservation measures.

**20. Conservation plans:** After knowing all the variation in the particular watershed area, suitable conservation plans will be proposed.

**21. Conclusion:** Correction of variation in the particular watershed area with suitable technologies helps to conserve the natural resources effectively and exploit the potentials of the area economically.

**For more details, refer the soft copy of the LRI manual and sample atlas loaded in the pen drive supplied as part of training kit.**

### **3. Hydrological assessments for watershed planning and management**

#### **Importance of Agro-hydrological Monitoring**

Agro-hydrology can be regarded as the study of hydrological processes and the collection of hydrological data, aimed at increasing the efficiency of crop production, largely by providing beneficial soil moisture conditions. However, the influences on the production of runoff and the ways that runoff affects the environment within which crops grow are very diverse and agro-hydrological study, of necessity, also includes the collection of information on climate, soils, vegetation, and topography. Rainfall amount and its spatial and temporal distributions determine the quantity of water that reaches the land's surface. Temperature and humidity, the type, amount and distribution of vegetation cover determine what proportion of this water re- evaporates. Vegetation, soil conditions and topography determine how much water infiltrates into the soil, how much runs off the land's surface and where it goes. It is the interaction of these complex processes and the volumes of runoff that these processes produce that form the core research of agro-hydrology. Knowledge of the hydrological environment is necessary to determine whether or not opportunities to create optimal soil moisture conditions exist, and how these opportunities can be exploited.

#### **Hydrological Field Measurements in the Selected Micro Watersheds**

##### **Installation of the equipment's**

To provide precise weather-related information, forecast and advisory to the farmers for planning agricultural activities and to minimize crop loss due to adverse weather conditions, automatic weather stations are set up in every model micro watershed. Rainfall information at every 15 minutes time interval will be captured. In addition to this, weekly rainy days, daily temperature, relative humidity, evapotranspiration, mean wind speed, etc. are recorded and effectively will be used in the REWARD project. The hydrological instruments (diver for runoff and groundwater measurement) will be installed at model micro watersheds to get periodical hydrological information and to support hydrological studies. The agro-hydrological parameters measured and monitored include soil moisture (surface and profile), groundwater levels, bore wells discharge and yield, water quality surface and groundwater, and canopy variables (LAI, biomass, crop yield, crop management activities).

In an experimental watershed, the following agro-hydrology components are monitored or measured:

## **Soil Moisture**

Surface Soil Moisture (SSM) plays a vital role in various processes occurring on the soil atmosphere interface. The evaporation is controlled directly by the surface soil moisture; the transpiration is controlled by the soil moisture present in the root zone. The precipitation passes through surface soil moisture to reach the root zone. Hence, surface soil moisture could be able to provide some insight into the root zone soil moisture. This means that surface soil moisture may be a useful variable to predict the hydrological cycle over land. Apart from hydrology, it is also useful in various other applications e.g., agronomy, drought management and in the improvement of disaggregation/downscaling of precipitation etc.

### **Surface soil moisture**

Currently, surface soil moisture is assessed for the following three main reasons:

- ✓ To validate the radiometer satellite data
- ✓ To calibrate the STICS crop model
- ✓ Calibration/Validation of SAR satellite data

The two methods for measuring the surface soil moisture are detailed in the following two subsections:

### **Volumetric Soil moisture measurement (Theta Probe)**

Surface soil moisture is measured using ML2x theta probe (Delta-T devices, Delta-T Devices Ltd, Cambridge, UK), which measures soil moisture averaged over 0 to 5 cm depth and equipped with a HH2 meter for spot measurements and display. Accuracy of measurements is  $\pm 1\%$ . Figure depicts a Theta probe and HH2 meter (Delta T Devices) assembly. The operating principle, steps to be employed during measurements etc. of this probe is given below.

### **Operating Principle**

Theta Probe measures soil parameters by applying a 100 MHz signal via a specially designed transmission line whose impedance is changed as the impedance of the soil changes. This impedance has two components; the apparent dielectric constant and the ionic conductivity. The signal frequency has been chosen to minimize the effect of ionic conductivity, so that changes in the transmission line impedance are dependent almost solely on the soil's apparent dielectric constant. These changes cause a voltage standing wave to be produced which augments or reduces the voltage produced by the crystal oscillator, depending on the medium surrounding the measurement prongs. The difference between the voltage at the oscillator and that reflected by the rods is used by Theta Probe to measure the apparent dielectric constant of the soil. A linear correlation exists between the square root of the dielectric constant, ( $\sqrt{\epsilon}$ ), and volumetric moisture content, ( $\theta$ ), which is used to convert the measured dielectric constant to soil moisture.



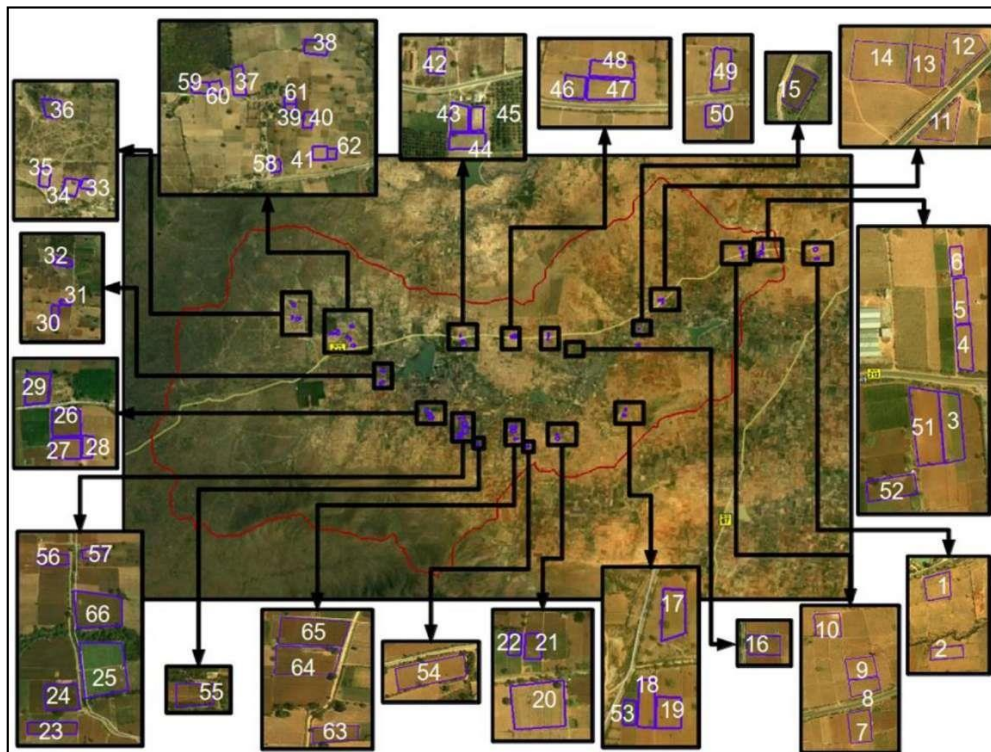
**Theta probe and HH2 meter (Delta T Devices)**

**Steps to be employed for the measurement**

- ✓ The theta probe needles should be inserted (penetrated) fully into the soil vertically. Take care while inserting the probe in stony soils as it may damage the needle. In such cases if it is difficult to insert the probe in a particular location try a few other locations in the plot where the needles can penetrate without much force being applied.
- ✓ Three readings should be taken for each plot (soil unit), to get the mean value that is representative of the field plot and variability.
- ✓ If the plot is with furrows and ridges (as in the case of turmeric), then take one reading at the top of the furrow, one in the ridge, one at another representative location.
- ✓ If the plot is partially irrigated, take at least two measurements in the irrigated area and mark the reading as irrigated.
- ✓ If the plot is irrigated the previous day of measurement, note it down in the field note. At least one measurement has to be made within the 2 sq.m area adjoining the location where the access tube is installed.
- ✓ Note down the label number of the Delta-T probe. (Usually, each Theta probe is given an identification number by the field team, this will help us in calibration) Do

not take soil moisture reading too close to a crop, as the probe may penetrate the root and measurements may be misleading.

- ✓ Do not take soil moisture reading in the loose soil as the presence of air gaps may affect the measurements.
- ✓ If the reading cannot be taken for the dry soil (hard to penetrate the needles), note down that in your diary. (This usually occurs in summer season in most soils) Note down the crop type.



Map showing a Typical Layout for Soil Moisture Monitoring Field-Plots

### Soil Moisture Profile

The procedure for profile soil moisture measurements, the instruments used and their operating principle, calibration techniques are discussed below. Profile soil moisture are being monitored/measured either continuously or intermittently at regular frequency in a watershed for cropped and uncropped areas.

### TRIME-PICO IPH Soil Moisture Sensor

#### Operating Principle

The TRIME device generates a high-frequency pulse (up to 1GHz) which propagates along the metal shells, generating an electromagnetic field around the probe. At the end of the shells, the pulse is reflected back to its source. The resulting transit time (3ps...2ns!) can be measured and enables determination of the propagation velocity, which is primarily dependent on the water content. The volumetric water content is then calculated by the velocity and is shown on the

display panel immediately. The particular probe that is used to depict the procedure is T3/44, which has moisture measuring range from 0 to 60 % (volumetric water content) and an accuracy of  $\pm 2\%$ . Measuring volume: The effective penetration depth of the probe T3 is about 15 cm with the highest sensitivity in the immediate vicinity of the access tube, and decreases exponentially as distance increases.

### **Installation of Access Tubes**

Access tube of TRIME contains three parts, the tube (1 m or 2 m long) with a metal ring at the bottom, a rubber cork (to seal the bottom of the tube) and a plastic cap to cover the top of the tube. It is necessary to maintain close contact between the access tube and the soil material for reliable measurements; hence the tubes should be installed as recommended by the manufacturer. Alternatively, the access tubes can be installed by following the steps below.

- ✓ Fix the rubber cork tightly inside the metallic ring at the bottom of the access tube, this can be fixed with the help of the auger provided with the instrument. (The specially designed auger has provision for tightening the rubber cork). Additionally, it is better to seal the bottom with cello tapes to ensure that no water seeps into the tube from the bottom. Close the top of the access tube with the plastic cap.
- ✓ Drill a hole to the required depth (1 m or 2 m) using the auger provided by the manufacturer. Save soil in a small bucket to mix with water to form a well-blended mud. Pour the mud back into the hole until it is full.
- ✓ Insert the Access Tube in an auger hole. Move the tube up and down (inside the hole) a few times to remove all air. Mud should come up to above surface level
- ✓ Fix the access tube in this position and insert the Probe into the access tube, slowly lower it to the bottom and note the readings, since the readings are taken immediately after installation all the readings should be in the high (40 to 50 %) and consistent.
- ✓ Lower readings indicate the presence of air gaps which should be fixed immediately by following step 3.
- ✓ Installation of access tubes can be carried out at least two weeks before the intended start of the experiment, since the newly installed access tube may take at least 10 days to settle.



### **TRIMEPICO IPH for Profile Soil Moisture Measurements**

#### **How to Measure**

- ✓ Open the cap of the access tube and insert the sensor slowly into the tube till the sensor is fully below the ground level. Note down the reading from the data logger.
- ✓ Now slowly push the sensor further down to the required depth (depth is marked in the cable with a white tape) and continue taking measurements. Continue this process till the whole of the access tube (1 m or 2 m) is covered.
- ✓ Note the reading and depth of measurement each time.
- ✓ Note also the crop type and general condition of the plot (like irrigated or rained etc.).
- ✓ In dry soil, sometimes it will be difficult to push the sensor inside the access tube, in such cases it is better to avoid taking measurements since the sensor may get struck inside the access tube and pulling it back by force may damage the connecting wires.
- ✓ Do not make the sensor or the data logger to hang from the cable while taking for field measurements since this will lead to wear and tear in the connecting cable and eventually the sensor unit may be disconnected from the logger. Always support the sensor and logger with hand or use the instrument box each time.

#### **Continuous Soil Moisture Monitoring**

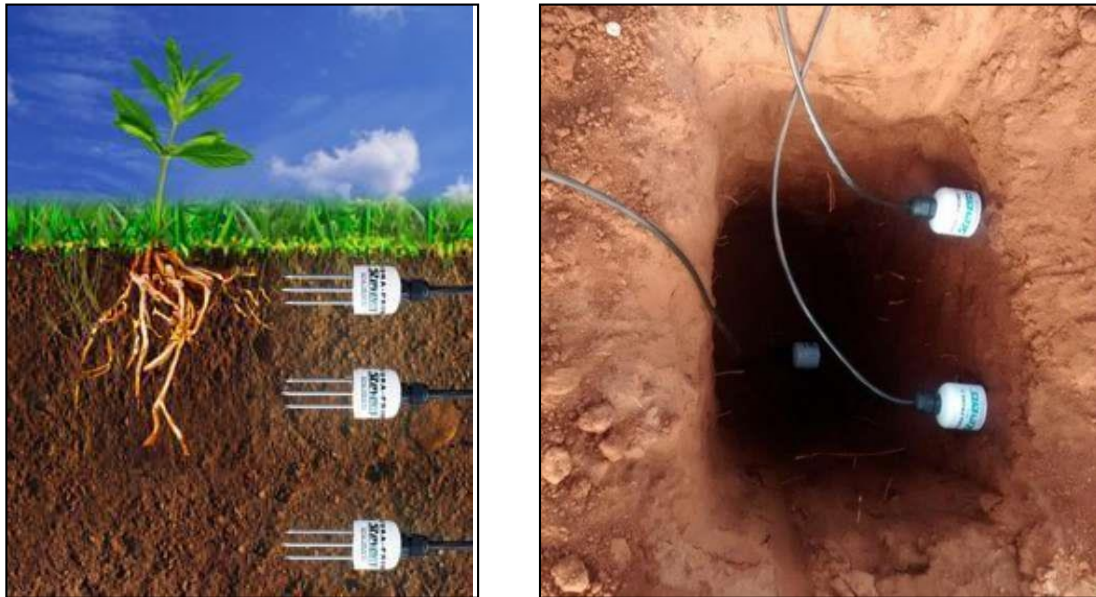
Continuous monitoring of surface and profile soil moisture is essential to understand the controls of soil moisture in the watershed. Such data can help in irrigation scheduling, calibration, and validation of satellite soil moisture products and in predicting drought.

### **HYDRA Probe Soil Moisture Sensor**

The Hydra Probe sensor uses the Coaxial Impedance Dielectric Reflectometry method in soil moisture measurement. The Coaxial Impedance Dielectric Reflectometry method of soil moisture measurement employs an oscillator to generate an electromagnetic signal that is propagated through the unit (usually by metal tines or other wave guide) and into the soil. The probe sends electrical signals into the soil, measures the responses, and relays this information to a data collection device known as a data logger. Part of this signal will be reflected to the unit by the soil, and the sensor will measure the amplitude of this reflected signal and the incident signal in volts. The ratio of these raw voltages is used in a mathematical numerical solution to Maxwell's equations to first calculate the impedance, then both real and imaginary dielectric permittivity which in turn is used to accurately estimate soil water content.

### **Installation and Calibration**

- ✓ Excavate a hole no larger than 25" x 25" square and 25" deep for the sensor installation pit. To best re-create the original soil horizons, these soil layers should be replaced in the pit in the same order they were removed.
- ✓ Trench from the location of the power source and data logger to the sensor installation pit. Assemble rigid or flexible PVC conduit to protect the sensor wires.
- ✓ Check that there is enough cable length to reach up through the soil pit and through the conduit to the data logger. Label sensor wires with sensor depth or position at both ends – the sensor end and the end that will be hooked up to the data logger.
- ✓ Before installing sensors into the soil, connect the wires to the data logger and power source. Test each sensor separately in moist soil to make sure that it is working as expected. A small cup with moistened soil works well for testing because each sensor should give very close to the same reading for soil moisture and temperature.
- ✓ Install the 50cm, 5cm, and 5cm sensors along the pit face in a staggered pattern, carefully backfill the soil in the rest of the pit and leave drip loops in all the wires.
- ✓ Gather all the wires together at the surface and seal the end of the conduit with duct seal putty. When all the sensors are in place and the installation is complete, bury the conduit in the trench

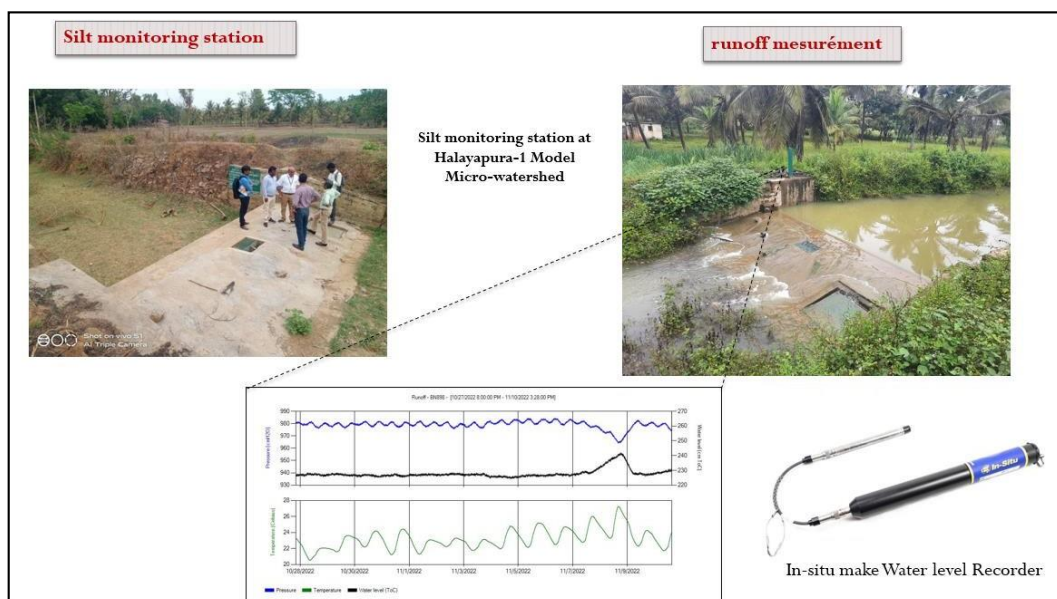


**Schematic of HYDRA Probe Soil Moisture Sensor**

**Measurement of Runoff**

The detailed monitoring surface runoff at the outlet of the micro watershed will be measured using a CTD diver and analysis will be done by using check dam weir formulae.

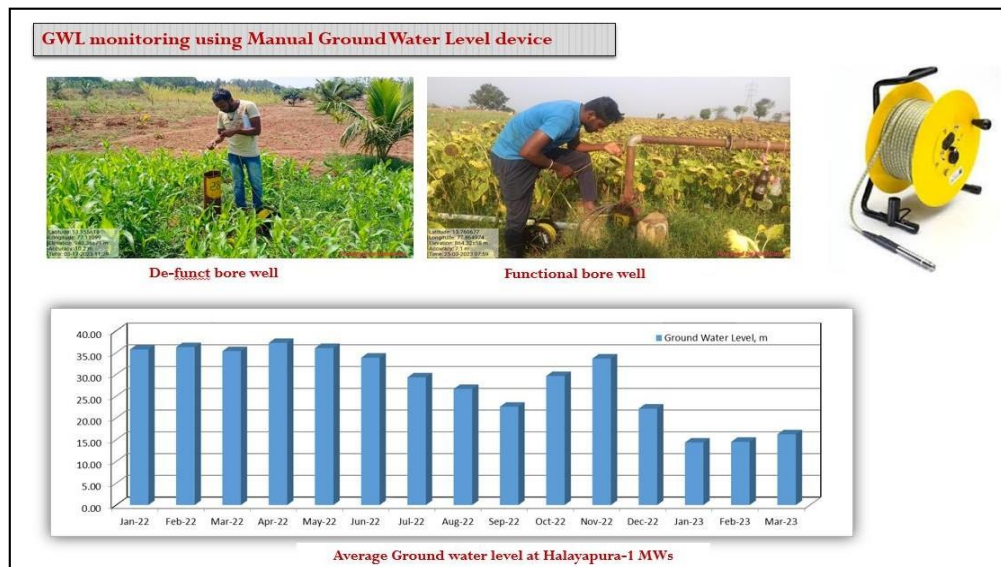
An in-situ water level recorder is a device designed to measure and record changes in water level within natural water bodies such as rivers, lakes, and wells. It is typically placed directly in the water or in a well, allowing it to accurately monitor fluctuations in water levels over time. This instrument is essential for hydrological studies, flood forecasting, and resource management, providing valuable data for understanding water availability and changes in water storage within various aquatic environments.



**Runoff measurement and silt monitoring station at outlet of the micro-watershed**

## Groundwater studies

The detailed monitoring of hydrological characteristics like water table fluctuation (Monthly) and water yield (seasonal) in the model micro watersheds will be observed. Totally 75 (including function, and defunct) wells will be selected for monitoring the groundwater table. The groundwater samples will be collected seasonally (Kharif, Rabi and Summer) and analysis will be done for different chemical parameters viz., pH, EC, Cl, SAR, and RSC to assess its quality for irrigation purposes.



### GWL monitoring using manual ground water level device and readings

## Evapotranspiration

The demand for fresh water is on a steady rise due to ever expanding human activities. Moreover, in the light of climate change; least and less developed nations are facing the threat of acute shortage of water in the future decades. The distribution of water is not the same across the globe and it is the top priority of the scientists in the field to understand the different processes of the hydrologic cycle and estimating the quantum of water available in each phase of the cycle at regional and country levels. In India, though stream flows and groundwater levels are observed periodically, reliable data on the quantity of water reaching the atmosphere through evapotranspiration (ET) is not available. This lack of data causes high uncertainties in closing the water budget and estimating the quantum of water available for human consumption. ET is a critical component of the hydrologic cycle and moreover, it is the terrestrial link to the atmosphere as it connects the energy and water cycle. Accurate estimation of ET is a major requirement for land surface modeling, numerical weather prediction and irrigation supply to crops etc. ET is the combination of two separate processes whereby water is lost on the one hand from the soil surface by evaporation and on the other hand from the crop by transpiration. Evaporation is the process whereby liquid water is converted to water

vapor (vaporization) and removed from the evaporating surface (vapor removal). Transpiration consists of the vaporization of liquid water contained in plant tissues and the vapor removal to the atmosphere

### ET Measurement using Agro-Meteorological Stations

Evapotranspiration is not easy to measure. Specific devices and accurate measurements of various physical parameters or the soil water balance in lysimeters are required to determine evapotranspiration. The methods are often expensive, demanding in terms of accuracy of measurement and can only be fully exploited by well-trained research personnel. However, there are other indirect methods like the Bowen ratio energy balance and the eddy covariance available to estimate ET. These indirect methods require input from data on several variables measured in Agro-Meteorological Stations install in the field. ET is estimated at any given site using the measurements from the 10 m tall micrometeorological tower (popularly called Agro-Met Station and abbreviated as AMS). The various instruments and the measured variables are listed in Table. Figure presents a picture of the AMS tower. All the parameters are measured at 5 m intervals and averaged for 30 m. The data for every half hour is stored in a data logger and transmitted through a yagi antenna to pre-determined server.

### List of Different Instruments and Observed Weather Variables at The AMS Tower

| Sl. No. | Observed parameter   | Instrument                      | Height(s) of installation   |
|---------|--|---------------------------------|-----------------------------|
| 1       | Air temperature  | Platinum resistance thermometer | 2 m, 4 m and 6 m            |
| 2       | Relative Humidity  | Capacitor Type                  | 2 m, 4 m and 6 m            |
| 3       | Wind speed and wind Direction  | Cup Anemometer                  | 2.5 m, 5 m and 10 m         |
| 4       | Atmospheric pressure   | Transducer                      | 2 m                         |
| 5       | Rainfall   | Tipping Bucket rain gauge       | 1 m                         |
| 6       | Net radiation <ul style="list-style-type: none"> <li>• Shortwave incoming</li> <li>• Shortwave outgoing</li> <li>• Longwave incoming</li> <li>• Longwave outgoing</li> </ul> | Four component net radiometer   | 3 m                         |
| 7       | Diffuse radiation  | Shaded pyranometer              | 3 m                         |
| 8       | Soil heat flux   | Flux plate                      | -0.05 m, -0.2 m             |
| 9       | Soil temperature   | Soil Thermometer                | -0.05 m, -0.15 m and -0.3 m |



**A typical AMS Tower Installed in the Field**

### **Preparation of Hydrologic Atlas/Outcomes**

Integrated hydrological assessment and monitoring involves hydrological data gathering, behaviour mapping & processes understanding at micro-watersheds scale. The objective is that the hydrological monitoring aided by advanced hydrological data & customized models developed in the process will aid in producing hydrological budgets at relatively higher temporal frequency (e.g., weekly/monthly) and at the desired spatial granularity in small/micro watersheds, for improved sustainable water management. The focus is to assess the links between groundwater conditions in the watersheds and design of soil & water conservation measures; groundwater level changes & water yields in hard rock aquifers; impacts of water stress on crop productivity; and land management changes and impacts on groundwater recharge & runoff. Further the additional objective is to integrate the hydrological variables & water budgets with the land resource inventory mapping for developing robust integrated watershed management plans.

Once the procedures are implemented for a given watershed and compilation of required primary and secondary data is done, the next step is to use these data to prepare several elements for the hydrological atlas for the watershed. Below section, methodology for computation and analysis associated with the preparation of hydrologic atlas is discussed.

### **Location and Index Maps for the Study Area**

At the very beginning of the study several hydrological and other required information are collected about the study area. Some of these are boundary and geographical location, location of monitoring sites, drainage network, habitation, cadastral boundaries, sub-watershed boundaries etc. This information is then transformed into several thematic GIS layers and then show them in map.

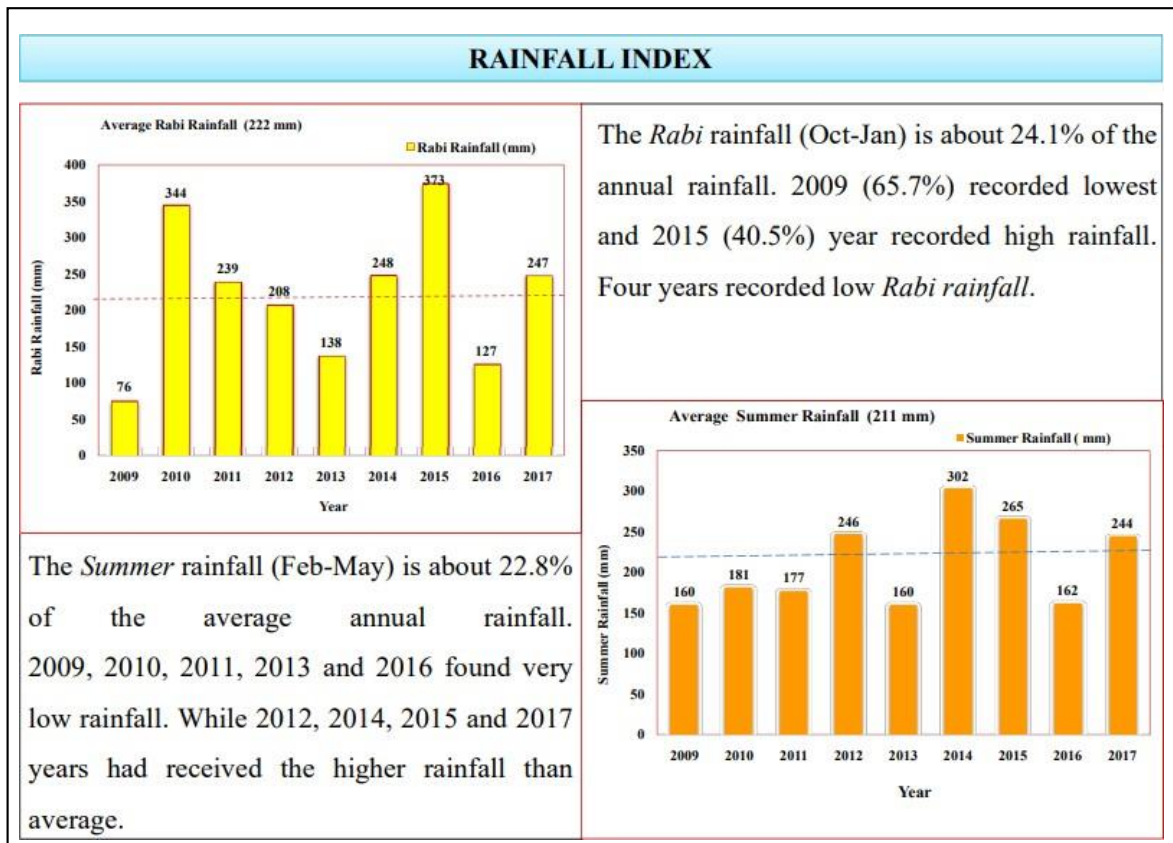
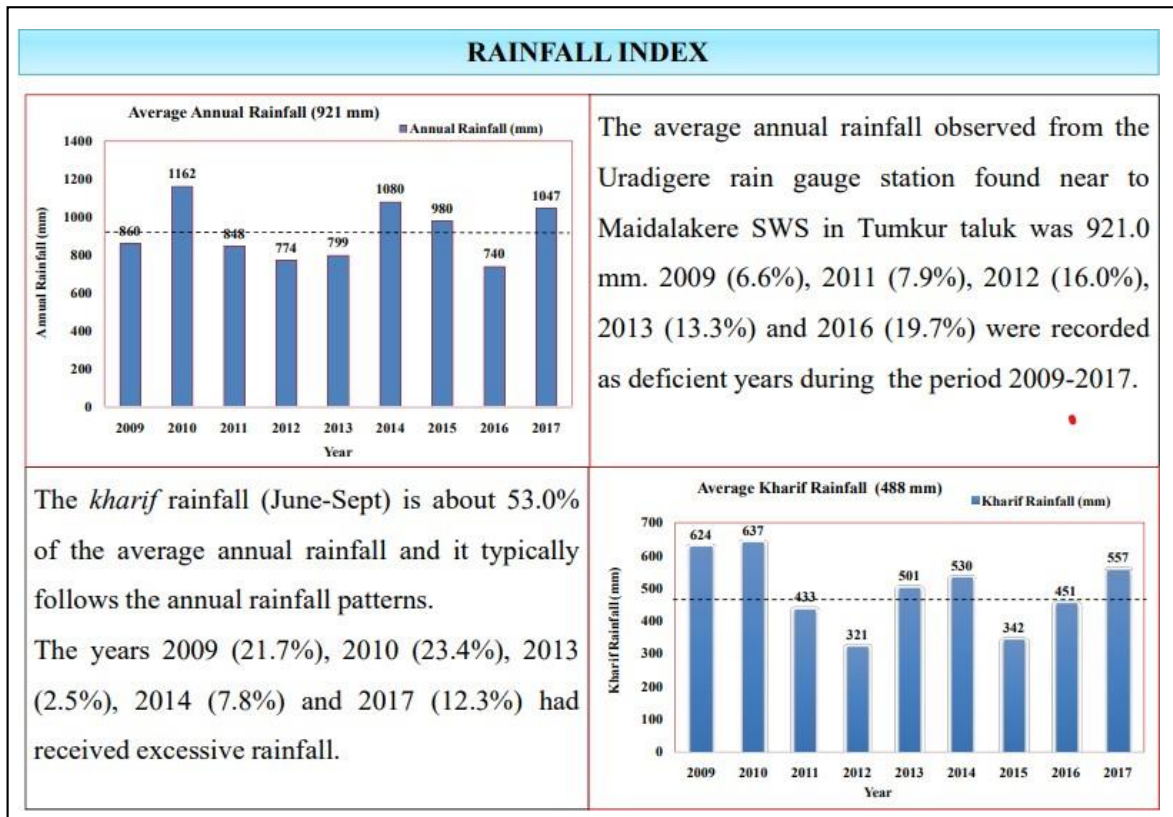
### **Rainfall indices**

The first task is to compile a catchment-averaged time series by combining the available rainfall data from several sources with lowest possible frequency and longest possible record. Depending upon data availability and context of the project objectives multiple such rainfall series may be prepared. Once that is done, many types of summary time series are to be prepared for the hydrological Atlas.

### **Summary Time Series Plots**

For the Maidalakere sub watershed following four types of summary time series plots are prepared using the available rainfall data.

- ✓ Annual Rainfall Time Series: These are prepared by aggregating the available daily (and sub-daily, as the case may be) rainfall over the calendar year for the period of record.
- ✓ Kharif Rainfall Series: The period from June to September has been considered as Kharif season for a particular calendar year and the corresponding time series is to be prepared in similar way as that of the annual series.
- ✓ Rabi Rainfall Series: The period from October to January has been considered as Rabi Season for a particular calendar year and the corresponding time series is to be prepared in similar way as that of the annual series.
- ✓ Summer Rainfall Series: The period from February to May has been considered as Summer Season for a particular calendar year and the corresponding time series is to be prepared in similar way as that of



**Summary Time Series Plots for Rainfall**

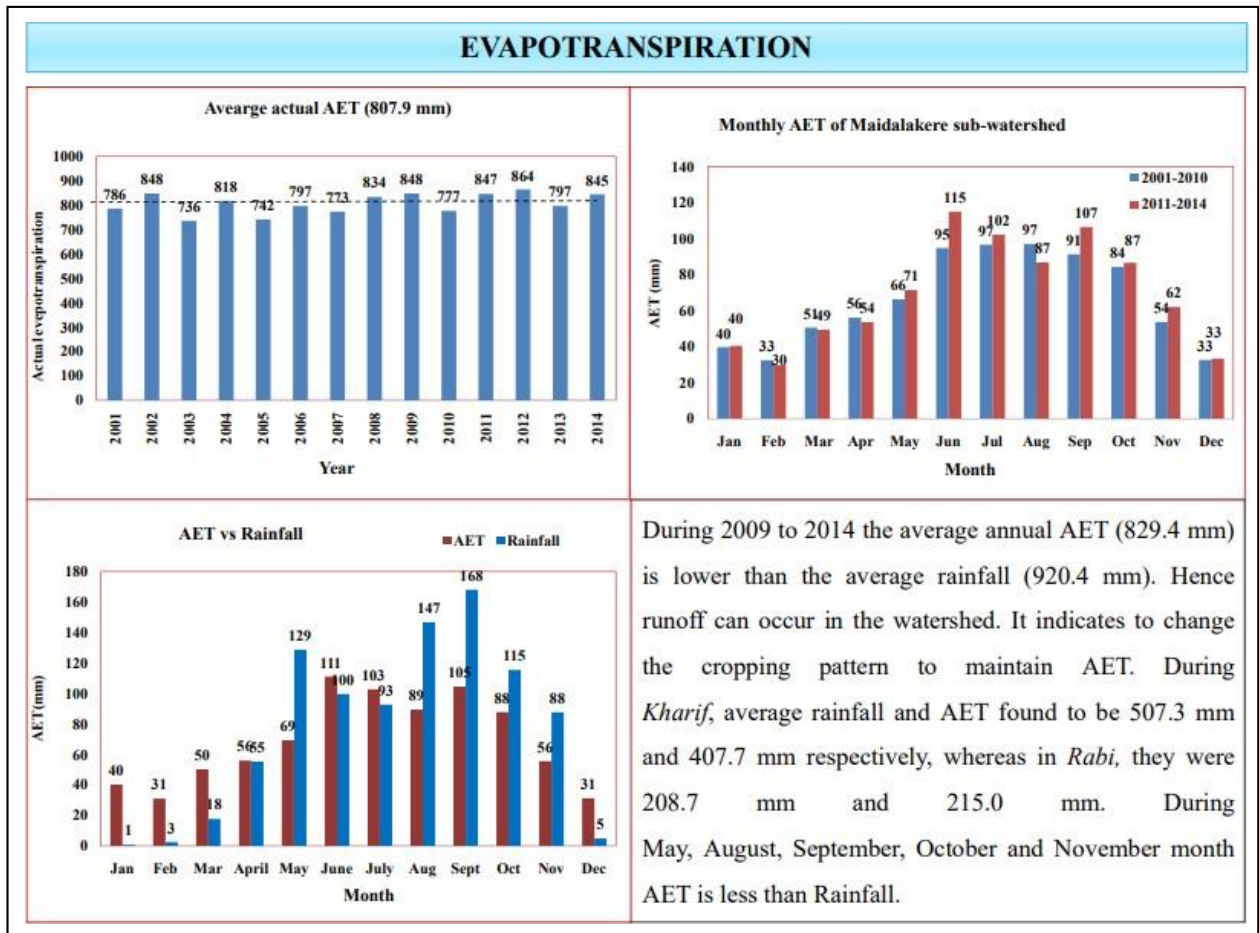
### Evapotranspiration and Associated Indices

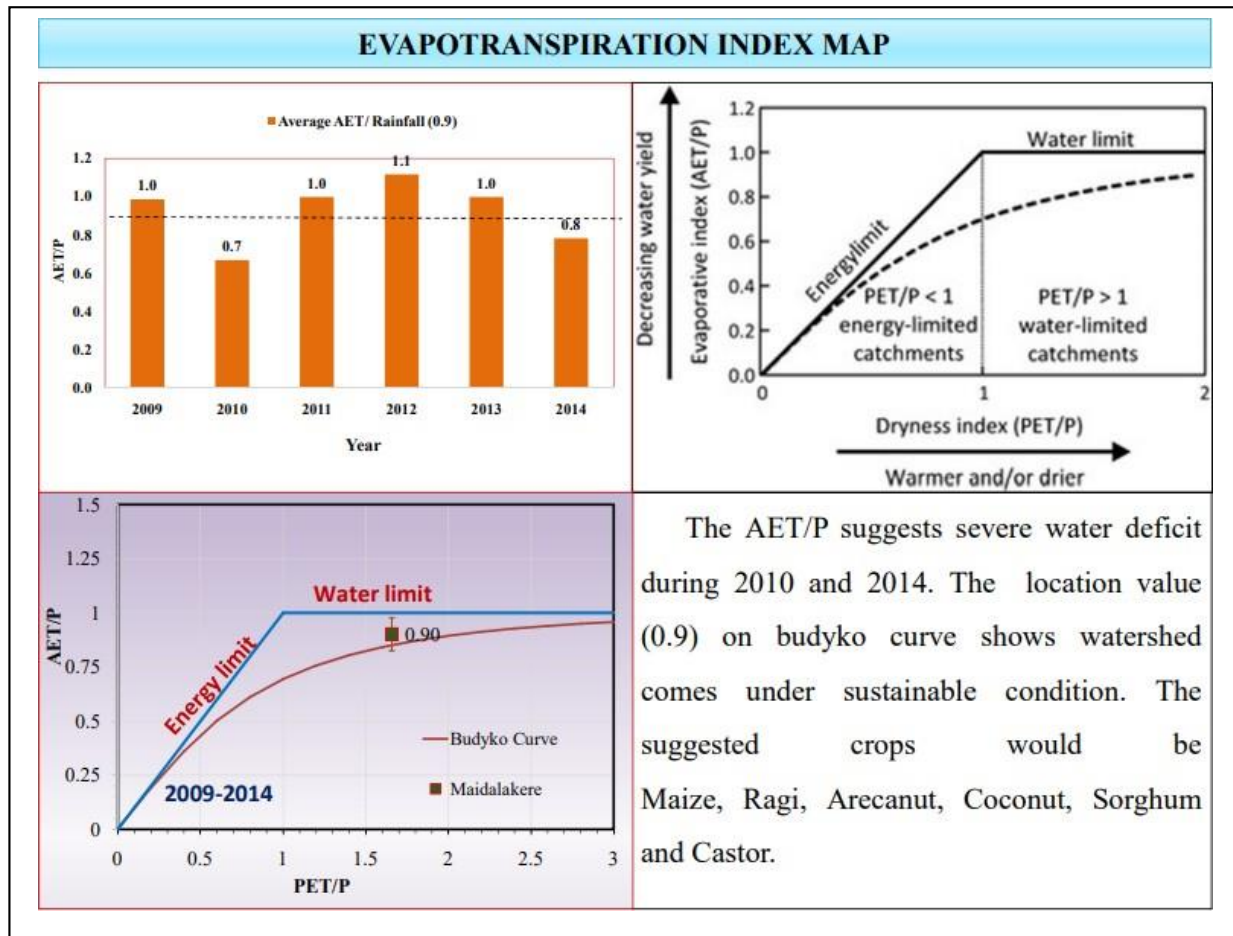
Several types of indices are developed using available time series of Actual Evapotranspiration (AET). Generally, AET time series are compiled at daily time step and with catchment-

averaged values. Using this time series data following summary time series are prepared and presented in graphical & tabular forms as part of the Atlas.

**Summary Time Series Plots**

- Annual total AET series over the period of record; from this series Annual Average value of AET for the given catchment is also computed.
- Annual Average AET series for each of the calendar month. In this case, temporal averaging is done over all the years in the period of record. Using this Monthly Average AET series following two types of summary plots are prepared:
- Month wise comparison of AET and Rainfall over the period of record.
- Month wise of variation in AET over two consecutive decades, depending upon the length of available time series of AET.





**Evapotranspiration and associated indices of Moidalakere sub-watershed**

### Surface Soil Moisture Data

Surface soil moisture data are generally depicted either as time series plot or as raster maps over the whole watershed.

### Spatial Maps

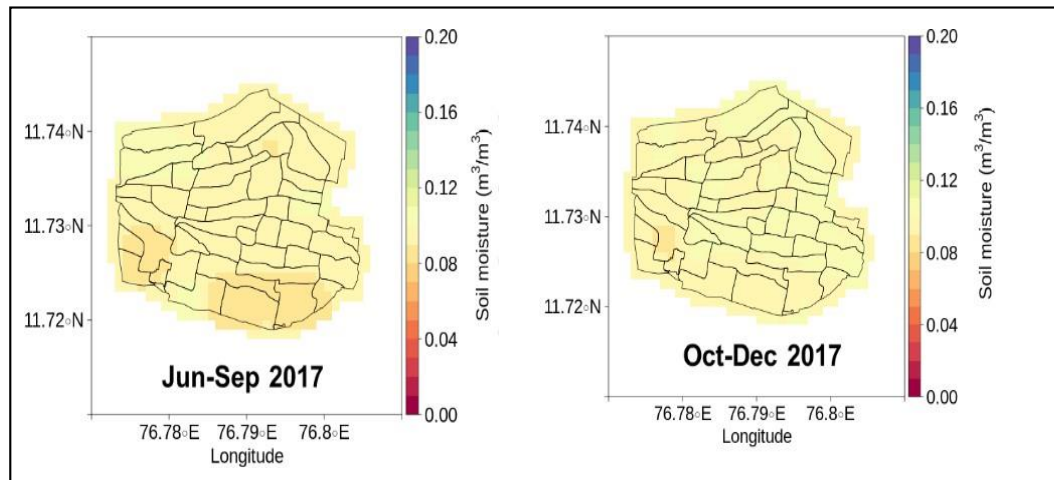
Surface soil moisture maps over a given micro-watershed for Kharif and Rabi Seasons is given below. These maps are prepared using satellite remote sensing products. The following facts are to be noted:

- Seasonal maps are prepared by aggregating multiple images over the watershed.
- Cadastral maps are always overlaid on top of soil moisture rasters.

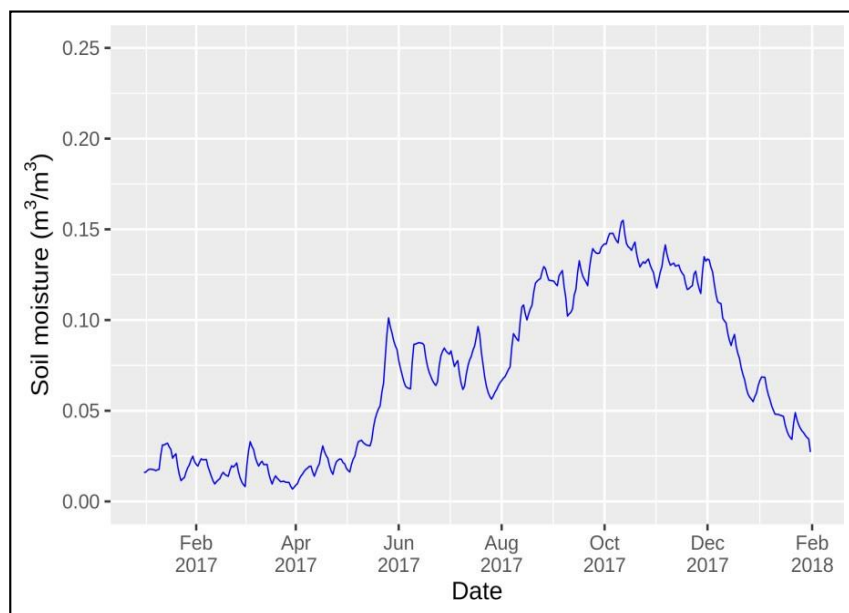
### Time Series Plots

Aggregating the surface soil moisture data over the study watershed a catchment aggregated soil moisture time series are prepared to assess the temporal variability.

Soil moisture comparison plots should also be created to evaluate the coincidence of the field and satellite observations to cross-check the data accuracy from both the sources

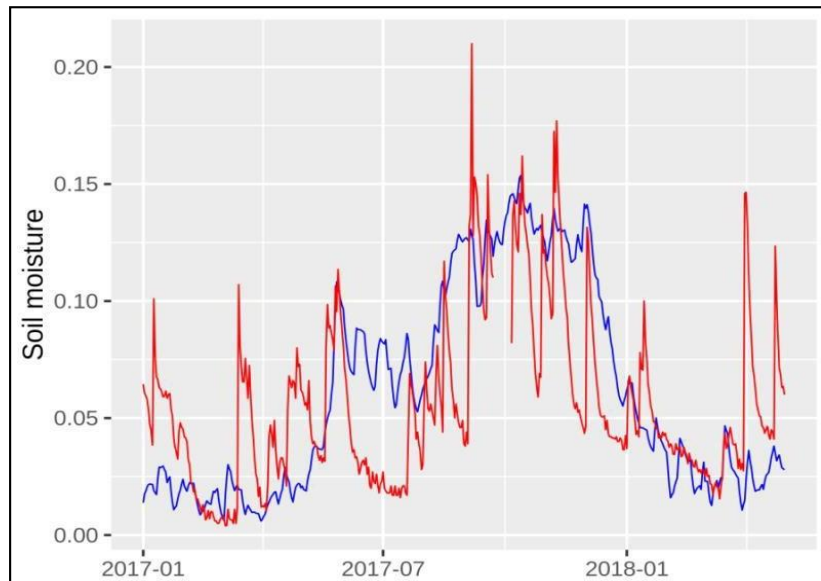


**Satellite-derived Surface Soil Moisture Maps over a Study Watershed for Kharif and Rabi Seasons**

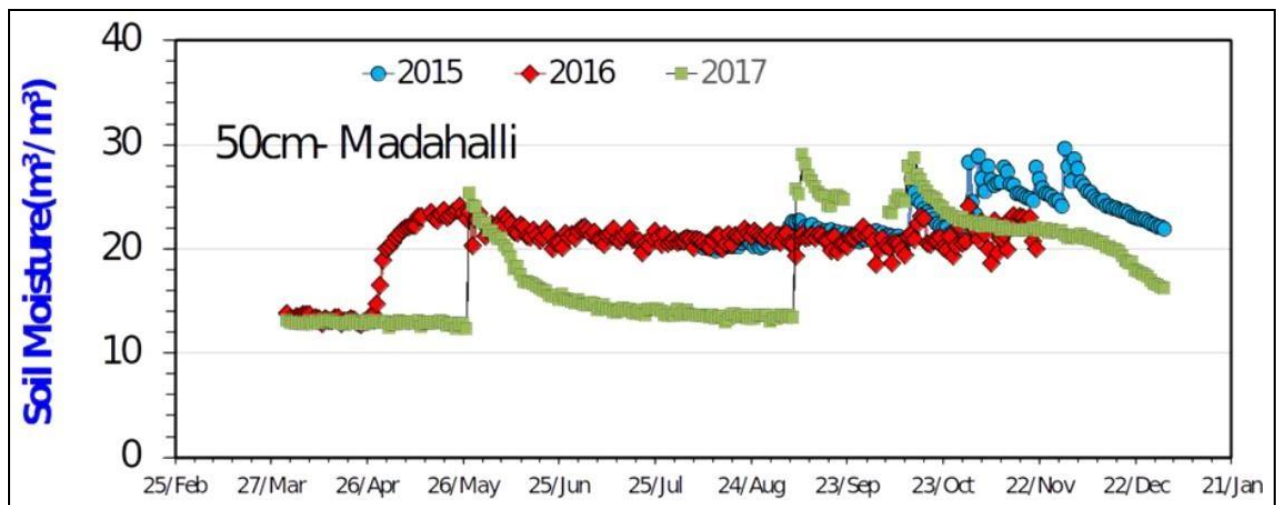


**Time Series Plot of Surface Soil Moisture over a Study Watershed**

The root zone soil moisture data is observed for dominant field crops in rainfed conditions. Subsistence irrigation may be required for attaining the potential productivity of these crops currently in practice.



**Comparison of Satellite-based and Manual Observation-based Surface Soil Moisture Data**

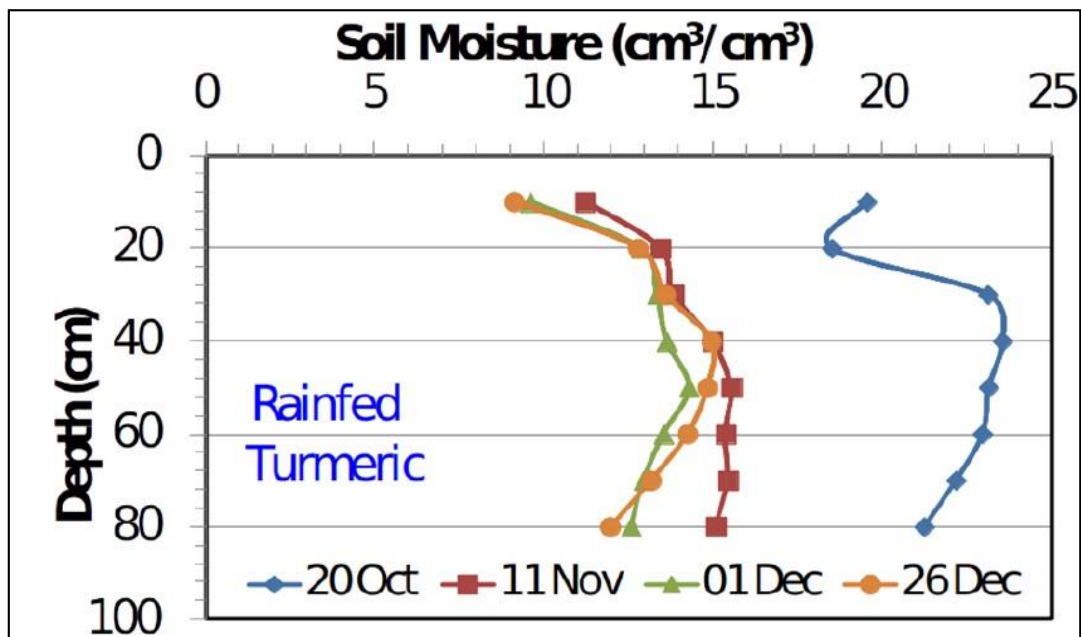


**Root Zone Soil Moisture Time Series Plot at the location in the study watershed**

**Profile Soil Moisture Data**

The following two considerations are to be noted for profile soil moisture data,

- Profile soil moisture should be observed every 10 days.
- Depth-wise measurements should be taken for an increment of 5 cm, up to the depth of 90 cm.



Sample Profile Soil Moisture Plot

### Spatial Distribution of Depth to Groundwater

DGW is point data and needs to be interpolated to prepare the spatial maps. Any of the following approaches can be used to convert the point data into spatial maps:

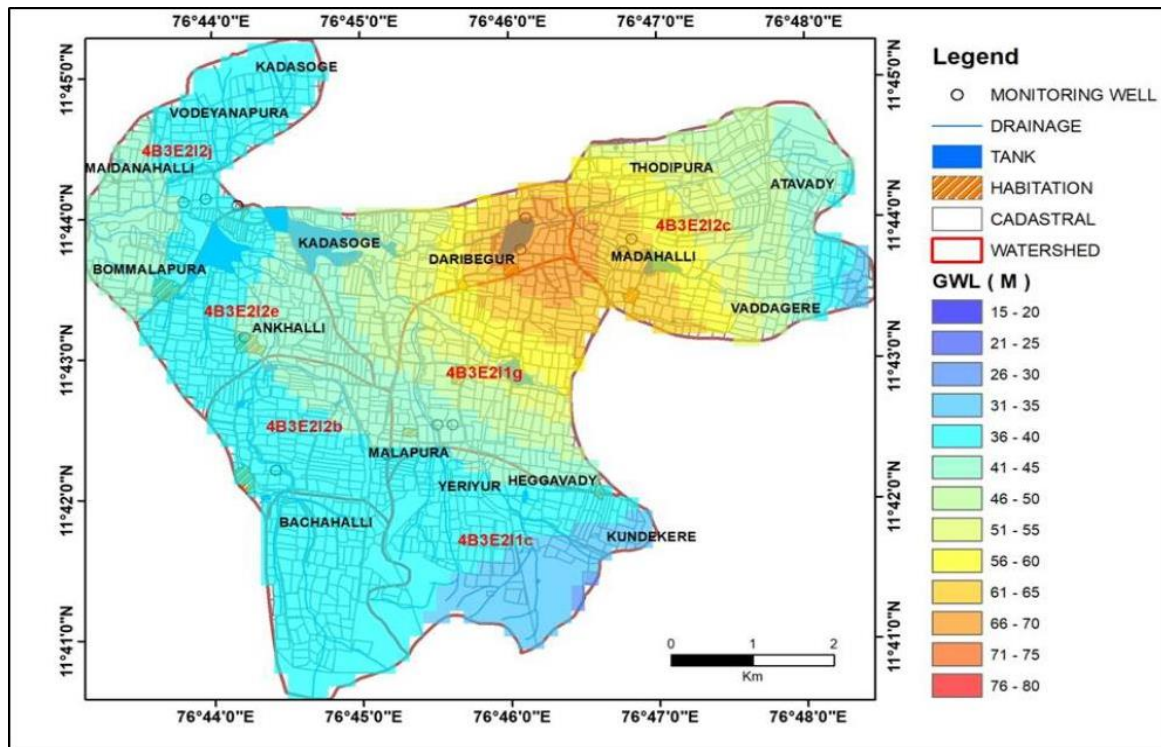
- Inverse Distance Weighted (IDW) Approach: In IDW, the value at an unknown point is estimated by giving weights proportional to the inverse of the distance (between the known locations and the unknown location) raised to the power value  $p$ . Typically, a value of  $p=2$  is used; however, care should be taken that it should not result in spurious behaviour in any part of the map. In that case, different values of  $p$  should be tried.
- Kriging-based Interpolation: Kriging provides the best linear unbiased estimation at an unknown point giving the values at known locations. Before performing the Kriging, variogram analysis is performed to understand the underlying statistical distribution of the process.

### Ground Water Recharge

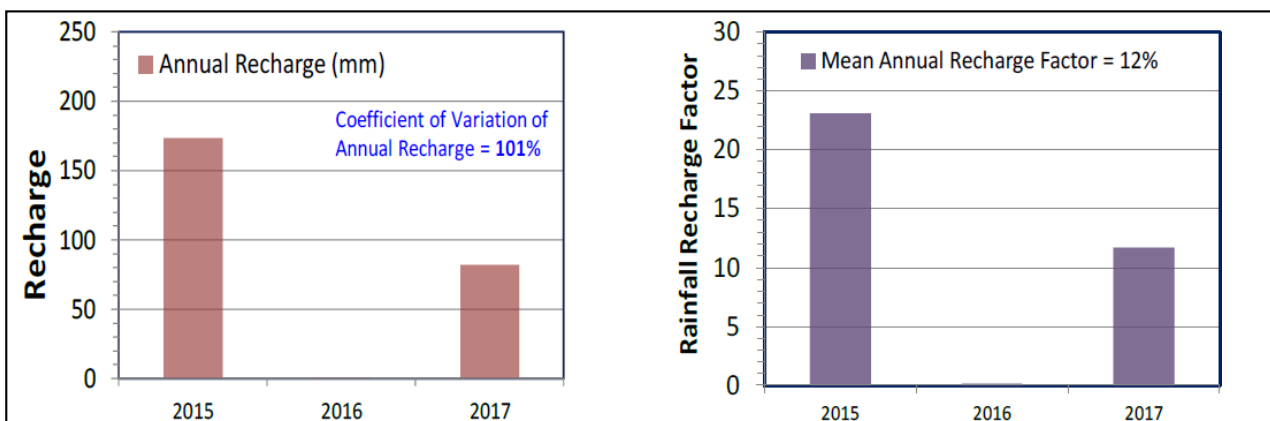
Figure shown below depicts Annual Recharge and Mean Annual Recharge Factor computed for Madahalli Micro-Watershed.

### Well Yield

The yield of the well should be monitored by filling a container of known volume and measuring the time required to fill the container. By taking the data of each monitoring well, a map of groundwater well yield shall be prepared following the IDW or Kriging method of interpolation.

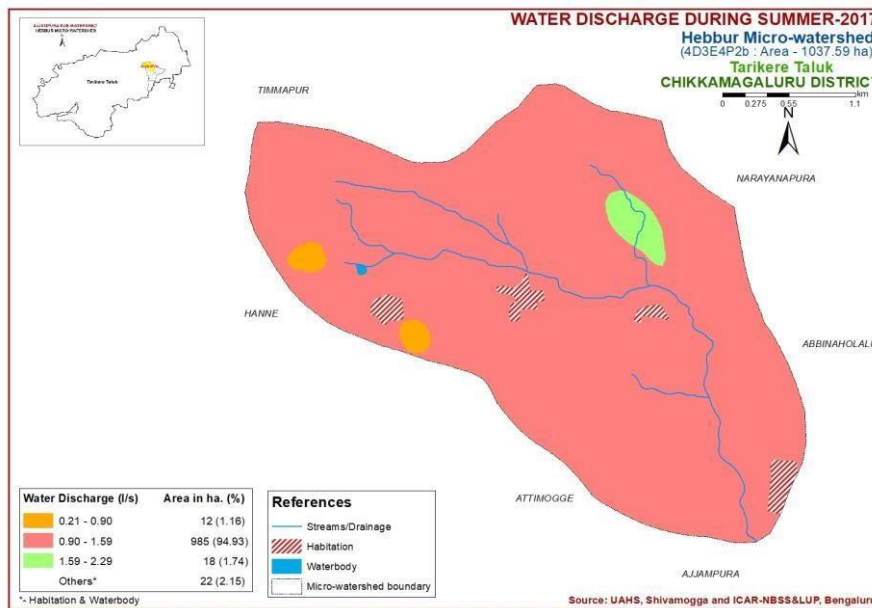


**Spatially interpolated map of DGW values over the Madahalli micro-watershed**

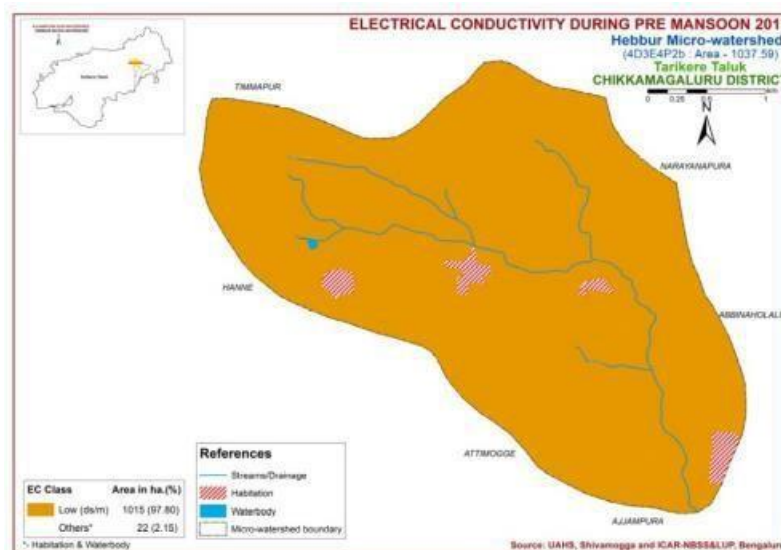


**Sample Plot showing Annual Recharge and Mean Annual Recharge Factor for Madahalli Micro-Watershed**

**Water Quality Maps-**The prepare the map of groundwater quality parameters following the IDW or Kriging method of interpolation. For example, Figure below shows spatially interpolated values of Electrical Conductivity over Hebbur Micro-Watershed.



**Sample Plot showing Spatially Interpolated Well Yield Values for the Hebbur Micro-Watershed**

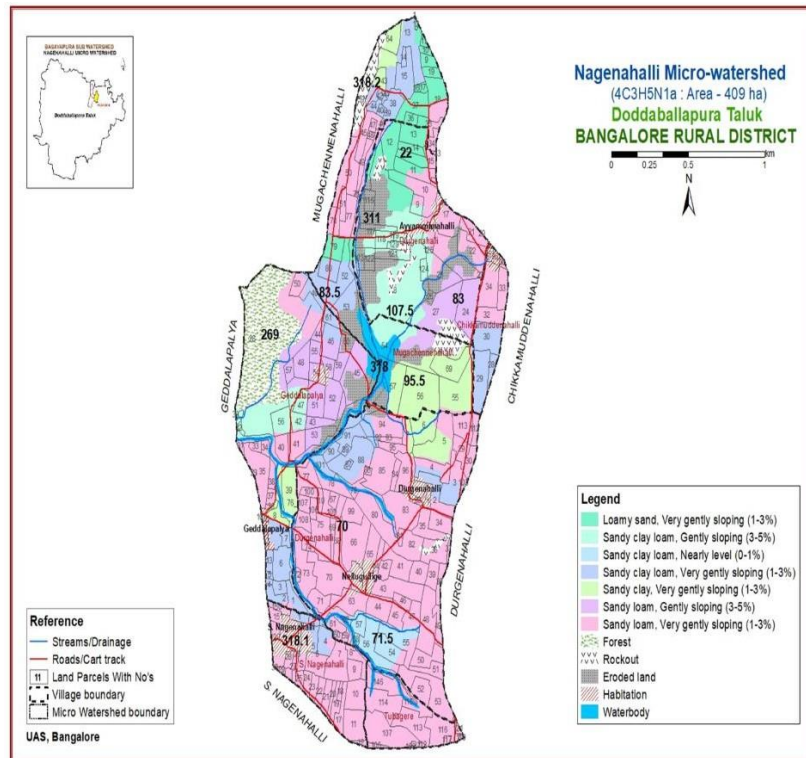


**Sample Plot showing Spatially Interpolated Electrical Conductivity Values for the Hebbur Micro-Watershed**

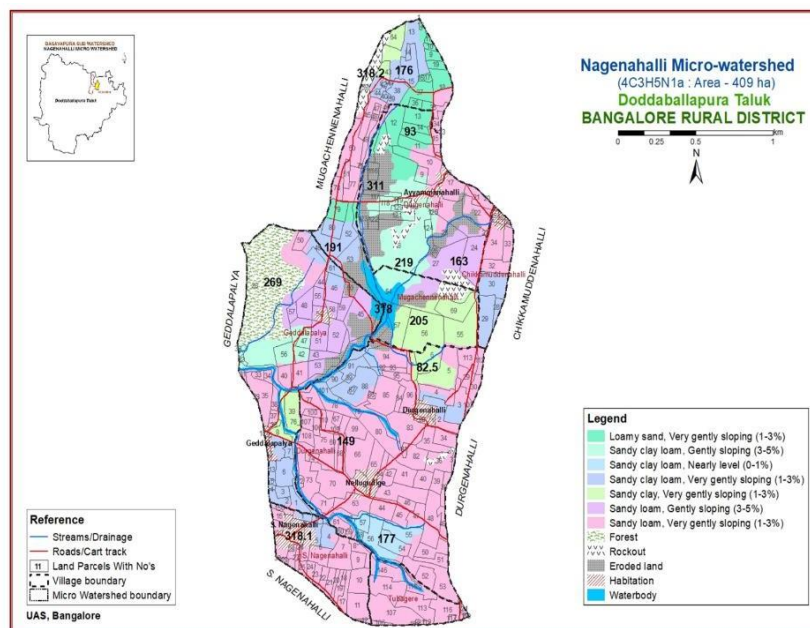
### Runoff Potential

Mapping unit wise runoff availability with effective interventions and with existing conditions for the target watershed is computed using infiltration intensity method. The runoff potential information is thus generated are then converted into spatial maps.

Figure shown below depicts with effective interventions and with existing conditions the simulated runoff for Nagenahalli micro-watershed using infiltration intensity method. The average annual rainfall of Nagenahalli micro watershed is 914 mm. This was approximately same for various years since the higher intensity rain events were about the same in each year.



**Mapping unit wise runoff availability with effective interventions against 914 mm (Average) rainfall during 2019**



**Mapping unit wise runoff availability with existing conditions against 914 mm (Average) rainfall during 2019**

## Water Budgeting

The concept of Water Budgeting aims to use water judiciously for people, agriculture and livestock with a view to optimizing benefits in the context of climate variability, erratic rainfall and drought. Water budget studies consider the volumes of water within the various reservoirs of the hydrologic cycle and the flow paths from recharge to discharge. Water budgets need to consider this information on a variety of spatial and temporal scales.

In simple terms a water budget for a given area can be looked at as water inputs, outputs and changes in storage. The inputs into the area of investigation (precipitation, groundwater or surface water inflows, anthropogenic inputs such as waste effluent) must be equal to the outputs (evapotranspiration, water supply removals or abstractions, surface or groundwater outflows) as well as any changes in storage within the area of interest. So, given a watershed under consideration, a water budget equation may be developed over various time periods, Monthly, Seasonal, Annual etc., depending upon the context.

For example, using the available concurrent data on Precipitation (P), Runoff (Q), Actual Evapotranspiration (AET) and Ground Water Recharge (R) for the period April-October over the years 2015-2018 following water budget equation has been developed for the Madahalli Watershed,

$$P=Q+AET+R+S$$

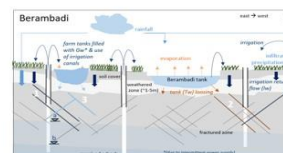
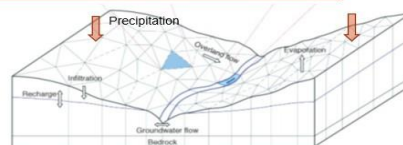
where all the variables are expressed in mm unit. Inserting following known values,  $P=501$ ,  $Q=44$ ,  $AET=540$ ,  $R=85$  into this equation, we get,  $S=-168$  mm. This implies that over the considered time period, precipitation was lower than evapotranspiration. This negative balance when combined with runoff and recharge results in a net negative soil water store for the Rabi season.

## Water Budget for the watershed

$$P = Q + E + R$$

$$P = Q + E + R + \Delta\theta$$

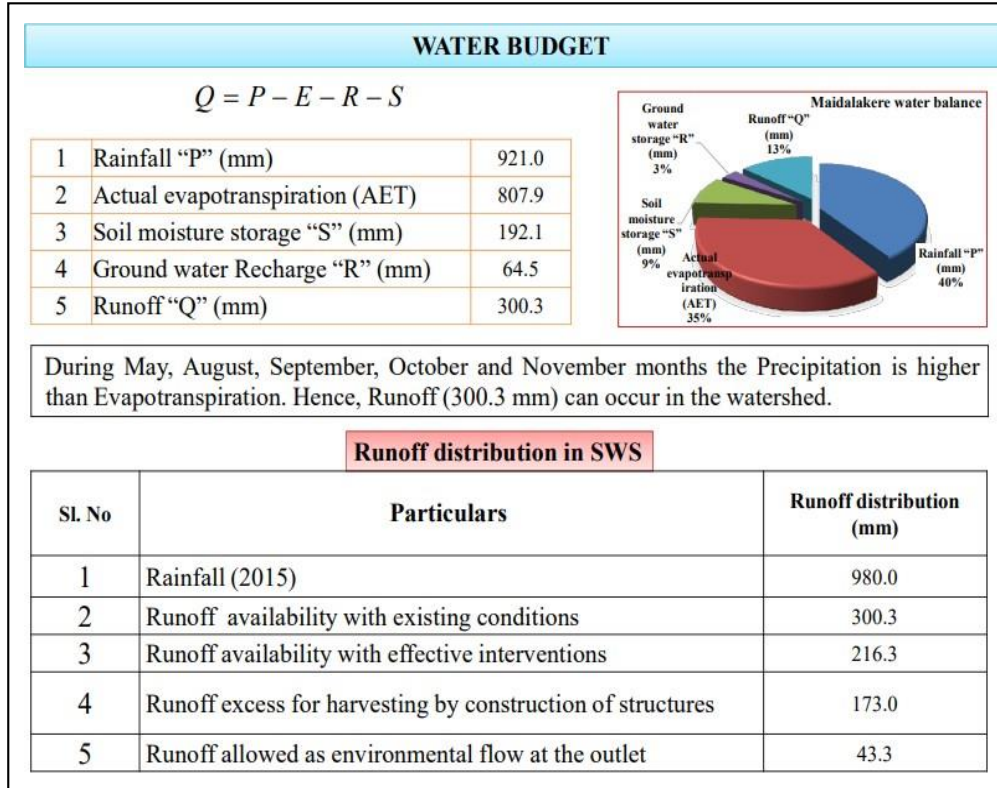
- P = Precipitation
- Q = Runoff
- E = Evapotranspiration
- R = Groundwater recharge
- $\Delta\theta$  = Change in soil moisture



Brauns et al. 2022

➡ **Models (customized) are required for estimating the hydrological components in micro-watersheds.**

➡ **Sensors/ monitoring installed in pilot micro-watersheds will help calibrate/ validate the models.**



**Water budget of Maidalakere sub-watershed**

For more details, refer the soft copy of the Hydrology manual and sample atlas loaded in the pen drive supplied as part of training kit.

#### **4. Digital library and LRI portal for accessing information**

The success and impact of all land-based programmes and interventions, whether it is soil and water conservation, productivity improvement of annual, perennial, or horticultural crops, improvement of soil health, drought proofing, climate mitigation or empowerment of farmers and youth in Agriculture depends on the availability of site-specific land resource information (on soil, surface and ground water, crops, weather, socio-economic data etc.) and advisories on real time basis. The lack of such site-specific information and advisories is found to be the major cause for the failure of many flagship programmes launched with huge plan outlays in the country. In this regard, the generation of farm level land resource information and development of Land Resource Inventory Portal, Decision Support System (DSS) and Mobile Applications, as part of the World Bank supported Sujala III project in Karnataka is a game changer by providing site-specific, farmer centric land resources information and advisories to farmers, planners, research institutions and other stake holders on real time basis.

This has brought in a paradigm shift in planning and implementation of soil and water conservation programs, crop selection, nutrient management, water budgeting etc., and convergence of all land-based programs at the field level by Watershed and other line departments. This was accomplished through

- Land Resource Inventory (LRI) to generate farm level site-specific soil, water (soil moisture, ground water), weather, crops, vegetation, land use, socio-economic database, and Thematic outputs by using state of art RS, GIS & Mapping techniques by a consortium of scientific and technical partners
- Integration of multiple spatial and non-spatial data sets generated through LRI in disparate locations into a seamless state-wide data set on a unified platform as Digital Library
- Facilitating easy access (over web and mobile applications) of the seamless data available to all the line departments, farmers and youth and other stakeholders for immediate use including planning, designing, monitoring, etc. through the establishment of LRI Portal
- Facilitating access of the data over mobile platforms to all the stakeholders for immediate use (from planners to the farmers and youths)
- Extending decision support to multiple stakeholders by modelling and analysing the data from digital library for conservation planning, crop selection, nutrient and pest management and other uses through the development of appropriate DSS
- Dissemination of LRI information and advisories to reach every farmer and youth in about 1.4 million hectares of rainfed area in the state through LRI cards, thematic maps, videos, mobiles, and other ICT outreach programmes.

To generate site-specific soil, site, land use, ground water, cropping pattern, socio economic conditions, and other resources at farm level, georeferenced cadastral map overlaid on high resolution imagery was used as a base followed by traversing, profiling and studying soil-site characteristics, grouping similar fields or areas into one mapping unit and showing their distribution on the cadastral map. This map out put forms the basis for making all land use decisions at the farm level. Then by pooling and integrating all the spatial and non-spatial land resources information available in the state and the cadastral level information generated from 14 lakh ha, LRI Portal was established. Apart from the above, all the cadastral maps of the

state, high resolution remote sensing imagery at different scales and resolutions, state-wide maps and datasets related to geology, geomorphology, landforms, land use, climate, socio-economic conditions, demographic details, marketing, and other details relevant for the management of the land resources of the state are migrated and integrated with the database already housed in the portal. It is a one stop portal that provides not only the data requirements of the line departments, but importantly, the critical advisories and inputs needed to the farmers and other stakeholders at the grassroots level in selecting the best suited crop, conservation practices, nutrient and crop water requirement, water budgeting etc., on a real time basis.

### **LRI portal**

This portal includes the Land Resource Inventory for Watershed Planning and Decision Support Systems for Soil & Water conservation plan, Crop Selection, Land Capability Classification, Nutrient Management, Surface Runoff, Designing of Size & selection of Farm Ponds and Check Dams, Crop Water Requirement, Water Balance and Water Budgeting.

### **LRI Digital Library**

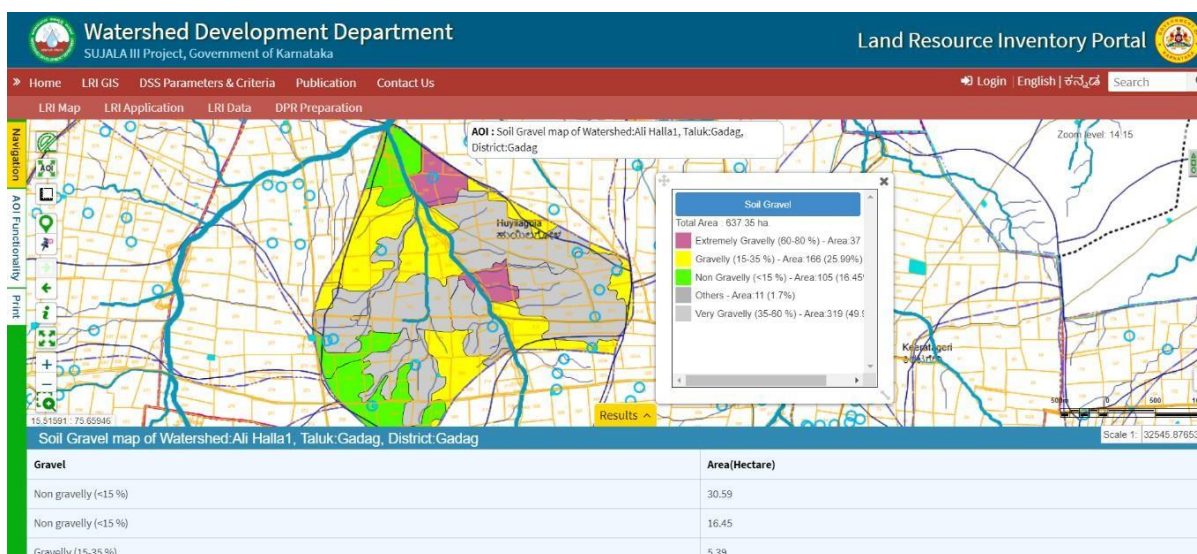
LRI Digital Library is centralized database comprising various thematic maps pertaining to natural resource and project component required for Decision Support System. This is hosted at Karnataka State Data Center which is being equipped with modern IT infrastructure enabling data sharing and collaboration. The data base also includes Land Resource Inventory data at micro watershed level (about 500 ha.) which have been prepared in collaboration with its partners (University of Agricultural Sciences, Bangalore, Raichur, Dharwad, Shivamogga and National Bureau of Soil Survey and Land-use Planning, Karnataka State Remote Sensing Application Centre, Karnataka State Natural Disaster Management Centre, Bangalore and Indian Institute of Science). More than 2000 micro watersheds have been already covered and atlases are ready which is providing parcel wise data like physical properties of soil, nutrient content in the soil, Land-use & Land-cover and also crop suitability for the different soil management units which is embedded in the portal.

The user can view weather, market prices on real time basis and, select the area of his interest and get the required data/map/information from the Portal. Apart from this, there is a log in facility for the farmers and other users, through which the farmer can register himself and access a host of benefits including advisories on crop selection, fertiliser requirement, pest and disease and their remedial measures, selection of farm ponds, crop water requirement, irrigation scheduling, market prices, weather advisory etc. Further, the user can select any area of his interest, view and generate base maps, thematic maps, query, upload, download, print, report generation, DPR preparation and others. The Portal also houses various non-spatial datasets like weather and climatic data, demography, land use, sources of irrigation etc. from census, farmer particulars from Bhoomi, package of practices for major crops, location of market yards, storage facilities, FPOs and other information.



Home page of the LRI Portal

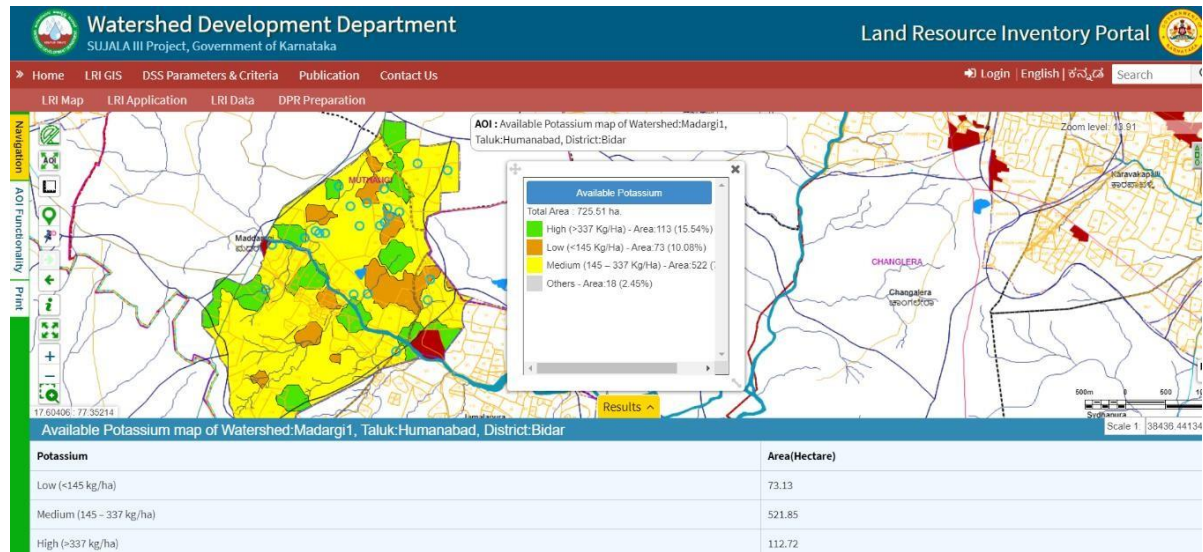
**Generation of thematic maps:** From the LRI database migrated and stored in the Portal, thematic maps on the constraints, potentials, status of soil nutrients, suitability for various crops and other land uses, hydrological parameters, and various other themes can be generated with the help of the interactive menu provided. The user can select the area and the theme of his interest from the menu to generate the required map which he can either view, save or print or even generate a report of the area. For example, the thematic map on gravel shows the amount, nature, and distribution of the gravel present in the soils of Ali Halla 1 micro watershed.



Soil gravel content in Ali Halla 1 micro watershed, Gadag Taluk

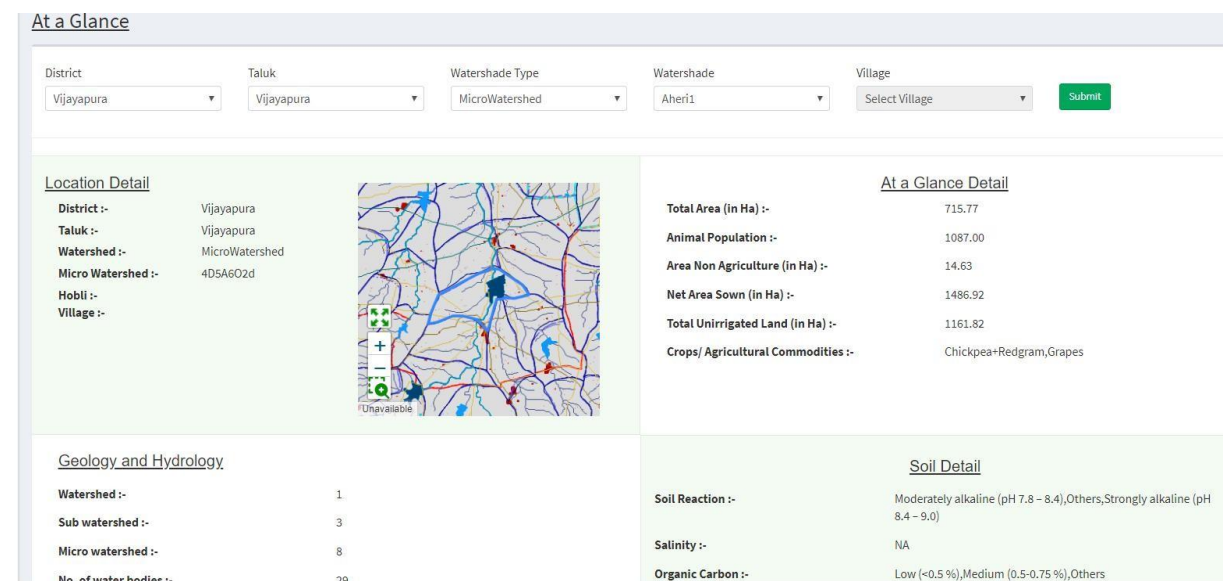
Similarly, the user can generate maps on erosion, slope, soil texture, soil depth, soil moisture, macro and micronutrients, suitability for various crops etc. from the Portal. The map on the status of the available potassium in the soils of Mandargi 1 watershed, shows that it is high in about 15 per cent of the area, medium in about 60 per cent of the area and low in only 10 per

cent of the area. Similar maps on the status of organic carbon, macro and micronutrients present in the soil can be generated for any area covered by LRI in the state.



**Distribution of available Potassium in Mandargi 1 watershed, Humanabad Taluk**

Apart from the above, the User Dashboards-provide users with the view of all the activities performed/to be performed by the user in the system. For example, the Watershed Commissioner can see the list of all the micro-watersheds with summary of work progress/DPR implementation etc., on the Dashboard. The Dashboard for Farmers will show the details of the farm, crop/crops under cultivation, weather forecast, suitability for various crops, nutrient status, and fertiliser requirement for the crop/crops, nearest APMC yards and prices of the commodities sold, and programs and other services available for his area.



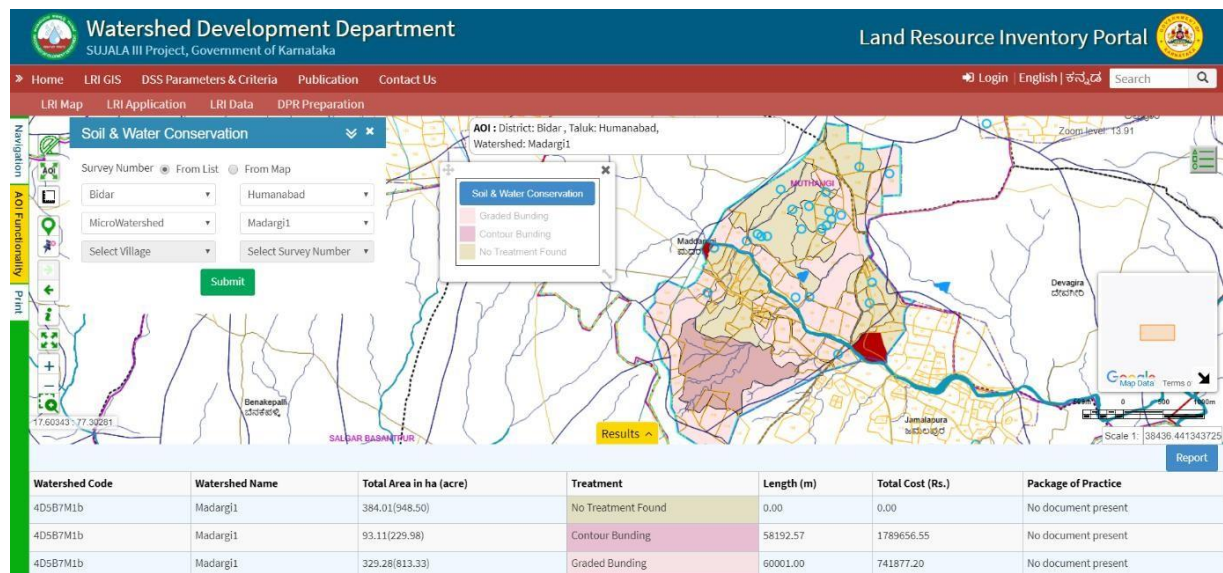
**Dashboard for Department Users**

### Role of Decision Support System (DSS) in Program convergence

The DSS is developed by integrating LRI data and data compiled from other sources with criteria, models and algorithms developed under this project. The DSS development is critical for the successful implementation of various schemes by line departments and for empowering farmers and other stakeholders in the state. As a part of Sujala III Project, nine Decision Support Systems are developed to facilitate the departments to take up key interventions and to provide advisories to the farmers and other stakeholders as indicated below.

- DSS for Soil & Water conservation plan-to identify the type of structures, their design and estimate, for both arable and non-arable lands/areas
- DSS for Crop selection (Based on physical suitability and cost benefit ratio)
- DSS for delineating prime farmlands/arable and non-arable lands based
- DSS on crop based Nutrient Management and Soil Health
- DSS for estimating Surface runoff at farm/MWS/SWS levels
- DSS for designing Size and location of Farm ponds and Check dams
- DSS for estimating the Crop water requirement
- DSS for estimating Soil Water balance at MWS or higher levels
- DSS for Water budgeting

The DSS on **Soil & water conservation** helps to identify appropriate conservation structures for the arable and non-arable lands based on site-specific parcel level information available in the Digital Library. The user can select the area of his interest from the drop-down menu and run the DSS in the Portal to get the conservation map of the area along with the output showing the type of structures, cost of the main and side bunds with waste weir and conservation practices to be followed as indicated below for the Mandargi 1 watershed. The DSS can also be run for the selected survey number or parcel of land to get the type of structures to be constructed along with the cost and other details.



**Conservation map of Mandargi 1 watershed**

Similarly, the DSS on **Crop suitability** compares the bio physical characteristics of the land like the soil-site characteristics, climate etc., with the requirements of the crop and generates

the suitability map. The suitability map will show the degree of suitability like highly, moderately, or marginally suitable or not suitable for the crop with their limitations and extent. The DSS model can also be run at the field or at any higher levels as per the needs of the users. This model is available for about 73 different crops that are under cultivation in the state at present.

The DSS on **Nutrient management** enables the farmer to choose the type, quantity and time of application of fertilisers to the selected crop based on the nutrient status of the soil. This model can be run at any levels from the farm, watershed or higher levels based on the availability of information. This helps to supply the required nutrients in a targeted manner and avoids misapplication of fertilisers, thereby reducing the cost of cultivation to the farmer. Similarly, the DSS on **runoff, number of check dams, water balance and water Budgeting** is also available in the portal for the users to select and generate the outputs needed for any areas of interest.

The functionalities of the Mobile application are almost like that of the LRI Portal. It allows for registration and update of information, and provides information on weather and climate, soils, nutrient status, crops and package of practices, agro-climatic features, seeds, soil health, fertilisers, pest and diseases in crops and their remedial measures, commodity prices, various departmental schemes, suitability of crops, nutrient management, departmental applications, expert advisory etc.

### **Effectiveness of LRI Portal, DSS and Mobile apps on Convergence of programs**

This Disruptive Technology Platform, established for science based site-specific interventions, has changed the way planning and implementation of many land-based programmes are carried out in the state.

- For example, due to the availability of site-specific LRI database on real time basis through the Portal, the interventions have become more focussed, and farmer and youth oriented rather than remaining as a blanket or general type as was the case in earlier programmes,
- The watershed cycle is reduced to 3 to 4 years which used to take about 6 to 7 years earlier,
- Real time convergence of various programmes and budgetary allocations to line departments as per the requirement have become more realistic,
- More than anything, the time, capital and manpower use efficiency has increased significantly due to the application of this approach.

Apart from the above, many flagship programmes with huge allocation of funds can benefit immensely with the use of LRI information and Decision Support Systems available from the Portal in planning and implementation of their schemes which can save the scarce capital, improve the delivery and most importantly the efficiency of the interventions on a sustained manner than any time in the past.

**Steps for accessing the LRI portal**

To access the portal, go to

<https://www.sujala3lri.karnataka.gov.in/>

Select language,

English

**To know the parameters and criteria considered,**

Go to

“DSS Parameters and Criteria”

Select the required module out of 9 DSS to know its module description and flowchart employed

**To get the publication made by WDD,**

Go to “Publications”

Go to “Hydrology atlas”

Select required District, Taluk, Hobli and Village

Or

Uncheck Hobli to get the atlas by SWS/MWS wise and select the Watershed

Go to “LRI atlas”

Select required District, Taluk, Hobli and Village

To get the DPR published, go to

“Detail Project Report”

**Similarly, one can also get the Technical manuals, User guides, Videos, Newsletters, Success stories and Glossary by selecting respective sections**

**For LRI card generation,**

Go to “LRI card” (Left bottom end) in the home page

Select required district, taluk, hobli, village and survey number

**For DPR generation,**

Go to “LRI GIS”

Select “DPR preparation”

Select required district, taluk, watershed type and watershed

Select required themes to be included in the DPR and click Submit

**To know the LRI of the specific survey number/SWS/MWS in brief**

Go to “LRI GIS”

Select “LRI at a Glance”

Select required district, taluk, watershed type and watershed

Uncheck Watershed type to get the information by village and survey number wise

**To access the nine DSS developed**

Go to “LRI GIS”

Select “LRI Map”

**To know the DSS by area of interest**

Go to “Select”

Select “AOI”

Select required district, taluk, watershed type and watershed

Uncheck watershed type to get the information by village and survey number wise

Click “Submit”

Select “Area of Functionality” from Navigation pane

One can select any DSS out of nine for the selected area of interest

For printing the same, Click “Print” from navigation pane

Or

User can also draw the desired area on the map by clicking

“User AOI”

To get the maps of a MWS

Go to Map

Select required layers to be compiled in the map from “Layers”

Then select “Theme”

Select “AOI”

Select required district, taluk, watershed and theme

Click “Display/Print”

Or

User can also draw the desired area on the map by clicking

“User AOI”

**To know the Individual DSS**

Go to “LRI GIS”

Select “LRI Map”

Select “Decision Support System”

**For Soil & Water Conservation**

Click “Soil & Water Conservation”

User can select from the map by using point and polygon feature

Or

Select “From list”

Select required district, taluk, watershed type and watershed

Uncheck watershed type to get the information by village and survey number wise

Submit

Displays the result in a table showing the information such as watershed name, survey number, area in hectare as well as information related to treatment proposed, its length, cost for the main bund, cost for side bund, total cost and also cost of waste weir.

### **For Crop Selection**

Click “Crop Selection”

User can select form the map by using point and polygon feature

Or

Select “From list”

Select required district, taluk, watershed type and watershed

Uncheck watershed type to get the information by village and survey number wise

Select Season, Crop type, Suitability type to be derived, Crop

Submit

Result displays the type of crop for the particular survey number/MWS, with season, suitability class, benefit ratio and the rank. system will also highlight the land parcel related to the selected survey number in GIS map

### **For Land Capability Classification**

Click “Land Capability Classification”

User can select form the map by using point and polygon feature

Or

Select “From list”

Select required district, taluk, watershed type and watershed

Uncheck watershed type to get the information by village and survey number wise

Submit

Displays result in a table showing the information such as survey number, farmer name, area in hectare, land capability classification, limitation, arable/non arable.

### **For Nutrient Management**

Click “Nutrient Management”

User can select form the map by using point and polygon feature

Or

Select “From list”

Select required district, taluk, village and survey number, season, crop and irrigation practice

Submit

Displays the result in a table showing the information such as survey number, farmer name, area in hectare, crop name, fertilizer required, total quantity in kg (a), basal dose kg (b), top dressing kg (c=a-b), total cost for fertilizer, action.

### **For Surface Runoff**

Click “Surface Runoff”

User can select form the map by using point and polygon feature

Or

Select “From list”

Select required district, taluk, watershed type and watershed

Uncheck watershed type to get the information by village and survey number wise

Select method of Runoff calculation

For SCS curve number method, select required date  
Submit

For Infiltration method, select required date, bund length manually or  
automated and per cent of vegetative cover  
Submit

For Rational method, provide maximum length of flow, difference in elevation and  
intervention structures employed  
Submit

**For Size & Selection of Farm Ponds**

Click “Size & Selection of Farm Ponds”

User can select form the map by using point and polygon feature  
Or

Select “From list”

Select required district, taluk, village and survey number, per cent vegetative cover,  
bund length manually or automated  
Submit

**For Size & Selection of Check Dams**

Click “Size & Selection of Check Dams”

Provide required district, taluk, MWS, storage capacity of check dams,  
per cent vegetative cover, bund length manually or automated  
Submit

**For Crop Water Requirement**

Click “Crop Water Requirement”

User can select form the map by using point and polygon feature  
Or

Select “From list”

Select required district, taluk, village and survey number, crop, total cropped area and date of  
sowing  
Submit

**For Soil Moisture Balance**

Click “Soil Moisture Balance”

User can select form the map by using point and polygon feature  
Or

Select “From list”

Select required district, taluk, village and survey number, crop, date of sowing,  
last date of irrigation with quantity (mm) and total cropped area  
Submit

**For Water Budgeting**

Click “Water Budgeting”

User can select form the map by using point and polygon feature Or

Select “From list”

Select required district, taluk, watershed, year

Provide information on water available in surface water bodies (m<sup>3</sup>/year) and  
ground water recharge (m<sup>3</sup>/year)

Select if there is any home cottage industry and provide water requirement for irrigation  
(m<sup>3</sup>/year)

Select per cent vegetative cover and bund length manually or automated

Submit

**To know the LRI Census Data**

Go to “LRI GIS”

Select “LRI Map”

Select “Data”

Select “Census Data”

Select required District, Taluk, Watershed type and Watershed

Uncheck Watershed type to get the information by village wise

Select “Aggregate”

Submit

**To get the report on individual nutrient for a MWS**

Go to “LRI GIS”

Select “LRI Map” Select

“Custom report”

Select fertility parameter required

Select required District, Taluk, Watershed and fertility rating

Click “Execute”

## **5. An overview of DSS modules used in REWARD program**

A Key component of Sujala-3 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 objectives of developing DSS

- To facilitate the project management in planning, execution and monitoring of various watershed development and other programs in the state
- To integrate Land Resource Inventory, Hydrology, and other database with GIS, MIS and other systems for easy retrieval of information and visualization.
- To support dynamic use of MIS and GIS, monitoring and evaluation, seamless integration of online and offline activities, and dynamic updating of the information.
- To facilitate the convergence of various programs implemented by Watershed, Agriculture, Horticulture, Forestry, Animal Husbandry, Rural Development and other line departments at the watershed/village level in the state.
- To develop criteria, algorithms and models, knowledge base and expert systems needed to help the decision makers to access relevant information from a combination of raw data, documents, and personal knowledge, or models to identify and solve problems and make appropriate decisions as and when needed.

The Decision Support System is developed primarily to serve the needs of planning, implementation and monitoring of watershed development programs in the state by 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 (Annexure 1) 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 Sujala-3 Project, nine 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.

### DSS modules developed as part of Sujala-3 project

| Sl. No.   | Decision Support System   |
|---|---|
| <b>Group 1</b> (Soil & Water conservation plan, Crop selection, Land Capability Classification and Nutrient management)                         |   |
| 1   | DSS for <b>Soil &amp; water conservation plan</b> -to identify the type of structures, their design and estimate, for both arable and non-arable lands/areas                      |
| 2   | DSS for <b>Crop selection</b> (Based on physical suitability and cost benefit ratio)  |
| 3   | DSS for delineating prime farmlands/arable and non-arable lands based on <b>Land Capability Classification</b>  |
| 4   | DSS on crop based <b>Nutrient management and soil health</b>  |
| <b>Group 2</b> (Surface Runoff, Size and location of Farm Ponds and Check Dams, Crop water requirement, Soil Water balance and Water budgeting) |   |
| 5   | DSS for estimating <b>Surface runoff</b> at farm/MWS/SWS levels   |
| 6   | DSS for designing the <b>Size and location of Farm ponds and Check dams</b> based on runoff model   |
| 7   | DSS for estimating the <b>Crop water requirement</b> at MWS/SWS levels based on the existing land use or crops that are planned to be taken up for cultivation                    |
| 8   | DSS for estimating <b>Soil water balance</b> at MWS or higher levels, considering the RF, crop requirement, Runoff, evaporation and other losses, soil moisture and ground water. |
| 9   | DSS for <b>Water budgeting</b> taking into consideration the needs of various uses/users at MWS/ Village level- crop needs, human needs, livestock needs etc.                     |

The DSS on **Soil & water conservation** helps to identify appropriate conservation structures for the arable and non-arable lands based on site-specific parcel level information generated through Land Resource Inventorisation and available to the users in the form of LRI and Hydrology Reports and Atlases. The user can select the area of his interest from the drop-down menu and run the DSS in the Portal to get the conservation map of the area along with the output showing the type of structures, cost of the main and side bunds with waste weir and conservation practices to be followed. The DSS can also be run for the selected survey number or parcel of land to get the type of structures to be constructed along with the cost and other details.

Similarly, the DSS on **Crop suitability** compares the bio physical characteristics of the land like the soil-site characteristics, climate *etc.*, with the requirements of the crop and generates the suitability map. The suitability map will show the degree of suitability like highly, moderately, or marginally suitable or not suitable for the crop with their limitations and extent. The DSS model can also be run at the field or at any higher levels as per the needs of the users. This model is available for about 73 different crops that are under cultivation in the state at present. The DSS on crop suitability assessment helps the planner to prepare a matrix of suitable and not suitable crops for a given area and the farmer to choose the best suited crop for the farm.

The DSS on **Nutrient management** enables the farmer to choose the type, quantity and time of application of fertilisers to the selected crop under cultivation based on the nutrient status of the

soil and the planner to identify the extent of deficient/sufficient areas for taking up appropriate interventions. This model can be run at any levels from the farm, watershed or higher levels based on the availability of information. This helps to supply the required nutrients in a targeted manner and avoids misapplication of fertilisers, thereby reducing the cost of cultivation to the farmer.

The DSS on Land Capability, Runoff, Farm Ponds and Check Dams, Crop water requirement, Soil moisture and water balance and Water budgeting facilitate the departments to take up key interventions and to provide advisories to the farmers and other stakeholders at different levels.

The development of the nine Decision Support Systems was based on the criteria, type of models, algorithms and state of knowledge available at present in the respective domains. The output from the model/DSS may or may not reflect the existing field situations due to various reasons. Hence the outputs generated by using the DSS needs to be verified/validated in the field and recalibrated/modified wherever necessary with inputs/feedbacks received from the stakeholders before they are finally deployed in the Portal.

**For more details, refer the hard copy of the DSS book/ soft copy loaded in the pen drive supplied as part of training kit.**

## Soil and water conservation treatments

Following are some of the treatments suggested for soil and water conservation. Understanding of these activities will be helpful to choose appropriate measures for a given condition in addition to decision criteria indicated for each measures.

- A. **Contour Bunding:** The contour represents the envelope of the normal drawn at any given level to the lines of the greatest slope of a given watershed. Since runoff from any given surface is along the lines of the greatest slope and the velocity of runoff increases inter alia with the vertical distance through which it is moved. Contour bunding is the best means for arresting runoff from the watershed (Liu *et al.*, 2014). These are applicable in areas receiving an annual rainfall of less than 750 mm and successfully practiced in all soils having infiltration rate of more than 8 mm per hour and slope less than 6 %.
- B. **Graded Bunding:** In situations where rainfall is not readily absorbed due to high rainfall or low intake of the soil, graded bunding recommended (Shinde *et al.*, 2019). Graded bunds are trapezoidal earthen embankments constructed on a grade across the major slope to lead excess runoff through a wide and relatively shallow channel formed on 0.2 to 0.4 % grade on the upstream side of the bund. These are suitable for areas receiving annual rainfall more than 750 mm, where runoff is high, surplussing are essential and having infiltration rate less than 8 mm per hour Slope is 5 to 10 %.
- C. **Contour border strips (CBS):** These are levelled strips of land constructed across the major slope at a vertical interval of 0.3 m with suitable drop structure in the waterways at the end of each strip (Singh *et al.*, 2007). Each strip separated from the next bund of 0.24 m<sup>2</sup> cross section. CBS are most suitable in moderately to deep soils with infiltration rate of more than 8 mm per hour and where the rainfall is not more than 750 mm annually.
- D. **Broad Base Terrace:** Recommended in deep black soils with high clay content develop deep cracks in summer and bunds in these soils breach extensively during rainy season, especially when the rains are of high intensity (Singh and Meena, 2020). A terrace is a combination of ridge and channel built across the slope on a controlled grade.
- E. **Zing terracing:** Adopted in lands with 3 to 10 percent slopes and bench terracing is recommended on steeper slopes (Zingg and Hauser, 1959). Zing terraces are constructed in medium to deep soils in moderate to high rainfall areas. The length of the field is divided into donor area and receiving area in the ratio 2:1 to 5:1, but usually 2:1. The donor area is not levelled whereas the lower receiving area is levelled and provided with bund of cross-section area 0.3 to 1.5 m<sup>2</sup>.
- F. **Bench terracing:** On steeply sloping and undulated land, intensive farming is possible only with bench terracing (Meena and Meena, 2017). It is usually practicing on slopes ranging from 16 to 33 percent. Bench terracing consists of principally transforming relatively steep land into a series of level strips or platforms across the slope of the land. The field is made into a

series of benches by excavating the soil from upper part of the terrace and filling in the lower part. A good soil depth is required to avoid exposure of unproductive soil during levelling. The vertical drop may vary from 60 to 180 cm, depending on the slope and soil conditions and width required for easy cultural operations.

**Types of terraces for different soil and rainfall conditions:**

| Type                | Suitability   |
|---------------------|---|
| Level and table-top | Area receiving medium rainfall (750mm) of even distribution with highly permeable deep soils. |
| Sloping outwards    | Low rainfall (<750) area with permeable soil of medium depth.                                 |
| Sloping inwards     | Heavy rainfall areas (>750mm) with soil of poor infiltration rate.                            |

- G. **Vegetative Barriers:** Closely spaced plantations, few rows of grasses or shrubs grown along the contour lines for erosion control in agricultural lands.
- H. **Grassed waterways:** Waterways dug to a shallow depth of 0.15 to 0.5 m with flat side slopes of 4:1. Based on the gradient decided by the existing slope of the land. Suitable perennial grass (not edible by the cattle, deep rooted and of spreading type) established subsequently for the stability of the waterway (*Panicum repens*, *Brachiaria mutica*, *Cynodon plectostahyus*, *Cynodon dactylon* and *Paspalum notatum*, etc.) (Meena et al., 2018).

While planning the activities for individual farmers in the micro watershed all the activities like conservation measures in the land owned by them, crop plan, nutrient plan, animal husbandry, livelihood activities etc., are to be prepared. To prepare the activities as a first step survey number wise details of farmers to be collected. The farmer details should include identifying information like name, father’s name, gender, land holding and caste category, village etc. Referring to LRI and hydrology atlases, the activities proposed to be taken are soil conservation and their technical specifications need to be mentioned along with the unit cost and total cost. Likewise, it should be detailed for all the farmers in the micro watershed.

## Drainage line treatments

The basic approach of drainage line treatment involves controlling the formation of gullies due to peak flow rates and provision of stable channel for flow that has to be handled. The first one, reducing the proneness to gully formation is accomplished by diverting the runoff, retention of runoff on the watershed by adoption of techniques like contour cultivation, strip cropping, vegetative strip cropping, cover crops, mulching *etc.* Second one, i.e. provision of stable channel for the flow is accomplished by stabilizing the gully slides and bed by establishing vegetation and reducing the gradient of the channel to maintain velocities below erosive level by temporary and permanent structures such as check dams, drop-spillways and chutes, *etc.* Common drainage line treatments are classified into vegetative and mechanical methods based on the technique on which treatments are made.

### Vegetative measures:

Strips of suitable vegetation planted across the drainage line or nala to check the velocity of water flow and to arrest silt.

1. **Sod strips:** These are taken up in gullies up to 1 m depth and with three ha catchments and 4 % bed slope. Three staggered rows of agave or other crop planted with 1 m width, 0.5 m height, refilling 0.35 m and 1 m interval between the rows.
2. **Sodded earthen strips:** These are taken up in gullies of 1 to 1.5 m depth and with 3 to 10 ha catchments and bed slope less than 4 %. The crest height 0.6 – 1.5 m, slope upstream side 2:1, downstream side 3:1, a bund with concave crest 0.3 m higher than at the middle is constructed across the gully and stabilized by sodding and planting suitable vegetation.
3. **Shrub checks:** These are taken up in gullies with more than 10 ha catchment. Shrub checks planted in a staggered way in three rows across the gully at intervals of 1 m to form a strip.
4. **Brush wood checks:** are porous checks constructed across the gully with wooden pegs and brush wood and are adoptable in all areas.

### Mechanical measures:

1. **Loose boulder checks:** These are porous checks across the nala constructed using loose boulders to check water velocity and to arrest silt.
2. **Gabions:** Dams made of wire-woven baskets filled with stones placed in trench of suitable size across steep-sloped gullies to trap erosion debris during rains. They are adoptable in all areas of high slopes and high rainfall.
3. **Drop spill way:** Masonry structures constructed across the gully with a spill way to serve as gully control and water harvesting structure, where in water flow is not blocked.

- 4. Chute spill way:** Chute spill way or flumes are concrete or masonry structures constructed across the flow in channels or nalas to transmit the flow in a safe manner over the elevation differences in the flow course.
- 5. Ravine reclamation structure:** This is a masonry structure consisting of a body wall, apron and header. The banks are protected by stone revetment to further scouring. They are constructed to control head movement of gullies, avoid further widening and deepening of ravine, reduce sedimentation of tanks/reservoirs, provide protective irrigation, drinking water for the cattle and wild life, increase moisture regime and recharge underground water table. They are constructed in ravines with depth of 2.5 to 3.5 m., width 8 to 15 m., and catchment area 15 to 25 ha.
- 6. Sunken ponds/ Farm ponds:** These are small storage structures made across waterways and/or gullies to collect inevitable runoff for subsequent use as supplemental irrigation, to recharge ground water and for improving availability of water for agricultural and other uses, in cultivate areas where slope is less than 5%. The most economical earthwork and desired water storage are the two guiding factors for locating the structure. The catchment should be large enough to yield sufficient runoff for filling the pond. They are preferably located in areas with impervious substratum.
- 7. Nala bunds:** This structure taken up with the objective of controlling runoff water, reducing sedimentation of tanks/reservoirs, providing protective irrigation, drinking water for the cattle and wild life, increase moisture regime and recharge underground water table. Consists of homogeneous earthen embankment-inner core bund and the outer main bund- constructed across the nalas or valleys which have distinct banks with width of about 5 to 15 m and depth of about 1 to 3 m. and the slope of the nala bund should be 1 to 3 %. A cut outlet also provided at one end of the nala bund where bank strata are hard and non-erosive. The catchment area of a nala bund would be 80 to 500 ha, where rainfall is below 750mm per year and 40 to 250 ha, where rainfall is more than 750 mm per year.
- 8. Check dams:** Check dams constructed across gullies to reduce the velocity of runoff, heal the gully, store water for use by livestock and recharge groundwater in wells lower down. Depending on the size of the gully, the check dam constructed with earth, rocks, boulders, masonry or concrete. A series of check dams constructed from top towards bottom for their efficiency in conservation. The dams should be so spaced so that the crest level of one coincides with the base level of the next dam upstream. Generally, a grade of 0.1 to 0.5% is provided. While preparing the treatment plan for a given micro watershed by using LRI and hydrology outputs and decision criteria for water harvesting structures indicate appropriate treatments.

### Exercise - 1

#### Delineation of arable and prime lands based on land capability assessment

1. Based on the soil phase characteristics, group each soil phase into various land capability classes and sub classes.
2. The parameters to be considered and the ratings to be used in grouping the land parcels into land capability units are given in Page No. 110-112 of DSS book.
3. To understand soil phase characteristics, refer Annexure at last of the DSS book (Page No. 219).

| Parameters | Depth   | Drainage  | e     |         | W        | s          |         |         | LCC |
|------------|---------|-----------|-------|---------|----------|------------|---------|---------|-----|
|            |         |           | Slope | Erosion | Drainage | Soil depth | Texture | Gravels |     |
| BNHhA2g1   | 100-150 | Well      |       |         |          |            |         |         |     |
| BNKaB1g1   | >150    | Imperfect |       |         |          |            |         |         |     |
| CKHcE2g2   | 25-50   | Well      |       |         |          |            |         |         |     |
| KBTmB3g1   | 100-150 | M. well   |       |         |          |            |         |         |     |
| YARhA1     | >150    | Well      |       |         |          |            |         |         |     |

## Exercise - 2

### Soil and water conservation for arable and non-arable lands

| <i>Steps</i> | <i>Description</i>  |
|--------------|---|
| 1            | Select a soil phase from atlas and study their land characteristics   |
| 2            | Select treatment for land characteristics based on decision rules (DSS book Page No. 14-20 for arable land black soils, 21-25 for arable red and lateritic soils) |
| 3            | Select vertical and horizontal interval based on decision rules (DSS book Page No. 29)  |
| 4            | Select cross-section of structure based on the decision rules (DSS book Page No. 30)  |
| 5            | Estimate length of Bunding per hectare (m) = $10000 \times S / (VI \times 100)$   |
| 6            | Estimate cost of conservation structure based on decision rules (DSS book Page No. 31 for Contour Bunding and TCB and Page No. 33 for Graded bunds)               |

**Exercise - 3**

Considering the crop suitability criteria in DSS book, for the given soil phases indicate suitability of Ragi (DSS book Page No. 60), Redgram (64), Arecanut (82) and Mango (84) as S1/S2/S3/N

| <i>Soil Phase</i> | <i>Characters</i> |            |            |              |                 | <i>r</i>     | <i>t</i>       | <i>g</i>       | <i>l</i>     | <i>w</i>        | <i>Class</i> |
|-------------------|-------------------|------------|------------|--------------|-----------------|--------------|----------------|----------------|--------------|-----------------|--------------|
|                   | <i>Depth</i>      | <i>SSG</i> | <i>SST</i> | <i>Slope</i> | <i>Drainage</i> | <i>Depth</i> | <i>Texture</i> | <i>Gravels</i> | <i>Slope</i> | <i>Drainage</i> |              |
| <b>Ragi</b>       |                   |            |            |              |                 |              |                |                |              |                 |              |
| Soil 1            | 50-75             | 0          | sc         | 1-3%         | mod. well       |              |                |                |              |                 |              |
| Soil 2            | <25               | 33         | sl         | 0-1%         | well            |              |                |                |              |                 |              |
| Soil 3            | 75-100            | 0          | ls         | 3-5%         | poor            |              |                |                |              |                 |              |
| <b>Redgram</b>    |                   |            |            |              |                 |              |                |                |              |                 |              |
| Soil 4            | 100-150           | 23         | c(r)       | 1-3%         | well            |              |                |                |              |                 |              |
| Soil 5            | 25-50             | 32         | scl        | 1-3%         | poor            |              |                |                |              |                 |              |
| Soil 6            | 50-75             | 8          | sc         | 0-1%         | mod. well       |              |                |                |              |                 |              |
| <b>Arecanut</b>   |                   |            |            |              |                 |              |                |                |              |                 |              |
| Soil 7            | 100-150           | 40         | c(r)       | 5-10%        | well            |              |                |                |              |                 |              |
| Soil 8            | >150              | 50         | s          | 3-5%         | well            |              |                |                |              |                 |              |
| Soil 9            | 25-50             | 14         | c(b)       | 1-3%         | very poor       |              |                |                |              |                 |              |
| <b>Mango</b>      |                   |            |            |              |                 |              |                |                |              |                 |              |
| Soil 10           | 25-50             | 10         | c(b)       | 1-3%         | well            |              |                |                |              |                 |              |
| Soil 11           | 75-100            | 17         | scl        | 0-1%         | poor            |              |                |                |              |                 |              |
| Soil 12           | >150              | 37         | s          | 3-5%         | well            |              |                |                |              |                 |              |

**Exercise – 4**

**Nutrient Management Plan**

|   |   |
|---|---|
| 1 | Select a micro watershed  |
| 2 | Select two crops suggested for a particular survey number in a soil phase                                     |
| 3 | Study the soil fertility status for major nutrients of the survey number in a soil phase                      |
| 4 | Select nutrient recommendation for the selected crops (DSS book Page No. 119)                                 |
| 5 | Adjust nutrient recommendation considering soil fertility status and RDF of selected crop                     |
| 6 | Select the suitable combination of fertilizers and estimate the quantity of fertilizers required for the crop |
| 7 | Estimate the dose at different stages of plant growth (Basal dose and top dressing)                           |
| 8 | Workout the cost per hectare  |

Status of nutrients for a particular survey number in a soil phase (refer the atlas)

| Soil phase | Survey number | Nutrient status (low/medium/high) |   |   |
|------------|---------------|-----------------------------------|---|---|
|            |               | N                                 | P | K |
|            |               |                                   |   |   |

Select Two crops and Two combinations of fertilizers, workout the per hectare nutrient requirement and the cost

| Item  | Crops |    |
|---|-------|----|
|   | 1.    | 2. |
| Nutrients recommendation (RDF)<br>(as per standard PoP) |       |    |
| Adjusted nutrient as per soil<br>nutrient status        |       |    |
| Type and quantity of fertilizers recommended            |       |    |
| <b>Combination 1</b>                                    |       |    |
| Urea  |       |    |
| SSP   |       |    |
| MOP   |       |    |
| <b>Combination 2</b>                                    |       |    |
| DAP   |       |    |
| 17-17-17  |       |    |
| Urea  |       |    |
| MOP   |       |    |
| Cost of fertilizers (Rs.)                               |       |    |

*Reference material, CoE-WM*

### **Exercise - 5**

#### **Designing the size of Farm Ponds and Check Dams based on Runoff Calculation**

Suggest the size of the farm pond for a given condition with cost estimates – Refer DSS book

Page No.181 for details

Catchment area - 1ha

Runoff - 30 mm

Soil type - Red

### Exercise - 6

#### Estimation of crop water requirement

Steps in estimation of crop water requirement

| # | Description of the steps involved  |
|---|--|
| 1 | Know the PET of the area and extent of crop area   |
| 2 | Estimate crop water requirement using crop coefficient (DSS book Page No.194)                            |
| 3 | Know the duration of the crop  |
| 4 | Multiply PET * area * Kc of the stage * duration   |
| 4 | Estimate stage-wise water requirement at parcel level and aggregate crop water Requirement of all stages |

Calculate the crop water requirement for the following crops in one soil phase

Place: Hodekallu micro watershed in Tumkur Taluk

Daily average PET during South-West monsoon is 4.33

Daily average PET during North-East monsoon is 4.49

Crop coefficient (Kc) values compiled for major crops (FAO, 1998)

| Crop      | Area (ha) | Initial Stage |                 |                         | Mid-Season |                 |                         | End-Season |                 |                         | Total water requirement ha mm |
|-----------|-----------|---------------|-----------------|-------------------------|------------|-----------------|-------------------------|------------|-----------------|-------------------------|-------------------------------|
|           |           | Kc value      | Duration (days) | Water Requirement ha mm | Kc value   | Duration (days) | Water requirement ha mm | Kc value   | Duration (days) | Water requirement ha mm |                               |
| Maize     | 7         |               |                 |                         |            |                 |                         |            |                 |                         |                               |
| Groundnut | 10        |               |                 |                         |            |                 |                         |            |                 |                         |                               |
| Sorghum   | 14        |               |                 |                         |            |                 |                         |            |                 |                         |                               |
| Soyabean  | 3         |               |                 |                         |            |                 |                         |            |                 |                         |                               |
| Sunflower | 9         |               |                 |                         |            |                 |                         |            |                 |                         |                               |
| Cotton    | 12        |               |                 |                         |            |                 |                         |            |                 |                         |                               |

## **6. DPR generation based on LRI and hydrology outputs, community consultation and approval protocols**

A detailed project report (DPR) is the final blueprint of a project after which the implementation and operational process can occur. In REWARD program, more advanced scientific approaches (LRI and hydrological assessments) are followed in assessing the status of natural resources for management of a watershed compared to earlier programs. Further, development of LRI portal with decision support system, automate the preparation of the DPR. Hence, there will be considerable reduction in time required for preparation of DPR leading to shortening of watershed management cycle.

### **Pre-requisites for DPR preparation:**

The prerequisites for DPR preparation in REWARD program are completion of LRI and hydrology inventories, uploading the outcome of these inventories to portal, development of decision support system (DSS)-a computerized expert interactive information system, to decide on the most appropriate interventions that can be taken up for implementation based on the available information.

The outcomes of LRI and hydrology inventories are transformed into atlases which contain (a) micro watershed wise cadastral maps, (b) current land use map, (c) soil, site & land use maps, (d) soil nutrient maps-macro & micro nutrients, (e) land capability maps, (f) ground water status maps, (g) existing well & cons. structure maps, (h) soil and water conservation plan maps, (i) drainage line treatment/WHS plans, (j) weather data-rainfall, RH, temperature, wind, ET, (k) hydrological data-runoff, soil moisture, ground water levels, (l) socio-economic data and reports, (m) package of practices, (o) crop suitability maps for cereals, oilseeds, pulses and horticulture crops.

Based on the stored data, the decision support systems are developed by integrating data with criteria, models and algorithms. The criteria tables include (a) selecting treatment for arable land, (b) selecting treatment for non-arable lands, (b) horizontal and vertical intervals for soil conservation treatments, (c) cross-section of soil conservation structures, (e) cost rate for conservation various structures, (f) land suitability for crops grown in the region, (g) soil fertility classes based on content of macro nutrients (kg/ha), (h) critical limits of micronutrients in soils, (i) crop wise fertilizer recommendation, (j) soil fertility for adjusting major nutrients recommendation. Regarding water harvesting structures, the information on runoff estimation and deciding type and number of structures and design criteria of structures are important to consider. Similarly, crop water requirement will be estimated considering (a) crop coefficient (Kc) values for major crops, (b) estimation of soil water (Moisture) balance and (c) water budgeting. The DSS serve as an important aid for planning, implementation and monitoring of watershed program and all agriculture related activities by concerned development departments.

### **Phases involved in preparation of DPR:**

The phases involved in the process of DPR preparation under REWARD are (a) pre- planning activities in the field, (b) DPR generation in the office, (c) community consultation and validation in the field and (d) compilation and approval of DPR. In each phase, several steps are involved and are detailed in the following paragraphs.

*Phase-1: Pre- planning activities in the field (4 weeks)*

Following activities have to be completed in the pre-planning phase

1. Land Resource Inventory (LRI) data generated and available in the LRI portal for the selected sub-watersheds are finalized and approved
2. A manual/User Guide on Detailed Project Report (DPR) generation using LRI portal outputs is prepared
3. Field-Non Government Organizations (FNGO)s are in place and trained at designated Training Centres
4. Baseline data of the selected watersheds is collected and uploaded into portal
5. Information, Education & Communication (IEC) materials are prepared and sequencing activities with time lines is finalized
6. Initial awareness activities are completed
7. Orientation for the Panchayat Raj Institution (PRI) members in local area is completed by Training Coordinator (TC)
8. Entry Point Activity (EPA) finalized and approved by Gram Sabha
9. Formation of Community Based Organizations (CBO), Watershed Executive Committees (WEC), Area Groups (AG) and Self Help Groups (SHG)
10. Formation of Watershed Development Team (WDT) comprising of 15-20 members including FNGO staff and FPO representatives is identified and notified by PIA, DPR Preparation Team at PIA level WDT
11. Roles and responsibilities of all those institutions and teams involved in the project need to be specified
12. Training at Block/Taluk level on the processes of generation and validation of draft DPR and community consultation

*Phase-2: DPR generation in the office (4 weeks)*

1. Prepare survey number wise conservation plan: Refer draft conservation plan map generated by LRI partners, link the same with the farmer's details obtained from Bhoomi, software developed and available in the GoK website along with cost details  
  
(In case of non-availability of conservation plan in the portal, select conservation measures manually based on decision criteria LMU wise and then Survey No wise)
2. Prepare drainage line treatment, water harvesting structures, and other interventions needed like common land treatment, waste land treatment reclamation *etc.* based on the inputs provided in the LRI atlas, reports and digital library

(Select water harvesting structures based on decision criteria, water budgeting and water balance manually if the plan is not available in the portal)

3. Preparation of survey number wise crop plan by using the crop suitability maps generated for the area and linking the same with farmer's details
4. Include the package of practices to be followed during the entire duration of the crop selected (Decision criteria for selection of crops and nutrient management based on LRI output)
5. Similarly, prepare tentative plan for suitable horticultural crops, forestry, sericulture, animal husbandry and other interventions for the watershed area
6. Draft DPR generation - consolidation of all activities for a MWS and consolidated for SW

*Phase-3: Community consultation & validation (4 Weeks)*

1. Draft DPR generated (MWS wise & consolidation for SW)
2. AG wise treatment plan preparation for each MWS for transect walk
3. Dividing WDT into Sub-groups for community consultation and validation of DPR
4. Community consultation and validation of DPR by sub-groups
5. Ensuring Environment & Social Systems Assessment (ESSA) compliance
6. Compiling Area group wise treatment plan into MWS plan along with PRA exercise

*Phase-4: Compilation and approval of SWS DPR (4 Weeks)*

1. Approval of MWS plans at Gram Sabha
2. Compiling MWS wise plans into SW plans and submission to PIA office
3. Verification of the consolidated SW plan at PIA level and submission to District Level Technical Committee (DLTC)
4. Technical review by DLTC, placing before WCDC and WCDC to forward the DPR to PEC for approval
5. Forwarding approved DPR to PIA for implementation

**DRAFT DPR GUIDELINES  
FOR INTERNAL USE ONLY**



**Government of Karnataka  
Watershed Development Department**

**DRAFT GUIDELINES FOR  
DETAILED PROJECT REPORT (DPR) GENERATION USING LRI DATA AND  
COMMUNITY CONSULTATION PROCESS**

**REWARD Program  
(Rejuvenating Watersheds for Agricultural Resilience through Innovative  
Development)**

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## ACRONYMS

|         |  |
|---------|--|
| AAO     | Assistant Agriculture Officer                              |
| ACF     | Assistant Conservator of Forest                            |
| ADA     | Assistant Director of Agriculture                          |
| AG      | Area Group   |
| AO      | Agriculture Officer  |
| CBO     | Community Based Organization                               |
| CEO     | Chief Executive Officer                                    |
| CPR     | Common Property Resource                                   |
| DATC    | District Agriculture Training Center                       |
| DC      | District Coordinator                                       |
| DLTC    | District Level Technical Committee                         |
| E & S   | Environment and Social Screening                           |
| EPA     | Entry Point Activity                                       |
| ESSA    | Environment and Social System Assessment                   |
| FGD     | Focus Group Discussion                                     |
| FNGO    | Field Non-Government Organization                          |
| FPO     | Farmers Producer Organization                              |
| GP      | Gram Panchayat   |
| IEC     | Information Education Communication                        |
| JDA     | Joint Director of Agriculture                              |
| LRI-EM  | Land Resource Inventory Extension Managers                 |
| MGNREGS | Mahatma Gandhi National. Rural Employment Guarantee Scheme |
| MWS     | Micro Watershed  |
| NGO     | Non-Government Organization                                |
| PAT     | Performance Assessment Tool                                |
| PIA     | Project Implementation Agency                              |
| PPR     | Pre Project Report   |
| RFO     | Range Forest Officer                                       |
| RKVY    | Rastriya Krushi Vikasa Yojana                              |
| RSK     | Raitha Samparka Kendra                                     |
| SADH    | Senior Assistant Director of Horticulture                  |
| SHG     | Self Help Group  |
| SWS     | Sub Watershed  |
| TC      | Training Coordinator                                       |
| TL      | Team Leader  |
| ToT     | Training of Trainers                                       |
| WA      | Watershed Assistant  |
| WCDC    | Watershed Cell Cum Data Center                             |
| WDT     | Watershed Development Team                                 |
| WEC     | Watershed Executive Committee                              |

## I. Introduction

### A. Context

Karnataka is the eighth largest State in India, with highest percentage (79%) of drought prone area (Plate-1). More than 66% of total lands (2/3rd) in Karnataka depend only on rainfed agriculture. Recurrence of drought is a common phenomenon in Karnataka State due to spatial and temporal variations in rainfall. Frequent droughts have caused colossal loss to crops and lives of distressed farmers which has directly affected their socio-economic condition and livelihoods. In recent days due to change distribution pattern of rainfall state is also facing loss of crop and soil due to flooding. In absolute terms, Karnataka has the second largest dry land next to Rajasthan. This valuable resource which serves as the main source of livelihood for the large chunk of the rural population over a long period of time, has been subjected to poor land management practices. This has led to deteriorating soil fertility, soil loss, declining productivity, depletion of water resources, deforestation, denudation, destruction of natural pasture and diminishing biomass production, leading to low economic status in rural areas of rainfed regions in the State. To address these challenges, it is

prerequisite to adopt an integrated and holistic approach of scientific watershed development covering both land based and non-land based interventions for ensuring sustained soil fertility by addressing the issues of equity, gender participation and optimum utilization of natural resources. In this context, Watershed Development approach has been widely acknowledged as an effective solution to address the needs of rainfed agriculture. This is owing to the fact that it looks at increasing productivity of degraded lands and developing, maintaining and using natural resources on a sustainable basis.

Though initially watershed development was looked as mere conservation of soil and water through various land treatment interventions; in recent years, there has been a paradigm shift from a conventional to a multi-sectoral participatory and scientific approach. This is designed not only to develop natural resources management and improving agricultural productivity but also for the precise planning through the use of Remote Sensing (RS), Geographic Information System (GIS)&Land Resource Inventory (LRI) information.

Karnataka is the first State in India to create Watershed Development Department during the year 2000. Since then, the department has implemented many watershed projects for watershed development. Karnataka Watershed Development Project-II (Sujala-III) is one such project implemented from 2013-2019 in 12 districts of the State with scientific approach in partnership state agriculture and horticulture universities. Under this project LRI was established 2534 MWS covering 14 lakh ha. Eleven pilot watersheds development projects were taken up

Frequently drought affected taluks in Karnataka



based on LRI recommendations in saturation mode. The scientific LRI information generated in the project was provided to farmers as site specific scientific advisories to help to select suitable crops and application optimum quantity of nutrients thereby achieving optimum yield with reduced cost of cultivation resulting in enhanced soil health and income.

Sujala III is the first of its kind in the country. Through this project, farming community in the project area are experiencing the utility of technological application in agriculture through farm specific scientific recommendations of land resource inventory, for effective crop, farm management, and soil& water conservation practices (Plate-2). Sujala-III project has provided inputs for better understanding of hydrological dynamics and climatic variability by developing tools for measuring them and merging innovations and decision support information to address the needs of rainfed farmers and to adopt in the watershed planning and implementation system. The inputs of Sujala-III project have also contributed in formulating the Karnataka State Farmers Producers Organisation (FPO) policy for organizing farmers into commercial entities. These collectives are considered to be most effective means to reduce both production and market risk faced by agriculture sector and improving access to technology, investment and market; particularly small and marginal farmers and also aggregation of both input and output will enhance their bargaining capacity resulting in remunerative prices for their produce.

### **Saturation watershed treatment as per LRI under Sujala-III project**



Sujala-III has created laboratories equipped with various advanced tools and equipment and other infrastructure facilities, skilled manpower in all the 5 State Agriculture and Horticulture Universities and National Bureau of Soil Survey and Land Use Planning (NBSS-LUP) for carrying out soil and water analysis and generation of data at field and laboratories and bringing out the output in digitized form using GIS to upload into the Digital Library and LRI inputs. Advanced equipment's were procured by the Karnataka State Remote Sensing and Application Centre (KRSAC) for providing State-wide cadastral maps and high-resolution imageries. Karnataka State Natural Disaster Management Centre (KSNDMC) was provided with improved weather monitoring systems and applications to disseminate continuous climate and weather data and for feeding the same into the Digital LRI inputs. The rich data generated by these Agriculture and Horticulture Universities is not only used for Watershed Development Department but also by other developmental departments for better planning and

implementation of their land-based schemes. Karnataka State has total 19.05 million ha. geographical area of which 12.97 million ha is the treatable area and in this 6.85 million ha area is already treated and 0.89 million ha is being treated under various watershed programs. Thus about 5.23 million ha (52.31 lakh ha) rainfed watershed area is yet to be treated on watershed approach. Hence, the improved infrastructure, skilled manpower and other knowledge created in the Sujala-III project is intended to be used effectively for scaling up the Sujala-III interventions in other parts of the State and to disseminate the scientific information generated by implementing REWARD (Rejuvenating Watersheds for Agricultural Resilience through Innovative Development) program in the State.

## **B. Brief about REWARD and key principles**

The REWARD is a World Bank assisted “P for R” (Program for Results) Program which will support the next phase of watershed development program of the Government of India’s (GoI), also referred to as the WDC-PMKSY. The proposed US\$60 million International Bank for Reconstruction and Development (IBRD) allocation to the REWARD Program is a sub- set of the new WDC-PMKSY that has an outlay of US\$4,600 million. While the GoI program is implemented across all States (except for the State of Goa), the REWARD Program will be implemented in selected States.

States are selected into the program when they meet specific qualifying and readiness criteria such as: a) extent of rainfed area in the State; b) socio-economic profile; c) financial readiness: the State leaders have agreed to take an IBRD loan and provide counterpart financing of 30 percent of the cost of the Program; d) financial performance: the States have demonstrated utilization of more than 85 percent of the funds released by the DoLR under the WDC-PMKSY in the past five years; e) institutional readiness: the States have established institutional arrangements at the State and district levels for watershed development and initiated partnerships with technical institutions; and f) demonstrated performance: the States have strong leadership in the SWD and demonstrated capacity to plan and implement watersheds at scale with evidence of results. The central agency DoLR will also borrow a modest IBRD loan for coordination and Knowledge activities

REWARD Program primarily benefits for the communities in rainfed areas which rely on land and water resources for livelihoods and ecosystem services. The sustainable development of watersheds based on better scientific inputs and technical capacities will conserve soil, improve surface and ground water availability and efficient usage and thereby enhance agricultural productivity and profitability resulting in sustainable improvement in income generation. In particular, it will have positive impacts on women, small and marginal farmers and agricultural laborers. The efforts to ensure social inclusion in watershed planning and management will also enhance the benefit the most vulnerable sections of the rural society.

## **C. Program description:**

Rejuvenating of Watersheds for Agriculture Resilience through Innovative Development (REWARD) is a World Bank supported watershed development program which will be implemented in 21 rainfed districts of Karnataka with a budget of Rs.600 crores. The budget will be co-shared by World Bank and Government of Karnataka (GoK) in the ratio of 70:30

and the program will be implemented by Watershed Development Department (WDD), Government of Karnataka. Program duration is from 24<sup>th</sup> March 2022 to 30<sup>th</sup> June 2026.

The Dept. of Land Resources (DoLR) is the Nodal Department at the National level and Karnataka identified as Light House State to provide technical support to other States.

Major Technical partner institutions of the program in state are National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), All State Agricultural and Horticultural Universities, Indian Institute of Science (IISC), Karnataka State Remote Sensing & Application Centre (KSRSAC), Karnataka State Natural Disaster Monitoring Centre (KSNDMC) etc.

Area selected for the program implementation across 21 districts given below (Table-1)

**Table 1: Details of area proposed for implementation of REWARD program**

| Sl. No.              | District        | Taluka        | Area Details             | No. of SWS | No. of MWS | Area for LRI (ha)  |
|----------------------|-----------------|---------------|--------------------------|------------|------------|--------------------|
| <b>NBSS&amp;LUP</b>  |                 |               |                          |            |            |                    |
| 1                    | Chikkaballapura | Bagepalli     | New area                 | 23         | 183        | 90,889.67          |
| 2                    | Bellary         | Harapanahalli | New area                 | 16         | 133        | 84,103.81          |
| 3                    | Koppal          | Yelburaga     | New area                 | 11         | 122        | 65,447.82          |
| 4                    | Gadag           | Ron           | New area                 | 14         | 163        | 78,048.11          |
| 5                    | Koppal          | Yelburaga     | Sujala -III balance area | 2          | 10         | 5,913.16           |
| 6                    | Gadag           | Ron           | Sujala -III balance area | 2          | 2          | 900.55             |
| <b>TOTAL</b>         |                 |               |                          | <b>68</b>  | <b>613</b> | <b>3,25,303.12</b> |
| <b>UAS Bangalore</b> |                 |               |                          |            |            |                    |
| 7                    | Hassan          | Arsikere      | New area                 | 20         | 175        | 1,07,240.06        |
| 8                    | Kolar           | Kolar         | New area                 | 11         | 121        | 67,238.55          |
| 9                    | Tumkur          | Sira          | New area                 | 21         | 225        | 1,18,871.98        |
| 10                   | Chamarajanagar  | Gundlupete    | New area                 | 15         | 128        | 64,845.49          |
| 11                   | Chamarajanagar  | Gundlupete    | Sujala -III balance area | 1          | 5          | 2,482.60           |
| <b>TOTAL</b>         |                 |               |                          | <b>68</b>  | <b>654</b> | <b>3,60,678.67</b> |
| <b>UAS Dharwad</b>   |                 |               |                          |            |            |                    |
| 23                   | Belagavi        | Athani        | New area                 | 14         | 121        | 66,960.88          |
| 24                   | Belagavi        | Bailhongal    | New area                 | 12         | 127        | 72,779.68          |
| 25                   | Haveri          | Hirekerur     | New area                 | 18         | 160        | 78,348.56          |
| 26                   | Haveri          | Ranebennur    | New area                 | 18         | 169        | 81,459.86          |
| 27                   | Dharwad         | Kundgol       | New area                 | 10         | 85         | 58,337.34          |
| 28                   | Belgaum         | Athani        | Sujala -III balance area | 2          | 5          | 2,294.57           |
| <b>TOTAL</b>         |                 |               |                          | <b>74</b>  | <b>667</b> | <b>3,60,180.88</b> |
| <b>UAS Raichur</b>   |                 |               |                          |            |            |                    |
| 18                   | Raichur         | Manvi         | New area                 | 13         | 129        | 70,489.38          |
| 19                   | Kalburagi       | Jewargi       | New area                 | 11         | 113        | 69,395.51          |
| 20                   | Yadgir          | Shahpur       | New area                 | 24         | 213        | 1,24,267.06        |
| 21                   | Raichur         | Lingsugur     | Sujala -III balance area | 5          | 27         | 15,495.02          |
| 22                   | Kalburagi       | Kalburagi     | Sujala -III balance area | 3          | 13         | 7,619.77           |
| <b>TOTAL</b>         |                 |               |                          | <b>56</b>  | <b>495</b> | <b>2,87,266.74</b> |

| Sl. No.                | District      | Taluka       | Area Details             | No. of SWS | No. of MWS  | Area for LRI (ha)   |
|------------------------|---------------|--------------|--------------------------|------------|-------------|---------------------|
| <b>UHS Bagalkot</b>    |               |              |                          |            |             |                     |
| 29                     | Bagalkot      | Hungund      | New area                 | 15         | 138         | 83,436.77           |
| 30                     | Bidar         | Basavakalyan | New area                 | 13         | 101         | 69,125.17           |
| 31                     | Vijayapura    | B Bagewadi   | New area                 | 22         | 204         | 1,19,343.97         |
| 32                     | Bagalkot      | Hungund      | Sujala -III balance area | 1          | 5           | 3,253.09            |
| 33                     | Bidar         | Basavakalyan | Sujala -III balance area | 3          | 9           | 7,035.96            |
| 34                     | Bidar         | Aurad        | Sujala -III balance area | 12         | 37          | 24,077.51           |
| 35                     | Bidar         | Humnabad     | Sujala -III balance area | 6          | 13          | 8,557.91            |
| 36                     | Vijayapura    | B Bagewadi   | Sujala -III balance area | 4          | 17          | 10,422.82           |
| 37                     | Vijayapura    | Vijayapura   | Sujala -III balance area | 13         | 34          | 18,745.71           |
| <b>TOTAL</b>           |               |              |                          | <b>89</b>  | <b>558</b>  | <b>3,43,998.91</b>  |
| <b>UAHS Shivamogga</b> |               |              |                          |            |             |                     |
| 12                     | Chitradurga   | Challakere   | New area                 | 26         | 159         | 1,13,841.86         |
| 13                     | Shivamogga    | Shikaripura  | New area                 | 17         | 153         | 78,811.16           |
| 14                     | Chikkamagalur | Kadur        | New area                 | 20         | 142         | 1,04,377.41         |
| 15                     | Chikkamagalur | Kadur        | Sujala -III balance area | 1          | 5           | 3,645.08            |
| 16                     | Chikkamagalur | Tarikere     | Sujala -III balance area | 4          | 15          | 9,361.46            |
| 17                     | Davangere     | Channagiri   | Sujala -III balance area | 6          | 19          | 11,126.48           |
| <b>TOTAL</b>           |               |              |                          | <b>74</b>  | <b>493</b>  | <b>3,21,163.45</b>  |
| <b>GRAND TOTAL</b>     |               |              |                          | <b>429</b> | <b>3480</b> | <b>19,98,591.78</b> |

The REWARD program addresses key issues in National watershed management programs which are constraining better results from being achieved. The key design feature of the program is to address the challenges that the sector faces by bringing a strong science and evidence-based watershed planning, implementation and management approach that is anchored in community participation and ownership. The program seeks to achieve this balance of “top-down” versus “bottom-up” approach by demystifying science and its tools and making them accessible and comprehensible to communities who are the primary stakeholders in a watershed. In short, the program seeks to put communities at the centre of watersheds, but with strong science-based tools available to them for decision making. The action plan will be prepared scientifically for the selected 20 sub watersheds with community consultation, by using parcel wise scientific recommendations and further implemented on a saturation approach wherein, every parcel of the land will be treated as per the LRI recommendations by considering hydrological parameters. This includes soil and water conservation measures, crop management, nutrient management, agro-horticulture, agro- forestry etc.

#### **D. Program development objective:**

The Program Development Objective (PDO) is “to strengthen capacities of national and state institutions to adopt improved watershed management for increasing farmers’ resilience and support value chains in selected watersheds of participating states”.

Implementation of REWARD program is aimed at collection of Land Resource information (LRI) scientifically to issue Land Resource (LRI) cards comprising site-specific recommendations for farmers to use at field level, and for preparation and

implementation of scientific Detailed project reports (DPR) for watershed development projects.

**Major components of the REWARD program:**

- 1) Carrying out Land resource inventory (LRI) in 19.98 lakh hectare rain-fed areas.
- 2) Watershed treatment on saturation mode in 1.0 lakh ha area (20 sub-watersheds) scientifically based on recommendations of LRI & Hydrological recommendations.
- 3) Strengthening Farmer Producers organizations (FPOs) and Value Chain Development - 25 FPOs
- 4) Providing improved site specific improved Agro-met advisories to farmers
- 5) Establishment of Centre of Excellence on science based Watershed Management at UAS Bengaluru

**E. Need for Community Consultation on DPR Generated Using LRI Data**

Traditionally DPRs were used to be prepared in consultation with the community by traversing the watershed area from ridge to valley with the help of RS and GIS maps. In the process interventions were identified in consultation with the farmers based on the soil type, slope, erosion status, length and width of the drainage lines etc. This process helps in engaging the community in planning different watershed interventions thereby establishing community ownership.

However, REWARD is designed to drive the frontiers of the watershed planning and management to higher levels with the advancement of science based tools. The program is implemented with the help of consortium of scientific institutions to carry out Land Resources Inventory (LRI) and hydrology and use the same for planning with the help of tailor-made algorithms and decision support systems. Besides planning, the project aims to develop LRI cards and agro advisory support for the target farmers and disseminate the same to adopt improved climate resilient agriculture practices which made available to the stakeholders through LRI digital.

This process, though helps in generating science based DPRs fails to address the basic principle of community participation, building community ownership and accountability mechanisms in line with the new generation watershed guidelines. Thus the DPRs developed through digital LRI inputs needs to be demystified about the science involved in it to the target communities for their understanding and adoption.

In this background there is a need for a detailed process guideline for undertaking the consultations with the community. This process guideline will help PIA members and gross root level functionaries like watershed assistants and NGO staff in demystifying the science based planning approach to farmers and to undertake social and environment assessment at watershed level.

## **II. Summary of Guidelines for Preparing Detailed Project Reports using LRI data**

### **A. Prerequisites for preparation of DPRs/Pre Planning Phase (4 Weeks)**

1. LRI data generated and available
2. PPRs for the selected sub-watersheds are finalized and approved
3. A manual/User Guide on DPR generation using LRI inputs is prepared
4. FNGOs are in place and trained at DATCs
5. Baseline data of the selected watersheds is established
6. IEC materials are prepared and sequencing activities with time lines is finalized
7. Initial awareness activities are completed
8. Orientation for the PRI members in local area is completed by DATC
9. EPA activity finalized and approved by Gram Sabha
10. CBOs - WECs, AGs and SHGs formed with as per the PMKSY guidelines.

### **B. Constitution of Watershed Development Team at SWS Level and Training**

1. Formation of WDT Team/ DPR Preparation Team at PIA level
2. Two days Training/workshop at Block/Taluk level for demonstration of generation and validation of draft DPR and community consultation

### **C. DPR Generation and Community Consultation (4 weeks)**

1. Downloading MWS wise DPRs from LRI inputs and consolidation for the SWS
2. AG wise treatment plan preparation for each MWS for transact walk.
3. Dividing WDT into Sub-groups for community consultation and validation of DPR
4. Community consultation and validation of DPR by sub-groups
5. Ensuring ESSA compliance
6. Compiling Area group wise treatment plan into MWS plan along with PRA exercise

### **D. Compilation and approval of SWS DPR**

1. Approval of MWS plans at Gram Sabha
2. Compiling MWS wise plans into SW plans and submission to PIA office
3. Verification of the consolidated SW plan at PIA level and submission to DLTC
4. Technical review by DLTC, placing before WCDC and WCDC to forward the DPR to PEC for approval
5. Forwarding approved DPR to PIA for implementation

### III. Detailed Guidelines for Preparing Detailed Project Reports using LRI data

#### A. Prerequisites for preparation of DPRs/Pre Planning Phase (4 Weeks)

1. Sub watersheds (SWS) selected for treatment by the concerned District Joint Director of Agriculture (JDA)
2. Land Resource Inventory (LRI) data generated for the selected sub-watershed and uploaded in the LRI inputs. The concerned person should ensure that LRI data available for generation of Detailed Project Reports (DPR) and to be thorough in using the LRI inputs.
3. A manual/User Guide on DPR generation from LRI inputs is provided to districts by State PIA.
4. Pre-project reports (PPRs) for sub-watersheds selected are to be finalized and submitted by the districts and get the approval of the State PIA.
5. Field-Non Government Organizations (FNGOs) are selected by State PIA and placed in the concerned districts
6. ToT for FNGOs staff along with implementing officers/field staff on CBOs training modules, DPR preparation, community consultation & validation of DPR, implementation process, Environment & Social Systems Assessment (ESSA) compliance, GP Assessment tool (PAT) reporting & documentation etc., by District Agricultural Training Centres (DATC) Mysore & Vijayapura.
7. Required baseline data of the selected sub watersheds is collected from the secondary sources including baseline of environmental and social baseline is collected and collated by the FNGO with the support of PIA. Suggested participatory methods for collecting baseline data, baseline required are furnished in **Annexure-I**.
8. IEC materials like videos, street play scripts, drone pictures on watershed status, wall painting, pamphlets, small audio & video bytes of popular persons/influencers/local elite farmers etc., on LRI technology, scientific watershed management and its importance - design and contents are prepared. Planning and sequencing of activities with time lines are finalized by the taluk PIA with the help of NGO team and RSK officials.
9. Initial awareness activities are completed-wide publicity using IEC materials Wall paintings, distribution of pamphlets, jathas, street plays, through small audio & video bytes using *Krishi Sanjeevini* vehicles etc., are completed in majority of the villages by the NGO team with the help of field staff.
10. Panchayat Raj Institution (PRI) members in the local area are oriented on their roles and responsibilities and program interventions under REWARD- organizing one day orientation program at DATC and after the training collecting the participants feedback in a simple questionnaire formats.
11. Training modules for Community Based Organizations (CBOs) are prepared by the DATCs in consultation with State PIA and provided to the districts and teaching aids should be prepared by the NGO and taluk PIA.
12. CBOs- Watershed Executive Committees (WECs), Area Groups (AGs) and Self Help Groups (SHGs) are formed (**Formation of CBOs, Roles & Responsibilities**)

**are in Annexure II)** by NGO in the program area and started functioning; one basic training should be completed for the CBOs members by NGO on the topics provided in **Annexure-IIIa**.

13. About 50 members per Micro watershed (MWS) comprising all WEC members with active Area Group members have taken to one exposure visit (one day) to a nearest successful watershed to understand the impact of natural resource management through soil and water conservation activities under watershed development programs.
14. Entry Point Activities (EPA) are finalized and approved by Gram Sabha, implementation started by the NGO.

Entry point activities are taken up by the field staff and NGO to build rapport with the village community and gain their confidence towards people-centric project development. EPA may be planned based on the public demand and considering local situation in the villages. EPA action plan should be finalized by proper consultation with the village community/WEC and get vetted from the Gram Sabha and forward it to the district JDA for approval. While taking up EPA field staff and NGO to ensure proper estimate, following guidelines and execution based on budget provision and to take preferably in convergence with other ongoing schemes like MGNREGS, RKVY etc., for sourcing the funds.

#### **B. Constitution of Watershed Development Team (WDT) at SWS Level and Training**

1. **WDT / DPR Preparation Team:** District JDA will form WDT team at PIA level. WDT is a core group of 15 to 20 members involving taluk ADA-head, SADH/ACF/ADH & RFO, RSK-AO & AAO, District coordinators (out sourced), LRI Extension Managers (out sourced), FNGO Team Leader & Watershed Assistants, WEC President & other two local Gram Panchayat (GP) members, 4 to 5 representatives from AGs, SHGs and local FPO.
2. Details of Composition, Roles and responsibilities WDT team is given in **Annexure-IV**
3. A two days Training workshop should be organized at taluk/block level including district and taluk level officials, PIA/WDT/NGO officers/representatives of WEC, AG & SHGs and active farmers. District, JDA to conduct the program with the help of concerned LRI partner and DATCs and also involve identified speaker's/resource persons to educate about significance of REWARD program.

Details of the program schedule and topics is given in **Annexure-V**

- a) Day-1: regarding use of LRI and Hydrology outputs in science based watershed planning and demonstration of generating draft DPR using DSS modules in LRI inputs.
- b) Day-2: Field visit at MWS level to understand the process of Validation of DPR and how to read/ use the DPR and conducting community consultation and PRI exercises. In this regard, standard checklist should be prepared for points to be observed during field validation of DPR and community consultation.

**C. DPR Generation and Community Consultation (4 weeks)**

1. Generation of MWS wise DPRs using LRI data and consolidate the generated plan at the SWS level, as per the format given in Annexure VI for private land and Annexure VII for Drainage line and Common land treatments.
2. Prepare AG wise treatment plan on as per the format given in Annexure VIII and carry the same during transact walk along with different thematic maps generated through LRI.
3. Draw date and AG wise plan for each AG and give wide publicity through public announcements and pamphlets.
4. Identify a suitable place for community gathering and give a brief about tasks to be accomplished during the transact walk.
5. Identify 2 to 3 CRPs for each MWS and orient them about DPR and community consultation.
6. Arrange for coffee/ tea, snacks, lunch packets and water during transact walk
7. Arrange for logistic support like vehicle, shamiyana, display boards etc.
8. Fix AG wise responsibility of mobilizing the farmers to Community Resource Persons (CRP) and FNGO staff.
9. WDT will be divided into 3 sub-groups and 3 to 4 MWS will be allotted to each group based on no. of MWS located in that SWS. Thus, sub-groups can be formed as follows;
  - a) AO+WA+FNGO-TL+LRI-EM+2 AG Reps+2 SHG Reps +1 to 2 WEC members+ local FPO President /CEO / Board Member.
  - b) AAO-1+WA+FNGO-TC+LRI-EM+2 AG reps+2 SHG reps+1 to 2 WEC members + local FPO President / CEO / Board Member.
  - c) AAO-2+WA+District Cordinator+LRI-EM+2 AG reps+2 SHG reps+1 to 2 WEC members + local FPO President / CEO / Board Member.

SADH/ACF, ADH & RFO of the respective district should actively involve with the teams and monitor the consultation and ground truthing activity closely and ensure the ESSA compliance in preparation and implementation of the DPR.

10. Teams member's involvement in community consultation;

| <b>Participants</b>                 | <b>Individual / Private lands</b>   | <b>Common lands and Drainage lines</b>  | <b>Vulnerable Groups</b>  |
|-------------------------------------|---|---|---|
| Field NGO                           | <ul style="list-style-type: none"> <li>• Field Guide and Community organizer</li> <li>• Technical Staff if any</li> </ul> | <ul style="list-style-type: none"> <li>• Field Guide and Community organizer</li> <li>• Technical Staff if any</li> </ul> | <ul style="list-style-type: none"> <li>• Field Guide and Community organizer</li> </ul> |
| Assistant Agriculture Officer (AAO) | AAO assigned to that micro-watersheds   | AAO assigned to that micro-watersheds   | AAO assigned to that micro-watersheds   |

| <b>Participants</b>              | <b>Individual / Private lands</b>   | <b>Common lands and Drainage lines</b>   | <b>Vulnerable Groups</b>   |
|----------------------------------|---|--|--|
| Watershed Development Team (WDT) | Specialist in <ul style="list-style-type: none"> <li>• Horticulture</li> <li>• Livestock</li> <li>• Agriculture</li> <li>• Forestry</li> </ul>  | Specialist in <ul style="list-style-type: none"> <li>• Horticulture</li> <li>• Livestock</li> <li>• Agriculture</li> <li>• Forestry</li> </ul>   | Optional   |
| SWS Executive Committee (WEC)    | Preferably the Entire committee<br>And <ul style="list-style-type: none"> <li>• President</li> <li>• Secretary</li> <li>• Treasurer</li> <li>• Gram Panchayat Representatives</li> </ul> Compulsorily:<br>Representatives from AGs and SHGs | Preferably the entire committee and <ul style="list-style-type: none"> <li>• President</li> <li>• Secretary</li> <li>• Treasurer</li> <li>• Gram Panchayat Representatives</li> </ul> Compulsorily:<br>Representatives from AGs and SHGs | <ul style="list-style-type: none"> <li>• President</li> <li>• Secretary</li> <li>• Treasurer</li> <li>• all SHG representatives</li> </ul> |
| Area Groups                      | All members belonging to the area   | All members belonging to the area  |  |
| SHGs                             | Representatives of the WEC  | Compulsorily:<br>All members of the SHGs dependent on CPRs in the mini-micro-catchment and the micro-watershed<br>Representatives to WEC   | All members of the concerned SHG, especially representatives of all the SHGs   |
| Individual families              | A male and female adult from each family whose land is included for planning  | Those families using common property resources or with lands adjoining the Nala etc.,  | Those in SHGs  |

**D. Steps for community consultation and validation of DPR;**

1. Each group will take print of draft DPR and treatment plan to each Area Group for community consultation and validation; follow the Ridge to Valley approach.
2. First team will visit each and every land (individual as well as common property) and discuss area specific problems and opportunities and ways in which people plan to upgrade their land to make it more productive.
3. Interact with the farmers and verify the local conditions specific to their lands and compare

the extent of land holdings, its location in the watershed, its structure and soil type, slope, vegetation, cropping pattern, land use, water availability (including irrigation), etc. with LRI inputs and mark if any corrections/inclusions required.

4. Compare map of the land showing existing structures, land use, drainage lines etc., with actual observations and do necessary corrections. Explain treatment plan generated using LRI inputs to AG and note down the any concern/modification/ feedback of the farmers.
5. Carry the AG wise DPR prepared as per the Format furnished in **Annexure VIII** and record the suggested modifications or deletions in **Annexure IX**.
6. Discuss with the community on pros & cons and impact of the proposed activities on social and environment aspects and document the same. Further, also record if any modifications required by the community as per format in **Annexure X**. For common land treatment opinion of the WEC and neighbor farmers should be recorded.
7. Prioritize the interventions over time line and prepare tentative year wise action plan with budget, each farmer should be aware of the investment to be made on his/her land and contribution to be paid, explain the cost sharing mechanism to beneficiary and take his consent. It may be suggested to issue a Beneficiary card to each farmer.
8. Make tentative land treatment plans for the lands of absentee owners by consulting their neighbors/friends or relatives with technical inputs from the WDT. As and when these farmers decide to become a part of the programme these tentative plans can be revised and reconfirmed. Request the local Area Group to keep these absentee persons informed.
9. Along with individual farmer wise plan, share the common land and drainage line treatments proposed as per the LRI based DPR, wherever proposed common land and drainage line treatments falls within the area of each AG.
10. It is expected that on each day one to two AGs could be completed, by assuming 3to 4 Area groups (1000 to 1500 ha. /group) and thus four days required for one MWS.

**E. Consolidating Area group wise treatment plan into MWS plan;**

1. End of the day after completion of transact, group will assemble at a pre-identified place and present summary of treatment plan on private land and CPRs and get the approval by taking signatures of representative of PIA, FNGO and WEC/GP and at least 5 to 6 farmers on back side of the DPR map as per the enclosed format in **Annexure XI**
2. Photo documentation during transact and at the end of the day meeting should be done, this responsibility should be entrusted to any one member of the task team having good quality camera in the mobile. Minimum of 10 - 12 photos, minimum of 3 photos while planning for CPRs from different angles/sides should be captured and documented.
3. If possible display the treatment plan on a tripod stand and take the photo while explaining.
4. On 5th day PRA exercise will be done as per the guidelines given in section-IV below.
5. Hence, 15 days required to complete DPR and get Gram Sabha (GS) approval for 3 MWS by each team. Thus, by assuming 9 MWS per SWS, planning for the entire SWS can be completed in 15 days by three teams, maximum it can be extended up to 20 days.
6. Take the opinion of the community on impact of activities on social and environment conditions and record if any modifications/suggestions required.

7. The AAO/DC/FNGO-TL/TC along with concerned WA should assess the environmental and social risks from activities (especially if any adverse effects on the vulnerable groups).
8. Ensure any banned chemicals and materials which are hazardous to environment are not suggested under the project and also inform about the same to farmers /Gram Sabha.
9. Plan any risk management measures together with community and eliminate any activities which seem to be high risk.
10. Append the ESSA details to the DPR- (Appendix-V & VI).
11. AG wise intervention plans for both private and common land are to be consolidated at MWS level and consolidated DPR for the MWS has to be prepared.
12. Conduct a PRA exercise at village level and get the approval for the consolidated MWS plan, if there are more than one village in a MWS, PRA can be conducted at major village by inviting all AG, SHG, WEC members concerned to that MWS.

### **Things to consider while planning for the common lands and drainage lines**

1. Visit these lands with the respective Area Groups and SHG members. Interact with the people to understand the specific issues related to these lands.
2. Assess the existing conditions compare it with the maps generated in LRI inputs
3. Share the details of rainfall, runoff, existing water bodies and potential for water harvesting, extent, type of erosion etc., and interventions proposed with estimated budget etc.
4. Observe details of existing structures, treatments already done and compare with map already generated.
5. Study the land and land uses in the Common Property Resources (CPRs)
6. Estimate the human and animal population dependent on the CPRs.
7. Take the community's opinion on planning to improve common lands and resources and interventions proposed in the plan and get their consent and note down if any changes or modifications suggested.
8. Identify the prominent users/beneficiaries of the CPRs developed and record their names and other details which should be annexed to the final DPR which will help in preparing Operation and Maintenance (O& M) strategy for CPRs.
9. Along with estimated budget for the interventions discuss the cost sharing arrangements with the community.

### **F. Consolidation and approval of MWS DPRs at SWS/GP/WEC Level:**

The multiple levels of planning at farmer's level, AG level and for common lands are consolidated at the micro-watershed level to develop appropriate MWS plans under REWARD.

### **Resource and intervention mapping:**

1. After completing the transect in all the Area groups area, on 4<sup>th</sup> day the Task Team with the lead taken by the FNGO, carries the Resource and Intervention mapping at the village level, if there are more than one village in a MWS, PRA can be conducted at major village. All the AG members and the SHG members and all families having stake in the MWS catchment are invited.

PRA exercise will be done for the following reasons:

- For triangulation (Cross-verification) of information gathered during transect done for planning.

- For seeking clarifications on any issue that might have arisen during transact.
- For finalizing the activities to be taken in the watershed on individual and common lands.
- For discussing implementation strategies, cost sharing aspects, labour availability for the works, etc.
- For carrying out ESSA (Environment and Social Systems Assessment) to ensure that there is no adverse effect on environment and social system by implementing the proposed activities (details in section VIII).
- To include the suggestions/modifications required in the MWS plan and place before GS.

**2. The modalities of carrying out PRA exercise are explained below:**

| <b>Steps</b>   | <b>Details</b>   |
|--|--|
| a) Call members from all AGs & SHGs and all those families who have stakes in the watershed. | The meeting should be conducted in a large open ground with some space to display charts, maps, etc.   |
| b) Display micro-watershed wise large digital Resource Map of the watershed (size 8X10 feet) | Prepare large Micro-watershed wise digital resource map of the watershed marked with proposed structures and display in the PRA.<br>The map should contain the following features: <ul style="list-style-type: none"> <li>• Drainage lines</li> <li>• Existing soil and water conservation structures</li> <li>• Various types of land with survey boundaries (common lands and individual lands)</li> <li>• Major land features</li> <li>• Vegetation etc.</li> </ul> |
| c) Explain proposed watershed activities indicated on the map                                | Explain the people about proposed watershed structures indicated on the map. Include all interventions on private lands and common property resources.   |
| d) Overview of the intervention proposed   | Referring to the consolidation sheets, discuss the various interventions proposed, the total budget - whether it is within the permissible limit of the project, cost sharing for various components, budget provision from the REWARD and budget coming from the convergence with other schemes etc. Technical appropriateness of the intervention need to be discussed.  |

|   |  |
|---|--|
| <p>e) Discuss broad implementation issues</p>           | <p><b>Discuss the following issues in great detail:</b></p> <ul style="list-style-type: none"> <li>• What is the total quantum of work, what is the labour requirement and what is the labour availability? How can additional labour be mobilized and what are the options if there is a shortage of labour. If machinery is to be used for earth moving - what is the impact on the budget and to what extent should machines be used?</li> <li>• Will the labour required for all the works come from the vulnerable families in the micro watershed?</li> <li>• Do the land treatment activities accommodate the livelihoods needs of the vulnerable groups?</li> <li>• Are there special activities with usufruct sharing mechanisms to support the vulnerable groups?</li> <li>• Do the interventions planned, complement the analysis of the PRA information-like in the fodder planned in the watershed sufficient for the cattle and livestock dependent on it.</li> <li>• Discuss the mechanisms to collect people's contributions for work and document the same</li> </ul> |
| <p>f) Environmental and Social Safeguard Strategies</p> | <p>Any physical treatment activity is having any adverse impact on environment and social systems? If yes, how to manage those?</p>  |

3. Include if any modifications suggested in the PRA and prepare revised MWS plans. Once the MWS plans are vetted in the PRA exercise, then generate farmer wise and survey number wise details in the form of net planning through LRI inputs.
4. Convene a General Body/ Gram Sabha meeting of the WEC (Quorum at least 50%) and present the overall MWS plans, budgets, contributions, mode of implementation (manual labour, machinery, contracts, etc.), common land and drainage line treatments, post management strategies, inter linkages between individual lands and common lands, etc.
5. Present entire plan along with Budget before the General Body and get its approval. WDT, FNGO team and WEC committee members should play major role in getting the approval. Proceedings should be recorded with photo/video documentation.
6. After General Body approval, the plans are to be finalized by FNGO and submit to PIA along with a summary of SWS plan for technical scrutiny.

### **G. Verification and approval of the Consolidated Sub-watershed DPR:**

1. Taluk PIA office will verify component wise project allocations, unit costs, contribution rates and total budgets allocation for all the MWS plans received from the different WECs and prepare a component wise consolidated plan for the SWS and submit to DLTC headed by district JDA for technical scrutiny.
2. DLTC go through the individual MWS plans for technical feasibility and prepare a convergence plan wherever possible and recommend the same to WCDC headed by district Deputy Commissioner for approval.
3. WCDC will verify the consolidated SWS DPR as well as convergence plan and recommends to the Project Empowered Committee (PEC) for approval. Upon approval of the WCDC, district JDA will submit the same along with minutes of DLTC and WCDC to State PIA/WDD to place before PEC.
4. State PIA/WDD will submit the SWS DPRs before the PEC and upon approval forward to district JDA.
5. JDA will forward the approved DPRs to Taluk PIA and in turn to field staff, FNGO & WECs to take up implementation.
6. Funds can now be transferred to the WECs for work implementation based on their requisitions.

### **H. Capacity building for different stakeholders**

Trainings for the CBOs formed namely Watershed Executive Committees (WECs), Area Groups (AGs) and Self Help Groups (SHGs) will be provided by NGO in the program area at village level in 3 phases of project i.e. Preparatory, Implementation and withdrawal phases. Training topics provided in **Annexure-IIIa**.

Further trainings for Project implementing Agency, FNGO staff, selected WEC members etc. will be conducted by DATC Mysuru and Vijayapura. Details of the trainings provided in **Annexure-IIIb**

### **I. Ensuring Gender and Social Equity**

Women are more vulnerable than men in their respective social groups and therefore are considered for special interventions under REWARD adopts the following policy to combat their vulnerability.

1. Priority should be given for women's SHGs. The General body of the SWS must enroll both men and women as members from each family. The Area Groups can also women as members even if the land ownership is with the men in the family. The FNGO must ensure that women actively take part in preparing the DPR.
2. When meetings are called to discuss the progress on land treatment both male and female members of the family should be called. These meetings should be frequent (at least thrice a year) and should discuss the status of contributions for private land treatment, the work planning and implementation.
3. 33% of the WEC members should be women - from either SHGs or Area Groups.

4. Either the president or the vice president should be women
5. For any exposure visits minimum of 30% should be women
6. Not less than 80% of the income generating activities should be allocated to women members of SHGs

#### **Opportunities for SCs/STs and small & marginal farmers**

1. All the SC/ST families and Small & marginal families must be covered in SHGs
2. The WEC must ensure that SC/STs are representation
3. At least 25% of participants in all training programmes and exposure trips must be from SC/ST families
4. 100% of SC/ST and small & marginal families must be covered through SHGs under skill training programmes (excluding those families who have already been covered under any other programme or scheme)
5. The SHGs must provide credit to all the SC/ST and small and marginal families to start micro enterprise on priority basis.

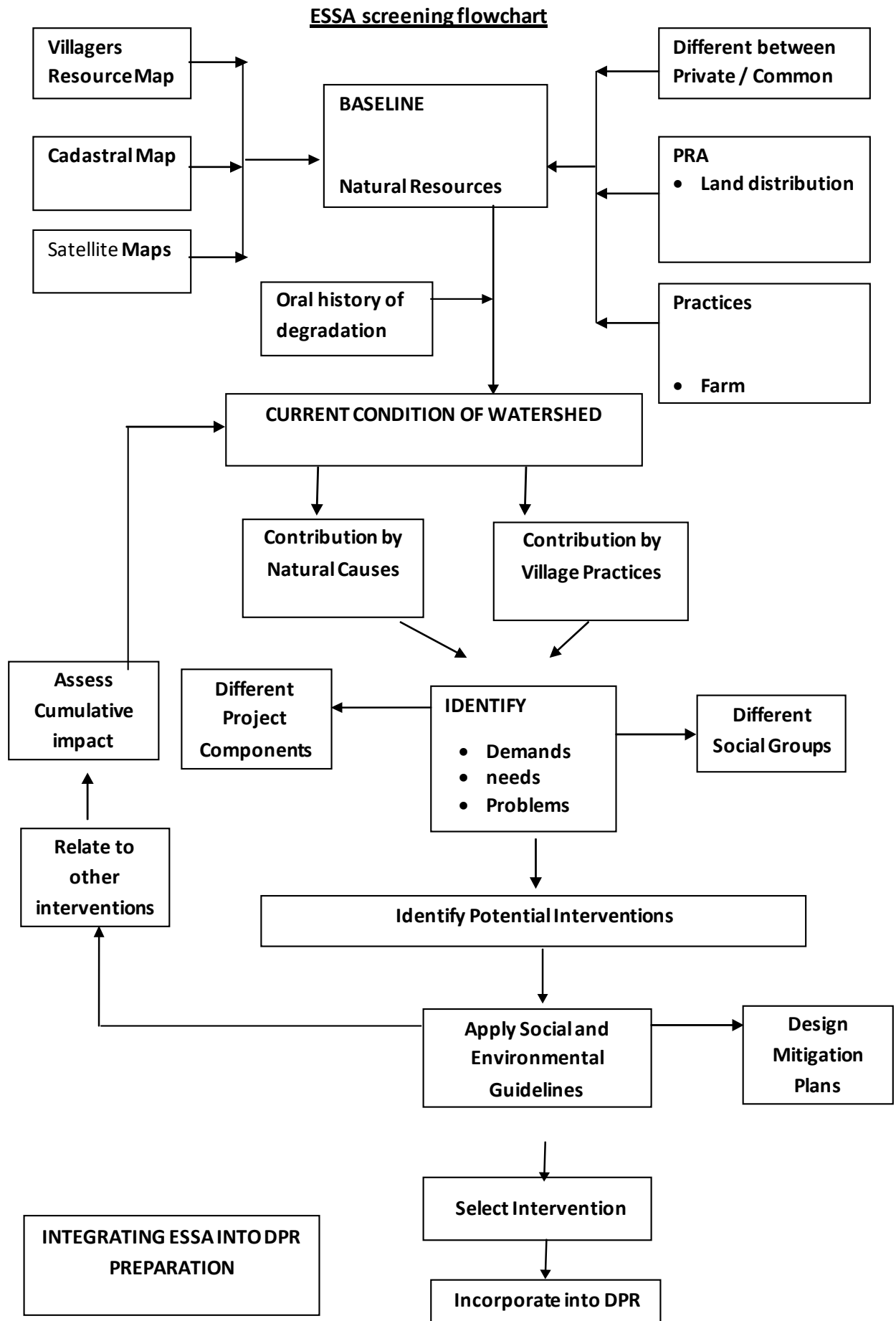
#### **J. Integrating Environment and Social Issues into DPR Preparation**

The methodology for mainstreaming social and environmental issues into integrated watershed planning at micro watershed level has been shown in the flowchart below. The significant steps are as follows:

1. The process of mainstreaming begins with establishing baseline data for the watershed. With respect to status of the natural resources, as well as the people's dependencies on the resources.
2. The inputs such as fragile and environmentally sensitive areas etc. would come from the different sources like secondary sources available with different departments, identified by the community and other locally available sources. which will be overlaid on the cadastral map, and supplemented by the satellite images prepared by KRSRAC.
3. The social baseline including different traditional practices followed by different sections of the village (farming, livestock, and non-farm activities), the geographical distribution of land and its ownership will be taken into consideration.
4. The baseline would be supplemented by documentation of oral history by the villagers to provide an overview of what were the causes of the degradation/ enhancement of natural resources over time and how this has affected the people's dependence.
5. The Current Condition of the watershed would thus be assessed in the context of the contribution over time and space, both by natural causes like floods, droughts and manmade causes like industrialization, road widening etc. as well as the village practices (cultivation, clearance, grazing).
6. This would lead to an identification of what are the demands of the different social groups (landowners, marginal farmers, landless), what are the needs of the watershed area (soil, water, vegetation), and what are the ensuing problems.
7. This would provide set of potential interventions that could fulfil the demands of the

people's dependency on the natural resources of the watershed, on both arable as well as non-arable lands, and focusing on harnessing the benefits of resources along the natural drainage lines.

8. When the social and environmental guidelines are applied to these potential interventions, they become an analytical tool for selecting the most optimum set of interventions that would enhance the productivity as well as equity of the watershed, and these are incorporated into the Action Plan.
9. In case the impact of the interventions is likely to be severe, then management measures have to be redesigned without altering science behind such intervention to suite the local needs and this feedback is critical for selecting/modifying/rejecting a particular intervention or activity.
10. Another critical issue to be addressed is to assess the cumulative impact of all these activities, which would then change the current condition of the watershed, the nature of the villagers' dependency on the resource base, and the consequent interventions.
11. Get community opinion by conducting one or two focus group discussions at each MWS level for each group once all the interventions are finalized after community consultation.
12. ESSA screening flowchart and formats are given below.



## ANNEXURE-I

### 1. Suggested PRA methods for establishing baseline on natural resources and vulnerable families in the watersheds

| Method   | Use   |
|--|---|
| Wealth Ranking                                 | Serves to rank families in the village according to their economic status and thus identify all families that are vulnerable. Further analysis in this exercise can yield data on who among the vulnerable group are members of existing SHGs and other CBOs.   |
| Resource Mapping                               | Helps to identify natural resources in the village/micro watershed and assess their status in terms of condition, ownership, usage, conflicts, dependency of vulnerable groups, etc.  |
| Social Mapping                                 | Identifies the existing village infrastructure and habitation patterns in the village, key infrastructure and other needs that can be used for identifying EPAs.  |
| Time line<br>Trend and<br>Seasonality analyses | Helps to understand the history of the village<br>Reveals the important trends in the condition of natural resources in the village (water availability, rainfall, forest cover, etc.) and the seasonal variation relevance to the watershed project (rainfall, pest and disease attacks, water availability, etc.) |

### 2. SWS wise baseline data to be established by FNGO

| #   | Particulars  | Source   |
|-----|--|--|
| 1.  | Population (OBC/SC/ST/Minorities/others and gender distribution)                       | Census /Taluk Office   |
| 2.  | Size class distribution of farmers   | Agril. Dept.   |
| 3.  | No. of landless households   | Agril. Dept.   |
| 4.  | Land use classification  | census   |
| 4.  | Livestock population   | Livestock census   |
| 5.  | occupational paten   | census   |
| 6.  | Work Force(Main workers & Marginal workers)  | census   |
| 7.  | Area, production and productivity of major crops                                       | Agril. & Horti. Dept.  |
| 8.  | Reserve forests & Eco-sensitive area nearby  | Forest Dept.   |
| 9.  | Any endangered species nearby  | Forest Dept.   |
| 10. | Soil quality issues  | LRI data   |
| 11. | Any factories or industries depending on the natural resources like water, timber etc. | District Industries Dept.                                      |
| 12. | Any heritage sites nearby  | District Directory, District at a glance                       |
| 13. | Identification of vulnerable groups  | Wealth Ranking   |
| 14. | Resource Inventory of Natural Resources and CPRs                                       | Resource Mapping   |
| 15. | Listing of Existing CBOs in the watershed area   | Grama Panchayat/Women & Social Welfare Dept./house hold visits |

|     |   |            |
|-----|---|------------|
| 16. | <ul style="list-style-type: none"> <li>• GIS map on eco-sensitive and cultural sites like reserve forest, areas reserved for endangered species, protected animal corridor, physical and cultural heritage monuments, religious or socially sacred areas etc.</li> <li>• area impacted with salinity (Ece=&gt;4.0) &amp; sodicity (ESP=&gt;25), waterlogged area, designated wet lands as per Ramsar classification etc.</li> </ul> | LRI inputs |
|-----|---|------------|

### 3. Format for collecting environmental baseline data

| 1. General information |  |                 |   |
|------------------------|--|-----------------|---|
| Sl. No.                | Criteria / Information to check for                              | Details         |   |
| 1.1                    | Date of Site Visit   | :               |   |
| 1.2                    | Site information   | Village         | : |
|                        |  | Micro Watershed | : |
|                        |  | Watershed       | : |
|                        |  | Gram Panchayat  | : |
|                        |  | Taluk           | : |
| 1.3                    | Name of site visit person  | :               |   |
| 1.4                    | Name and designation of information provider                     | :               |   |
| 1.5                    | Visiting in presence of (Full name & Designation)                | :               |   |
| 1.6                    | Type of utilization (mention agriculture/wasteland/fallow)       | :               |   |
| 1.8                    | Land pattern of the area (Plain / Valley / Hilly / Plateau etc.) | :               |   |
| 1.9                    | Land Ownership   | :               |   |
| 1.10                   | Land pattern/type and utilization to adjacent upper ridge area   | :               |   |

| Sl. No.             | Criteria / Information to check for  | Details | Issues or Management Measure in brief |
|---------------------|--|---------|---------------------------------------|
| <b>2. Resources</b> |  |         |                                       |
| <b>2.1</b>          | <b>Forest Land</b>   |         |                                       |
| 2.1.1               | Nearest forest area (Reserve forests, Protected forest or Revenue Forest)  |         |                                       |
| 2.1.2               | Distance from project Watershed  |         |                                       |
| 2.1.3               | Is the Project located in ecologically sensitive zones? Mention distance of nearest ecologically sensitive area with details |         |                                       |
| 2.1.4               | Is there any Wildlife sanctuary, Bio-reserve, National Park or notified Eco Sensitive Zone in the area of influence?         |         |                                       |
| 2.1.5               | Important/ Sensitive animal (fauna)  |         |                                       |

|        |  |  |  |
|--------|--|--|--|
| 2.1.6  | Important/Sensitive plant (flora)  |  |  |
| 2.1.7  | Current use of forest for any livelihood activity  |  |  |
| 2.2    | <b>Grazing Land</b>  |  |  |
| 2.2.1  | Area (indicate any encroached area separately)   |  |  |
| 2.2.2  | Fallow Land  |  |  |
| 2.2.3  | Pasture Land   |  |  |
| 2.2.4  | Culturable Waste Land  |  |  |
| 2.2.5  | Season of green fodder scarcity  |  |  |
| 2.2.6  | Season of green and dry fodder scarcity  |  |  |
| 2.2.7  | Major animals grazed in land   |  |  |
| 2.2.8  | Nearest grazing area from the watershed (km)   |  |  |
| 2.3    | <b>Biodiversity</b>  |  |  |
| 2.3.1  | Major type of animals in area  |  |  |
| 2.3.2  | Major type of plants in area   |  |  |
| 2.3.3  | Are there any migratory birds?   |  |  |
| 2.3.4  | Season of the migratory birds found  |  |  |
| 2.3.5  | Primary habitat of migratory birds   |  |  |
| 2.3.6  | Important/Sensitive animal (fauna) in locality   |  |  |
| 2.3.7  | Important/Sensitive plant (flora) locality   |  |  |
| 2.3.8  | Any medicinal plants found in area   |  |  |
| 2.3.9  | Are there any diseases found in domestic animals   |  |  |
| 2.3.10 | Is there available any veterinary doctor/hospital?   |  |  |
| 2.4    | <b>Agriculture</b><br>Need to check if ground data is align to LRI and DSS data, if not then have to mention it clearly in Remark column |  |  |
| 2.4.1  | Cropping pattern (mono-cropping/ mixed cropping/crop rotation)   |  |  |
| 2.4.2  | Main crops grown (Rabi, Kharif, and horticultural crops)   |  |  |
| 2.4.4  | Pesticides/ fertilizer usage   |  |  |
| 2.4.5  | Source of irrigation   |  |  |
| 2.4.6  | Extent of irrigation (% of sown area which is irrigated)   |  |  |
| 2.5    | <b>Soil Quality</b>  |  |  |
| 2.5.1  | Any Soil Quality issue including salinity range of soil  |  |  |
| 2.5.2  | Any heavy metal or pesticide reported in soil.   |  |  |
| 2.6    | <b>Ground Water</b>  |  |  |
| 2.6.1  | No of tube wells   |  |  |
| 2.6.2  | Total number of dried-up tube wells  |  |  |
| 2.6.3  | Depth of Ground water of active and in use tube well (indicate feet or meters) approximate   |  |  |
| 2.6.4  | Mention Ground water quality issue (like salinity, nitrate, Fluoride, Heavy metals etc.)   |  |  |
| 2.7    | <b>Surface Water</b>   |  |  |
| 2.7.1  | No of ponds  |  |  |

Reference material, CoE-WM

|       |  |  |  |
|-------|--|--|--|
| 2.7.2 | Details of Wetland (Ramsor classification) with its location with its watershed number |  |  |
| 2.7.3 | Details of any canals, streams with location in respect to watershed                   |  |  |
| 2.7.4 | Mention any surface water quality issue.   |  |  |
| 2.7.5 | Period of water availability in ponds  |  |  |
| 2.7.6 | Distance of Major river from the watershed   |  |  |
| 2.8   | <b>Common Property Resources</b>   |  |  |
| 2.8.1 | Is there any common property resource area located within the watershed                |  |  |

## Community Based Organizations under REWARD

### 1. Self Help Groups under REWARD

#### How to involve Self-Help Groups?

Identifying the vulnerable families

- ◆ Identify and prepare the list of existing SHGs
- ◆ Identify vulnerable families in the villages in the micro watershed through PRA using Wealth Ranking Exercise.
- ◆ Find out if any of the vulnerable families are not covered under existing SHGs
- ◆ If there are such families, try to accommodate them with the existing SHGs or else form new SHGs for left out families.
- ◆ Corroborate the outcome with BPL list for the village
- ◆ Crosscheck the findings with the villagers and by visiting concerned families in case of mismatched data.

#### Formation of SHGs

If there are any vulnerable families were not covered under the existing SHGs additional SHGs can be formed by following below points.

- ◆ Hold formal or informal meetings with those families that are eligible to form SHGs and provide them with sufficient information to clarify why they need to be in SHGs and how they can form a group
- ◆ If required expose them to nearby well-functioning SHGs
- ◆ Once a group of people agree to form a self-help group facilitate them to conduct their meetings regularly at a fixed time and place and maintain basic documents like the Minutes Book and passbooks, cashbook, etc. Ask the members to get registered in the respective groups by paying a minimum membership fee fixed by the group itself.
- ◆ Help the group to start regular savings, to fix the amount to be saved and the frequency of savings
- ◆ Facilitate the group to purchase essential books, registers, seal, identify its representatives, etc.
- ◆ Support the group to open a savings Bank Account in the name of the group
- ◆ Introduce detailed book-keeping systems, train the bookkeeper of the SHG
- ◆ Support the SHG to form its own rules, regulations and norms regarding sanctions if rules are violated
- ◆ During the process provide the SHG members with the essential modules of training

### **Functions of Self-help Groups:**

Self-help Group members have a responsibility to improve their economic position by regular savings and credit in the SHG. Self-help Groups must play a pivotal role in the REWARD by being active partners of the WECs by addressing the issues, concerns and rights of the vulnerable groups in the program. Their role and functions in REWARD are as follows:

- All members of the SHG are members of the general body of the WEC. Additionally, they should meet weekly, ensure at least 80% attendance in their weekly meetings, save regularly and maintain required books.
- Each SHG must select a member to represent the group in every WEC; some of them will be members of WEC and others are invitees, the SHG must also change this representative every year
- The SHG should attend all the general body meetings of the WEC
- The SHG, by virtue of being a part of General Body, can review the progress and accounts of the WEC and suggest areas for improvement; the SHG may also request the WEC to call a special meeting for the same
- Assist the WEC to collect contributions for the watershed activities.

### **Vulnerable Group Sub-Plan related**

- Prepare and submit a Vulnerable Group Sub-Plan to support its members for non-farm or on-farm income generating programmes (IGPs)
- Select suitable candidates for Entrepreneurship Development and Skill Training programmes with a preference to landless and marginal farmer members.
- Assist the Entrepreneurship Development FNGO (EDP) to frame proposals for individuals and groups in the SHG.
- The SHG representative to the EC should participate in preparing the DPR and share the information with SHG members.
- Prepare and submit a list of people who need employment opportunities and willing to provide labour for watershed activities
- Actively involved in planning activities for common land treatment so that SHG members and other vulnerable families can be benefited from these activities in the long-term through usufruct rights and income generation
- Actively involved in implementing activities on common land by taking up contract for such activities.
- Influence the WEC to ensure equal wages for men and women

### **Learning and Linkages related**

- Attend all training and exposure programmes conducted.
- Establish linkages with banks and other institutions for the social, economic and political betterment of the members.
- The SHG representative in the W E C must come back and share all the W E C meeting proceedings with their respective groups.

## **2. AREA GROUPS (AGs)**

Area Groups of farmers owning land in a particular mini-micro catchment within a micro watershed. By forming Area Groups, the project aims to decentralize some of the micro management decisions and increase people's participation beyond the Watershed Executive Committee.

- **Membership:** All farmers owning land in a particular mini-micro-catchment are members of Area Groups. The catchment is delineated in such a way that 40-50 farmers have land in the area. This way membership of the AG is limited to a small number. In case a farmer owns land in more than one mini-micro-catchment, s/he may choose to be a member of any one Area Group as per the convenience.
- Since plans are prepared first at the farmer level and then consolidated at the Area Group and the MWS level, the role of Area Groups becomes very important during planning, monitoring and post project management.

### **How to form Area Groups?**

- Download the sub-watershed and micro watershed maps showing drainage lines and cadastral boundaries from the digital library.
- Identify smaller drainage lines on the micro watershed map and superimpose the drainage map on a cadastral map. Demarcate smaller contiguous area around these drainage lines covering about 100 to 150 ha.
- Form such 4 to 5 area groups per MWS.
- Generate survey no. wise Khatedar list showing the names of farmers owning lands in each group.

### **Functions and Role of Area Groups:**

- All members of the AGs are constituents of the General Body of the WEC and are expected to function similar to Self-help Groups in planning and implementation.
- Their main responsibility is to plan the programs in their area and get the work executed.
- The AG should attend all the general body meetings of the WEC and suggest areas for improvement; the AG may also request the WEC to call a special meeting for the same if required.
- Assist the WEC to collect contributions for the watershed activities

### **Watershed Planning and Implementation**

- All AG members should participate in preparing the sub-plan with technical guidance of watershed development team, the AAO and the FNGO staff.
- AG representatives to the WEC should involve in the consolidation of DPR and share the information with the AG members.
- AG members should be aware of the environment and social aspects and comply with any issues identified.
- Collect the contribution for watershed activities and remit the same to the WEC.

- Maintain the structures created in their micro watershed
- Mobilize funds for maintenance and development works on their lands
- Attend all training and exposure programmes conducted.
- The AG representative in the EC must come back and share all EC meeting proceedings with their respective groups.

### 3. Watershed Executive Committee (WEC)

#### i) Composition of watershed executive committee

Watershed EC is the conglomeration of community-based organizations, elected representatives of GP, WDD officials and NGO representative. Watershed -Executive Committee is constituted to implement the watershed projects with the technical support of multi-disciplinary team of Watershed Development Department (WDD). The Watershed Executive Committee (WEC) is constituted as a subcommittee of Grama Panchayat under Karnataka Gram Swaraj and Panchayat Raj Act 1993, Section 61 (A). It operates at Gram Panchayat (GP) level consisting of following representatives;

| Sl. No. | Members   | Designation             |
|---------|---|-------------------------|
| 1       | President of Gram Panchayat                       | Chairperson             |
| 2       | Gram Panchayat Member from project area           |                         |
| 3       | Area Group members (5-6)                          | Member                  |
| 4       | SHG Members (4-5)                                 | Member                  |
| 5       | Farmer Producer Organization Members (2-3)        | Member                  |
| 6       | Agriculture Officer/Assistant Agriculture Officer | Treasurer cum secretary |

\*Note: In order to ensure gender participation, gender equity and social inclusion, preference will be provided for women and SC and ST members.

#### ii) WEC office

The Watershed Executive Committee (WEC) would be provided with an office space in the premises of GP office or housed in the nearby RSKs. The office will be supervised by the treasurer/secretary of the respective WEC/RSK wherein the records and documents related to the respective watershed area along with land resource information data sets will be maintained. This office shall be equipped with minimum office infrastructure. The office expenses including rental expenses if any shall be charged from the administrative expenses of the project.

#### iii) Roles and responsibilities of the WEC

The most important people's body responsible for the project success is the WEC, as it shall shoulder the major responsibility for preparing and executing the project plan. It shall be guided all along by the WDT.

- To ensure active partnership of the project community in planning and implementation.
- To approve works and activities to be taken up as per action plan and DPR. It shall adhere to cost norms approved by the State Government, i.e., Schedule of Rates

- (SRs) for different infrastructure works. In case of individual beneficiary activities, the rates as prescribed under the scheme shall be the norm.
- c) To prepare plans for implementation at GP level and submit it in the planning module of e Gram Swaraj LRI inputs with the help of WDT.
  - d) To open two separate bank accounts in one a zero balance joint bank account in one of the scheduled banks and operate it under the joint signature of the account holders (President-WEC, Project leader of PIA & Treasurer cum Secretary-WEC) and second for operating WDF fund.
  - e) To receive funds entitled under these Guidelines into the bank account and after expenditure submit utilization certificates to PIA for further submission.
  - f) To focus on nurturing community participation by supporting various Area Groups, Self- Help Groups as well as FPO. It shall enforce regulatory norms relating to various assets and resources created and developed through action plan with the help of Gram Panchayat.
  - g) To conduct annual audit of natural resources leading to asset maintenance plan, water budgeting exercise, twice a year for establishing regulatory norms on water use, and laying down protection norms for regeneration of the common land.
  - h) To own resources during the implementation of project activities and enforce its implementation by taking necessary support of Gram Panchayat and PIA. The new generation watershed development program is expected to generate wider experiences in community managed participatory governance of natural resource management for universalization.
  - i) To finally transfer the assets created to the Gram Panchayat at the end of the project. Further, it shall take an active part in inspecting the assets and works from time to time and ensure their repair, maintenance and up gradation as required. For this, financial resources available from ongoing schemes under GP and Watershed Development Fund (WDF) may be accessed.

**iv) Role of secretary cum treasurer, WEC**

Concerned RSK AO will be the Secretary cum treasurer of the WEC (WC), would work under the direct supervision of the Project Implementing Agency (PIA) and President of Watershed Executive Committee (WEC). The Secretary will be responsible for the following tasks:

- a) Convening meetings of the Gram Sabha, Gram Panchayat,
- b) Facilitating the decision-making processes in the context of Watershed Development.
- c) Taking follow up action on all decisions.
- d) Maintaining statement of accounts and all other records of project activities and proceedings of the meetings
- e) Ensuring payments and other financial transactions.
- f) Record of all works and activities carried out and assets transferred to the GP.

**v) Role of gram Panchayat**

- a) GP shall assist in the process of social mapping that helps to understand the socio-economic condition of the GPs and of households that mutually helps in deciding and allocating resources in the watershed area besides helping in formation of FIGs and market linkage activities.
- b) Assisting WEC in identification of beneficiaries for watershed Developmental activities.
- c) Facilitate the convergence of various projects/ schemes to institutions of watershed development project.
- d) Convening Gram Sabha for getting approval of the DPRs
- e) Provide office accommodation and other requirements to WEC.
- f) Allocate usufruct rights to deserving area groups/ SHGs over the assets created. Maintain asset registers and WDF fund during and post watershed development period.

**Trainings for CBOs****I. SHG Trainings:**

| <b>Project Phase</b>     | <b>Module</b> | <b>Topic</b>  |
|--------------------------|---------------|---|
| Preparatory Phase        | S1            | Orientation on REWARD Program, functions, roles and responsibilities, ESSA compliance and participatory planning. |
| Implementation Phase     | S2            | Gender and social Inclusion, implementation and Maintenance, accounts and book keeping                            |
| Project Withdrawal Phase | S3            | Project Withdrawal Strategy, Linkages and Post-Project Maintenance.   |

**II. Area Group Trainings (AGs):**

| <b>Project Phase</b>     | <b>Module</b> | <b>Topic</b>  |
|--------------------------|---------------|---|
| Preparatory Phase        | AG1           | Overview of REWARD, formation, functions, roles and responsibilities, ESSA compliance, gender & social inclusion, participatory planning and DPR preparation. |
| Implementation Phase     | AG2           | Environmental and social Screening under REWARD and gender & social inclusion   |
| Project Withdrawal Phase | AG3           | Project Withdrawal Strategy and Post-Project Maintenance  |

**III. Watershed Executive Committee (WEC):**

| <b>Project Phase</b>     | <b>Module</b> | <b>Topic</b>   |
|--------------------------|---------------|--|
| Preparatory Phase        | E1            | Orientation about REWARD, roles & responsibilities, DPR preparation and community validation   |
| Implementation Phase     | E2            | Book Keeping, Accounting, Transparency, reporting, Beneficiary Contribution, Implementation and monitoring and Gender & social Inclusion |
| Project Withdrawal Phase | E3            | Project Withdrawal Strategy and Post-Project Maintenance.  |
|                          | E4            | Exposure Visit   |

**Trainings to be conducted by DATCs for field level stakeholders**

| Sl.No. | Training title  | Participants  | No. of Participants | SWS | Total Participants | No. of Trg | Duration (Days) |
|--------|---|---|---------------------|-----|--------------------|------------|-----------------|
| 1      | Induction training for FNGO staff   | TL-1, WM-1, WA-5, and Ac-1                                  | 8                   | 20  | 160                | 4          | 4 days          |
| 2      | Orientation program for the Department Staff  | JDA, DDA, ADA   | 3                   | 20  | 60                 | 2          | 2days           |
| 3      | Orientation , DPR preparation, ESSA, Implementation Staff   | RSK AO, TO, AAO   | 5                   | 20  | 100                | 3          | 3 days          |
| 4      | Training on Social mobilisation, CBO formation and functioning, roles and responsibilities, book keeping and accountancy, LRI based DPR preparation | FNGO (TL & TS), AAO, Dist. Coordinator                      | 4                   | 20  | 80                 | 2          | 3 days          |
| 5      | Environmental and Social Assessment Training  | FNGO (TL & TC), AAO, Dist Coordinators                      | 4                   | 20  | 80                 | 2          | 2 days          |
| 6      | DPR preparation, validation and Implementation  | WA, TC  | 6                   | 20  | 120                | 4          | 2 days          |
| 7      | DPR preparation, validation and Implementation  | 3 from each EC, FGNO-TL and WM, Avg 4 LRI extn Managers/SWS | 9                   | 20  | 180                | 6          | 2 days          |

Reference material, CoE-WM

|    |  |                                      |    |    |      |    |         |
|----|--|--------------------------------------|----|----|------|----|---------|
| 8  | Technical trainings on insitu soil and water conservation structures                 | AO / AAOs                            | 3  | 20 | 60   | 2  | 5 days  |
| 9  | Implementation of DPRs in model watersheds and Quality control                       | WA                                   | 5  | 20 | 100  | 2  | 3 days  |
| 10 | Technical training on water harvesting structures and Quality control                | AO / AAOs                            | 3  | 20 | 60   | 2  | 5 days  |
| 11 | Technical training on Agro-Horti-silvi pasture                                       | ACF, RFO, SADH, AHO                  | 2  | 20 | 40   | 2  | 2 days  |
| 12 | Training on Income Generating and Livelihood Activities                              | Training Co. and TL, Dist Co         | 3  | 20 | 60   | 2  | 3 days  |
| 13 | Refresher course on soil and water conservation structures and Quality control       | AO / AAOs                            | 3  | 20 | 60   | 2  | 3 days  |
| 14 | Documentation of Success stories, Project Exit Strategy and post project maintenance | 3/EC, FGNO-TL, TS, District Co., AAO | 9  | 20 | 180  | 4  | 2 days  |
| 15 | Maintenance of community WHS using WDF   | PDO, EC president, AO                | 9  | 20 | 180  | 4  | One day |
| 16 | Induction Course in case of staff turnover (30%)                                     | AO, AAO, NGO staff                   | 3  | 20 | 60   | 2  | 3 days  |
| 17 | Training to EC members in one model Sub watershed in each DATC                       | EC members                           | 45 | 2  | 1080 | 12 | 2 days  |

**I. Composition of Watershed Development Team (WDT)**

1. Assistant Director of Agriculture of the Taluk-Team leader
2. Senior Assistant Director of Horticulture
3. Assistant Director of Horticulture
4. Assistant Conservator of Forest
5. Range Forest Officer
6. Agriculture Officer of respective RSK
7. Assistant Agriculture Officer of the respective RSK
8. District REWARD Coordinator
9. FNGO team leader
10. FNGO training coordinator
11. FNGO Watershed Assistant
12. WEC President
13. Two GP representatives
14. Two to three representatives from the Area Groups
15. Two to three representatives from the SHGs
16. Two to three representatives from the local FPO

**II. ROLE OF MAJOR PARTNERS DURING PLANNING:**

**Role of Agriculture assistant (AAO) / Watershed Assistant (WA)**

- Be a part of the task team and actively participate in planning
- Make available all the maps related to the area, the khatedar list, etc.
- Give the required technical assistance during planning.
- Check the appropriateness of the interventions suggested by the farmers with regards to their location, their size, the utility, technical feasibility, etc.
- Participate actively in the resource and intervention mapping and give technical inputs during the process.
- Assist the FNGO in consolidation of plans prepared at farmer and Area Group level. Bring to the notice of the FNGO in case of technical inappropriateness of any intervention.
- Facilitate the process of approval of the DPR by the General Body and answer queries related to technical aspects if any.
- Environment and Social Impact assessment to be carried out by using the prescribed formats.

- Assist the documentation officer of the FNGO to compile the field information.
- Verifying the compiled information – once again with the AG's, before finalizing.
- Prepare annual action plan for implementation.

### **III. Role of FNGO**

- Lead role along with AAO/WA and WEC in the entire planning process starting from planning on farmers land to the preparation and finalization of SWAP.
- Conduct resource and intervention mapping exercise at each mini-micro catchment and micro watershed level.
- Consolidate the DPR at the Area Group and micro-watershed level and present the finalized document to the scrutinisation committee.
- Ensure integration of Environmental and Social issues in DPR by helping to generate ESA in prescribed formats.
- Ensuring participation of SHGs, Area Groups in DPR preparation.
- Ensure participation of all the vulnerable families dependent on the resources of the common property while planning on common lands.
- Ensure that the vulnerable families are benefited from planning on the common land - in terms of labour availability, sharing of usufructs, etc.
- Ensure that the landless and other category of people dependent on agriculture labour for their livelihood are not deprived of it in this project.
- Assist the SHGs and Area Groups in preparing plans for maintenance of the assets and help them to develop norms for equitable sharing of benefits and resources.
- Facilitate the approval of DPR at the General Body.
- Facilitate the WEC to prepare Annual Action Plan along with AAO / WA.
- Help in resolving any conflicts that arise during planning.

### **IV. Role of the Watershed Executive Committee (WEC)**

- Be a part of the task team and actively participate in the planning process starting from the farmer level planning to the preparation of the DPR.
- Based on their experience from the exposure visit, try to educate the farmers about the various activities that can be taken up under a watershed programme.
- Orient the farmers about the contribution aspects of the works proposed and stress on the need for timely payment of contributions.
- Ensure participation of all the vulnerable families dependent on the resources of the common property while planning on common lands.

*Reference material, CoE-WM*

- Ensure that the vulnerable families are benefited from planning on the common land - in terms of labour availability, sharing of usufructs, etc.
- Actively participate in preparation of annual action plans
- Ensure that the landless and other categories of people dependent on agriculture labour for their livelihood are not deprived of it in this project.
- Plan for management and maintenance of the common property resources with active participation of all the people dependent on those resources.
- Call for the General Body meeting and get the SWAP approved.
- Follow up the process of DPR approval.

**DPR Training**

**Program schedule for 2 days district level training workshop on DPR preparation using LRI inputs**

| #                                      | Subject   | By  | Timings              |
|--|---|---|----------------------|
| <b>Day-1</b>                           |   |   |                      |
| 1                                      | <b>Introduction about REWARD program</b> , Program objective, Uniqueness, Activities & Implementation methodologies, Institutional arrangements, M&E etc.,  | District Joint Director of Agriculture                  | 10.00 am to 10.30 am |
| 2                                      | <b>Land Resource Inventory (LRI) and Hydrological studies under REWARD:</b> Data collection, analysis & integration into Digital library & LRI inputs, Adoption of LRI and Hydrological recommendations for Watershed development projects.   | Nodal scientists from concerned partner institution.    | 10.30 am to 11.30 am |
| <b>Tea Break:</b> 11.30 am to 11.45 am |   |   |                      |
| 3                                      | <b>Orientation about Preparation of draft Detailed project reports (DPR)</b> for watershed treatment using LRI & Hydrological data/atlas & running DSS in the LRI inputs: Process involved in preparation of draft DPR, community consultations & approval, EPA, implementation in convergence with other schemes like MGNREGA. | Deputy Director of Agriculture, DATC, Mysore/Vijayapura | 11.45 am to 12.30 pm |
| 4                                      | <b>Orientation to Watershed development team (WDT)</b> about their role in preparation and approval of draft DPR by involving community and adoption of ESSA principles in implementation.  | Deputy Director of Agriculture, DATC, Mysore/Vijayapura | 12.30 pm to 1.00 pm  |
| 5                                      | Orientation of WEC, AG & SHGs about their role in preparation and approval of draft DPR by involving community.   | Concerned NGOs representative                           | 1.00 pm to 1.30 pm   |
| <b>Lunch Break:</b> 1.30 pm to 2.00 pm |   |   |                      |
| 6                                      | Live demonstration of DPR preparation through LRI inputs for a selected micro-watershed.  | M/s Ceinsys Tech Pvt. Ltd.                              | 2.00 to 3.00 pm      |
| <b>Tea Break:</b> 3.00 pm to 3.15 pm   |   |   |                      |
| 7                                      | Practice sessions regarding draft DPR preparation through LRI inputs for the participant members.   | M/s Ceinsys Tech Pvt. Ltd.                              | 3.15 pm to 5.30 pm   |
| <b>Day-2</b>                           |   |   |                      |
| 1                                      | Field visit to nearby project micro-watershed for demonstration of field validation and community consultation of draft DPR prepared  | Entire Team led by ADA                                  | Forenoon             |
| 2                                      | Demonstration of PRA Exercises  | FNGO staff led by team leader                           | Afternoon            |

## Private Land Treatment Plan Format:

| SI No | MWS_CODE | Hobli | G.P Name | Village | Survey_hissa | Acre | Gunta | Area_ha | Owner Name | Gender (M/F) | Caste (SC/ST/OBC /Minority/General) | Category (MF/SF /MEF/LF) | Farmer code | AG Code | Fruit ID | Soil Phase | Activity (SWC /HORT./ FORT. /DLT) | Sub Activity (TCB, GB, SCB, FP, WW, HORT, AGRO FOR) | Size / Section | Quantity | Actual RMT / HA / NO | Unit Cost | Total Activity Cost | Total Beneficiary Cost | S1 | S2 | S3 |
|-------|----------|-------|----------|---------|--------------|------|-------|---------|------------|--------------|-------------------------------------|--------------------------|-------------|---------|----------|------------|-----------------------------------|---|----------------|----------|----------------------|-----------|---------------------|------------------------|----|----|----|
| 1     | 2        | 3     | 4        | 5       | 6            | 7    | 8     | 9       | 10         | 11           | 12                                  | 13                       | 14          | 15      | 16       | 17         | 18                                | 19  | 20             | 21       | 22                   | 23        | 24                  | 25                     | 26 | 27 | 28 |
| 1     |          |       |          |         |              |      |       |         |            |              |                                     |                          |             |         |          |            |                                   |   |                |          |                      |           |                     |                        |    |    |    |
| 2     |          |       |          |         |              |      |       |         |            |              |                                     |                          |             |         |          |            |                                   |   |                |          |                      |           |                     |                        |    |    |    |
| 3     |          |       |          |         |              |      |       |         |            |              |                                     |                          |             |         |          |            |                                   |   |                |          |                      |           |                     |                        |    |    |    |

## Drainage Line and Common land treatment details

|         |         | <b>District :</b>             |                           |          |                    |                        |                               |          |           |            |                             |    |          |        |       |            |
|---------|---------|-------------------------------|---------------------------|----------|--------------------|------------------------|-------------------------------|----------|-----------|------------|-----------------------------|----|----------|--------|-------|------------|
|         |         | <b>Taluk :</b>                |                           |          |                    |                        |                               |          |           |            |                             |    |          |        |       |            |
|         |         | <b>Sub Watershed Name :</b>   |                           |          |                    |                        | <b>Sub Watershed Code :</b>   |          |           |            |                             |    |          |        |       |            |
|         |         | <b>Micro Watershed Name :</b> |                           |          |                    |                        | <b>Micro Watershed Code :</b> |          |           |            |                             |    |          |        |       |            |
| Sl. No. | Village | Survey No.                    | Identification /Ownership | Location | SWC/HORT/FORT/DLT) | Sub Activity           | Dimension / Section           | Quantity | Unit Cost | Total Cost | Expected No. of Beneficiary |    |          |        |       | User Group |
|         |         |                               |                           |          |                    |                        |                               |          |           |            | SC                          | ST | Minority | Others | Total |            |
| 1       | 2       | 3                             | 4                         | 5        | 6                  | 7                      | 8                             | 9        | 10        | 11         | 12                          | 13 | 14       | 15     | 16    | 17         |
| 1       |         |                               |                           |          |                    | Boulder Check          |                               |          |           |            |                             |    |          |        |       |            |
| 2       |         |                               |                           |          |                    | Rubble Check           |                               |          |           |            |                             |    |          |        |       |            |
| 3       |         |                               |                           |          |                    | Check Dam              |                               |          |           |            |                             |    |          |        |       |            |
| 4       |         |                               |                           |          |                    | Gokatte                |                               |          |           |            |                             |    |          |        |       |            |
| 5       |         |                               |                           |          |                    | Institution plantation |                               |          |           |            |                             |    |          |        |       |            |
| 6       |         |                               |                           |          |                    | Nala Rivetment         |                               |          |           |            |                             |    |          |        |       |            |
| 7       |         |                               |                           |          |                    | Nala Plantation        |                               |          |           |            |                             |    |          |        |       |            |
| 8       |         |                               |                           |          |                    | Tank Development       |                               |          |           |            |                             |    |          |        |       |            |
| 9       |         |                               |                           |          |                    | Water Way              |                               |          |           |            |                             |    |          |        |       |            |
| 10      |         |                               |                           |          |                    | Block Plantation       |                               |          |           |            |                             |    |          |        |       |            |
| 11      |         |                               |                           |          |                    | RRS                    |                               |          |           |            |                             |    |          |        |       |            |
| 12      |         |                               |                           |          |                    | RTW                    |                               |          |           |            |                             |    |          |        |       |            |
| 13      |         |                               |                           |          |                    | Nala Bund              |                               |          |           |            |                             |    |          |        |       |            |
| 14      |         |                               |                           |          |                    | Diversion channel      |                               |          |           |            |                             |    |          |        |       |            |

**Annexure VIII**

**Area Group Treatment Plan:**

Area Group Name & Number: \_\_\_\_\_

Name & Code of the MWS \_\_\_\_\_

Total Area of Area Group: \_\_\_\_\_

Name of the Village \_\_\_\_\_

Taluk \_\_\_\_\_

District: \_\_\_\_\_

**(The above information should be on cover page of AG wise treatment plan. The print out of AG wise DPR excel sheet needs to be carried for transect walk and if any changes/ corrections suggested by farmers at the time of transect walk, they need to be noted down in the below format. The changes/modifications should be based on field situation and in line with LRI inputs.)**

**Annexure IX**

**Any suggested modifications or deletions should be recorded in the following format**

| Sl. No. | Soil Phase | Survey No./Nos. | Farmer name | Private Land(PL)/CPR | Recommended Intervention | Suggested Modification/Deletion |
|---------|------------|-----------------|-------------|----------------------|--------------------------|---------------------------------|
|         |            |                 |             |                      |                          |                                 |
|         |            |                 |             |                      |                          |                                 |
|         |            |                 |             |                      |                          |                                 |

**Precaution to be taken while recording the modifications or deletions;**

- Suggested modifications should not lead to altering the entire plan
- Concerted efforts to be made to convince the beneficiary about the plan prepared keeping in view of existing condition of the soil and topography
- Ensure complying key recommendations of LRI and ESSA principles

**Screening Guidelines on Social Issues**

| Sl. No. | List of Questions   | Yes | No |
|---------|---|-----|----|
| 1.      | Will the implementation of the activity adversely impact the Labour force available within the area?  |     |    |
| 2.      | Will the implementation of the activity adversely impact the Livelihoods of the people dependent the resource?  |     |    |
| 3.      | Will the intervention on Common Property Resources/pasture lands deprive rights of vulnerable community?  |     |    |
| 3.      | Do the Vulnerable families have a share in the benefits accrued out of the common property resources?   |     |    |
| 4.      | Will the implementation of the activities displace any of the families concerned?   |     |    |
| 5.      | Does the activity promote Child Labour?   |     |    |
| 6.      | Does the activity have any adverse impact on the Health?  |     |    |
| 7.      | Does the activity promote any conflict among the Community?   |     |    |
| 8.      | Does the activity have any adverse impacts on the indigenous people/vulnerable families in terms of displacement or their livelihoods being affected? |     |    |
| 9.      | Does the activity have any adverse impact on the health of the people?  |     |    |

*Note: If any of the answer to the questions is “YES”, then the intervention may be avoided or taken up with mitigation measures? If mitigation measures are applicable, list out the measures.*

After completing the environment and social screening summarize the issues, mitigations planned, and management plan against the core **Principles of ESSA** in the following table;

| #  | Core Principles                                  | Remarks/mitigation and management plan  |
|----|--|---|
| 1. | Environmental and Social Management              | Is ESSA issues are brought to the notice of the community, No.of FGDs done, append proceedings of the FGDs with date, place and photo documentation   |
| 2. | Natural Habitats and Physical Cultural Resources | Are there any Natural Habitats and Physical Cultural Resources within watershed area or with in the radius of 1 km. If yes, is it discussed with the community, is there any impact on them? If yes measures taken?   |
| 3. | Public and Worker Safety                         | Whether safety measures are taken while executing the works? What measures are taken avoid accidental drowning in water bodies?<br>Are the farmers being aware of safety measures to be taken while using chemicals and fertilizers and safe disposal of empty cans/bottles? Is measures are taken to safely dispose the solid waste generated during construction works? |
| 4. | Land Acquisition                                 | Is there any land acquisition proposed? If yes, is it acquired with acceptance of the legal owner and compensation paid?  |
| 5. | Indigenous Peoples and Vulnerable Groups         | Are there indigenous people in the watershed area? Are their cultural values are taken into consideration before taking any activity? Is land of all the vulnerable families  |

| #  | Core Principles | Remarks/mitigation and management plan  |
|----|-----------------|---|
|    |                 | are taken up for treatment? Weather all landless people are included in vulnerable sub plan (IGA)?  |
| 6. | Social Conflict | Are there any social conflicts while planning for intervention, particularly for drainage line interventions and CPRs? If yes, mention in detail and how it was resolved? |

**Annexure XI**

**Below points were discussed with the group during transact walk;**

1. The existing condition of the land and water resources were widely discussed and importance & scientific approach about watershed activities were explained to the members present.
2. Survey no. wise interventions proposed based on LRI studies were brought to the notice of the farmers
3. Inputs regarding suggestions and modifications with respect interventions proposed by the farmers were also recorded for further needful action.
4. Importance of considering the environment and social issues were also brought to the notice of the farmers and ESSA screening was also carried out for the activities and observations were also recorded in the suggested formats.
5. Other issues discussed \_\_\_\_\_

Name & Signature of the PIA representative      Name & Signature of the FNGO representative      Name & Signature of the WEC/GP representative

| Sl. No. | Name of the farmer | Gender (M/F) | Category | Signature |
|---------|--------------------|--------------|----------|-----------|
|         |                    |              |          |           |
|         |                    |              |          |           |

## **7. Approaches for implementation of LRI and hydrology approaches under WDC-PMKSY 2.0**

New Generation Watershed Development Project WDC-PMKSY 2.0 envisaged to effect certain shifts in watershed management to make it more effective. They are as follows:

1. Firstly, transition from the current predominant practice of engineering treatments to more agriculture engineering measures. Implying overwhelming focus on trees, cropping systems, soil moisture conservation and management and soil organic matter.
2. Secondly, effective use of rain water by relying more on water productivity by adopting integrated measures to enhance water percolation for storage of rainfall in the soil profile for longer periods. Supplementing of moisture deficits in crops with water that is harvested by constructing small water harvesting structures like field bunds, trench cum bunds, contour trenches, continuous contour trenches, farm ponds, diversion weirs, embankments, percolation tanks, check dams etc.
3. Thirdly, diligent planning for crop systems diversification for risk management; enhancing productivity by adopting water use efficient crops and opting for crop alignment as a principle. An important initiative would include aligning crop growth phase with water availability, to provide a protective irrigation at critical stages of crop growth.
4. Fourthly, risk management plans for adaptation and mitigation of adverse impacts of climate variability and change diversification of the watershed economy by adopting integrated farming systems (IFS) with agronomic and horticulture crops, livestock, agro-forestry, fishery, poultry etc.
5. Fifthly, promotion of economically vibrant institutions, like Farmers Producers Organization (FPO), to promote agri-business services and impart efficiency to transactions at both input and output management stages
6. Sixthly, setting up and nurturing of community groups that will take interventions beyond mere creation of assets and promote responsible ownership and management. Formation of User Groups based on common identities and interests around natural resources and work consciously towards integrating the principle of sharing.
7. Seventhly, focus on decentralization, flexibility, community empowerment and greater role for village-level institutions in the planning process with a view to accommodating the local social and traditional strengths.
8. Eighthly, rejuvenation of springs by taking up appropriate watershed activities in the watershed development projects.
9. Ninthly and most importantly, building land resource inventory (LRI) through compilation of basic site and soil characteristics; hydrological and meteorological data; and socio-economic status are important. To begin with, States should cover at

least 10% of projects under LRI system. Owing to the advantages of LRI approach in terms of savings in cost of conservation measures by restricting to actual need, advocating more suitable cropping and nutrient management plan, convergence of programs of different departments, minimizing the time for watershed planning.

Sequential steps in advanced scientific approaches for watershed management under REWARD program followed are (a) generation of scientific data through LRI and hydrology assessments, (b) interpretation of data, (c) its transformation into the digital library and storage in the portal, (d) development of decision support system based the decision criteria and its storage in the portal, (e) automation of the whole system to get detailed project report for a given watershed, (f) downloading the DPR from the portal as a draft smart / table top DPR and (g) validating generated draft DPR through community consultations and adherence to the approval protocols. These steps are further elaborated in the succeeding paragraphs.

### **I. Map inputs for Investigation and drawing inference:**

The map inputs are prerequisites to carryout scientific investigations. Under REWARD program, the following maps are being obtained from Karnataka State Remote Sensing Application Centre (KSRSAC).

1. Physiography and geology map of Watershed
2. Sub-watershed boundary
3. Micro watershed boundary
4. Village boundary
5. Drainages, waterbodies, roads, railways, habitation
6. Cadastral map (survey no plots - 1:7920 scale)
7. Grids (points) at 320 m interval
8. Two metre contour lines overlaid on satellite imagery
9. Satellite imagery (False Colour Composite) 5 m resolution
10. Sl. no 2 to 8 are to be overlaid on satellite imagery

### **II. LRI approach-pre field, field and post field work and output:**

The steps carried out to generate LRI data are given below.

1. Image interpretation for physiography and preparation of base map at 1:7920 scale
2. Traversing the watershed area with the help of cadastral maps, imagery and toposheets to verify and correct the features on the base map
3. Identifying rock types, landforms, land use and their description
4. Selecting transects representing landform units and subunits
5. Opening profiles in selected fields up to 2 m depth- Average 20/MWS
6. Studying site & soil characteristics, horizon wise up to the bed rock / 2 m
7. Grouping pedons (profiles) studied into soil series
8. Grouping similar areas based on their soil-site characteristics into soil phases

and mapping their extent

9. Mapping land use/land cover, location of wells (well inventory map), existing soil and water conservation structures etc.,
10. Collection of soil samples from representative profiles (master profiles) for analysis
11. Collection of surface soil samples at 320 m grid interval for fertility analysis
12. Collection of water samples for water quality analysis
13. Finalization of soil map (Phase level) of the watershed with detailed description of mapping units identified
14. Submission of soil map to GIS lab and soil samples for lab analysis
15. Interpretation of LRI data into Land Capability and Land Suitability Classes
16. Generation of thematic maps
17. Preparation of LRI report and Atlas
18. Input to Digital Library

### **III. Hydrological Assessment:**

Following steps are to be followed to generate hydrology data

1. Field Study: Existing Structures, locations and dimensions
2. Weather parameters: Rainfall Index: Kharif, Rabi, Summer, ET index
3. Rainfall= Infiltration + soil moisture + ground water recharge + runoff
  - i. Infiltration-Soil phase wise (l/s): Double ring infiltrometer
  - ii. Soil Moisture-Soil phase wise (%): TDR, Hydroprobe
  - iii. Ground water recharge (mbgl): CTD diver
  - iv.  $\text{Runoff (Q)} = \text{Rainfall(P)} - \text{AET(E)} - \text{ground water recharge(R)} - \text{soil moisture storage(S)}$
4. Assessment of Runoff distribution
  - i. Runoff availability with existing conditions
  - ii. Runoff availability with effective interventions
  - iii. Runoff excess for harvesting by construction of structures
  - iv. Runoff allowed as environmental flow at the outlet

### **IV. DSS modules:**

Under REWARD program, following nine DSSs are being developed and used. Few more DSSs will be developed and used. At present, following nine DSSs may be used by the States planning to implement LRI based approach in watershed management.

1. Soil & Water conservation plan
2. Crop selection
3. Delineating arable and non-arable lands based on LCC
4. Crop based Nutrient Management and Soil Health
5. Estimating Surface runoff at farm/MWS/ SWS levels
6. Designing size and location of farm ponds and Check dams
7. Estimating the crop water requirement at MWS/SWS levels

8. Estimating soil water balance at MWS or higher levels
9. Water budgeting – need of crops, human, livestock etc.

**V. Digital Library, LRI Portal, Mobile Applications:**

1. The output of LRI and hydrology, relevant data generated from different sources and the DSS are migrated and integrated in a single platform in the portal for its access by different stakeholders. The information stored in the portal are:
2. Spatial and non-spatial database and thematic maps generated from LRI and hydrology
3. Information compiled from different sources
4. Decision Support Systems developed
5. Mobile applications

**VI. Table top / Smart DPR generation:**

From the portal, the DPR to be downloaded as table top DPR. The detailed procedure in generation of table top / smart DPR is explained in the subsequent chapters.

**VII. DPR Approval protocols:**

After generation of table top/ smart DPR, its validation through community consultations and the protocols to be followed in approval of DPR are described in the previous chapter.

## **8. Action Plan for implementation of LRI based approach under WDC-PMKSY 2.0**

With a view to implementing ten per cent of the projects using the advanced scientific approach of developing watershed plans based on LRI and hydrological assessments, following are the suggested strategies.

As at present, this new approach is in vogue in Karnataka and Odisha, where REWARD program is being implemented since 2022. As part of the REWARD program, technical institutes having expertise in LRI and hydrology have been identified and involved in the REWARD program as consortium partners to carryout LRI and hydrological activities. In the absence of this mechanism in the other States, it is important to identify potential technical institutes to support SLNAs in generating the required data from the field.

Suggested strategy for adoption of LRI based approach in WDC-PMKSY 2.0 as PAN India approach include, identification of potential technical consortium partners in the States to be involved for LRI and hydrological assessments assumes greater importance and it is the first step in the suggested strategy.

### **Possible Institutions for carrying out activities are as follows:**

1. RS and GIS can be done by State Remote Sensing Centres and NRSC
2. LRI and Hydrology assessments can be carried out by the State Agricultural Universities under the technical guidance of ICAR-National Bureau of Soil Survey and Land Use Planning for LRI and IITs, WALMI and ICAR Institute of Water Management, Bhubaneshwar and Centre of Excellence on Water management, Bhopal (under NIT) for hydrology. A specimen copy of tasks assigned to carryout LRI in REWARD, Karnataka, is given in Annexure.
3. ICAR Indian Institute of Soil and Water Conservation main and regional centres and SAUs can be involved to finalize the decision criteria for conservation and water harvesting measures
4. Development of decision support system which is a computerized expert interactive information system, integrated in a Geographic Information System (GIS) environment, to support decision-making in watershed planning and management. To develop decision support system, important requirement is finalization of decision criteria, models, algorithms, and guidelines for selection of appropriate interventions for comprehensive watershed development management. Important decision criteria for selection of soil and water conservation interventions are, slope, erosion, gravels, soil texture, soil depth and rainfall. The decision criteria for selection of water harvesting structures are water balance and water budgeting. The decision criteria for selection of crops are land capability classification, slope, drainage, surface texture, gravel content, depth, salinity, sodicity, length of growing period etc. The decision criteria for nutrient and soil health management are status of macro and micro nutrients, CEC, pH, EC etc. After development of decision criteria, models, algorithms etc.

*Reference material, CoE-WM*

After identification of technical consortium partners, the SLNA of the Watershed Development Department/ Agency should enter in to MoU with clear terms of reference.

The CoE-WM, UAS, Bangalore can conduct training to strengthening the capacities of identified technical consortium partners of each State, on scientific approaches in assessments and arriving at outputs.

The identified scientific institutes consortium partners can complete LRI and hydrological assessments in the defined watershed area within three months' time and the outputs are to be stored in the digital library and portal.

SLNA in consultation with DoLR, has to decide about the budget required for LRI Work. According to Karnataka's experience, to generate data in all respects, it would cost about Rs. 550/ ha.

The CoE-WM will provide training / technical backstopping to the Project implementing Agency on DPR generation and other related technologies as per the need.

**Annexure**

**Part of MoU between Watershed Development Department and National Bureau of Soil Survey and Land Use Planning for carrying out LRI in selected sub-watersheds of Karnataka**

**OUTLINE OF THE TASKS TO BE CARRIED OUT UNDER LRI**

The tasks are broadly classified into Trainings / Workshops, Field work, Manuals / Guidelines & Advisory services. The Specific tasks will include (but not limited to)

| #   | Tasks   |
|---|---|
| <b>Trainings / Workshops</b>                  |   |
| 1   | Assisting and co-ordinating with WDD in organizing stakeholder workshops for orientation of the project partners, project staff, line departments, NGOs and others  |
| 2   | Train the SAUs and SHU in RS, GIS and Land Resource Inventory (LRI) and other data base collection  |
| 3   | Assisting the WDD and other line departments to prepare their Detailed project report (DPR) for watershed interventions and their field validation  |
| 4   | Participate in the stakeholder workshops organised by WDD in project districts for validating the watershed treatment plans (DPR) and incorporate the outcomes into the DPR                                       |
| 5   | Co-ordinating with WDD in Capacity Building programmes for WDD staff/KVK staff/DATC/community for use of LRI data, LRI cards, etc.  |
| <b>Field Work</b>                             |   |
| 6   | Undertake Land Resource Inventory (LRI) <sup>1</sup> , well inventory, identification of soil and water conservation and harvesting structures, etc. (see Annexure II for more details)                           |
| 7   | Migration of all spatial and non-spatial data, maps, reports etc to the Digital Portal hosted by the State Data Centre, GoK through the migration tool developed  |
| 8   | Periodic review and setting priorities related to field survey, correlation and data interpretation, data integration, generation of thematic layers and authentication   |
| 9   | Establish soil series after review and correlation of soil series identified from the project districts   |
| 10  | Establish benchmark soils from the areas covered by LRI in the project districts  |
| 11  | Assisting M&E agency in collecting data with reference to technical monitoring and evaluation and maintain probes and equipment installed in benchmark sites in both REWARD and Sujala III Project areas.         |
| <b>Manuals / Guidelines (As Lead Partner)</b> |   |
| 12  | Provide standard protocols, Proforma and Manuals, revised wherever necessary based on Sujala 3 experience, for field survey and laboratory analysis for soil & water samples and for establishing benchmark soils |
| 13  | Undertake one pilot sub-watershed and one MWS assessment involving all project partners and bring out model report for partners to follow in other areas  |

<sup>1</sup> Watershed Development Department, 2016, Field Guide for Land resource Inventory, SUJALA III Project, Karnataka

|  |   |
|--|---|
| 14   | Assist to Refine/modify the criteria, guidelines, flowcharts related to the DSS already developed (Annexure –III) and to provide necessary support to validate the DSS developed based on the feedback from the users   |
| 15   | Assist to Develop guidelines to prepare soil and water conservation plan, crop plan, nutrient management plan etc at the watershed level and their convergence with other programs of the line departments in association with WDD and other project partners                   |
| 16   | In association with IISc and other technical partners finalise modalities of integration of LRI and hydrology data into the LRI report  |
| <b>Advisory Services (As Lead Partner)</b>                 |   |
| 17   | Guidance in establishing additional facilities wherever necessary and strengthening GIS, RS and Analytical Laboratories and Field facilities in LRI partner institutions  |
| 18   | Advise WDD and other partner institutions more specifically SAUs/ SHU on the requirement of various RS inputs / imageries, base maps/theme maps as per the project needs  |
| 19   | Guidance and protocols needed in strengthening the Digital library in LRI partner institutions with outputs from REWARD project areas   |
| 20   | Provide inputs needed to develop new Develop Decision Support System (DSS) as identified by the WDD from time to time in collaboration with WDD and project partners  |
| 21   | To provide data and other inputs needed for the establishment of Management Information System (MIS) for the watershed programs of WDD and their periodic updating  |
| <b>Supervision and Quality Assurance (As Lead Partner)</b> |   |
| 22   | Supervise periodically (at least once a quarter for each partner) in both field and lab work being carried out by partner institutions and provide report to WDD on quality of work being done  |
| 23   | Take up pilot studies to develop rapid and accurate soil characterisation using NIR/MIR spectrometer. Validate and Calibrate method of soil characterisation and cost effectiveness of using NIR/MIR spectrometer as against traditional method on sample basis in REWARD area. |

**Deliverables:**

The Deliverables are broadly classified into Trainings / Workshops, Manual / Guidelines, Reports and Documentation. The deliverables are listed below

| #                           | Deliverables   |
|-----------------------------|--|
| <b>Training / Workshops</b> |  |
| 1                           | Stake holder Workshops for Project orientation, Periodic review, and report generation |
| 2                           | Training project partners, Line Departments including WDD and community                |
| 3                           | Participation in Community interfacing Workshops for validating treatment plans        |
| <b>Manuals / Guidelines</b> |  |
| 4                           | Assist WDD to develop guidelines for preparation of conservation plan, crop plan,      |

|  |  |
|--|--|
|  | nutrient management plan, water balance, water budget etc at the watershed level and their convergence with other programs of the line departments   |
| 5  | Manual on Standard protocols, Proforma and Manuals for field survey and laboratory analysis for soil & water samples and benchmark soils   |
| 6  | Manual on Protocols for RS inputs / imageries, cadastral / theme/base maps needed for taking up LRI  |
| <b>Reports</b>   |  |
| 7  | Field survey progress review reports and data / output, authentication protocols   |
| 8  | Model sub-watershed and MWS assessment reports   |
| 9  | Land Resource maps and reports including soil series descriptions, profile, landscape and land use photos, analytical results, thematic maps, and treatment plans for the micro-watersheds surveyed by ICAR-NBSS & LUP |
| 10   | Sub watershed reports  |
| 11   | Soil series correlation report for the project districts (At the end of the project)   |
| 12   | Benchmark soils Report (At the end of the project)   |
| 13   | Generation of LRI Cards for the watersheds covered   |
| 14   | Periodic supervision report based on field visits and lab visits to partner institutions' sites.   |
| <b>Documentation</b>                                       |  |
| 15   | LRI based Thematic and pilot   |
| 16   | Case studies and Success stories based on LRI  |
| <b>Supervision and Quality Assurance (As Lead Partner)</b> |  |
| 17   | Report of Validation and Calibration soil characterisation of Samples from REWARD area using NIR/MIR spectrometer with its cost effectiveness and benefits.  |

### Schedules for completion of tasks

| # | Task  | Time Schedule                                      |
|---|---|--|
| 1 | Establishing dedicated Project unit at Bangalore centre consisting of Subject experts   | Within 1 month from the date of signing agreement  |
| 2 | Updating of LRI Field Guide, other manuals, protocols, proforma etc.  | Within 2 months from the date of signing agreement |
| 3 | Training/orienting LRI partners and their teams on carrying out LRI survey, preparing reports   | 3 months from signing agreement                    |
| 4 | Organizing training workshops for orientation of the WDD staff, Line Departments, KVKs, DATC NGOs, community and other stakeholders on use of LRI data, LRI cards, etc. (Logistical arrangements/ funding have to be arranged by WDD) | Up to 36 months from the date of signing agreement |
| 5 | Assisting partners in establishing or Strengthening of RS, GIS, Laboratory, and field facilities in Project partner institutions  | 2 months from the date of signing agreement        |
| 6 | Indicating requirement of Equipment, Goods, consumables, Hardware & Software and Manpower necessary   | 1 month from the date of signing agreement         |
| 7 | Indicating Configuration/specifications/Quality   | 1 month from the date of                           |

|    |   |   |
|----|---|---|
|    | Standards of required Materials, Equipment, Goods, Hardware & Software and time when required   | signing agreement   |
| 8  | Inputs and advise needed for the Preparation of procurement documents for the required tools, equipments and materials  | 3 months from the date of signing agreement                                       |
| 9  | Advise WDD and other partner institutions more specifically SAUs / SHU on the requirement of various RS inputs / imageries, theme maps as the project progresses  | Up to 36 months from the date of signing agreement                                |
| 10 | Train the SAUs and SHU / community in RS, GIS Techniques and Land Resource Inventory in collaboration with KRSRAC and other partners  | Up to 6 months from the date of signing agreement                                 |
| 11 | Undertake model micro watershed assessment involving all project partners and local communities   | 12 months from the date of signing agreement                                      |
| 12 | Undertaking Land Resource Inventory in micro-watersheds in project districts and submission of all reports <sup>2</sup> to WDD and their migration to the Portal  | 42 months from the date of signing agreement                                      |
| 13 | Co-ordinate Land Resource Inventory, well inventory, mapping of existing structures   | Throughout the Land Resource Inventory work by the partners                       |
| 14 | Characterization of correlated soil series from the project districts   | 36 months from the date of signing agreement                                      |
| 15 | Benchmark soils report from the areas covered under Sujala 3 and from REWARD areas (At the end of the Project, provided LRI data is shared by SAU partners)   | As and when SWS study is completed  |
| 16 | LRI Cards   | As and when MWS study is completed  |
| 17 | Periodic review and setting priorities related to field survey, correlation, data interpretation, data integration, generation of thematic layers and authentication  | Throughout the MoU period   |
| 18 | LRI data migration to DL and Portal   | Throughout the project period but not later than 42 months from signing agreement |
| 19 | Assisting WDD in Validation and Refinement of the DSS developed on Soil and water conservation, crop suitability, nutrient management and Land capability grouping in collaboration with WDD and project partners | As and when needed throughout the project period                                  |
| 20 | Provide inputs needed for the development of new DSS in association with partners and WDD   | As and when needed  |
| 21 | Assisting WDD for Development/modification of the guidelines for preparation of conservation plan and other interventions in convergence with other ongoing programs of various line departments                  | 12 – 18 months from the date of signing agreement                                 |

<sup>2</sup> See annexure for list of outputs/reports/maps/data sets needed to decide that LRI study of a MWS/SWS is completed. This is an indicative list only.

|    |   |                                       |
|----|---|---------------------------------------|
| 22 | Co-ordinating with WDD in Capacity Building programmes (Logistic and funding by WDD)  | Entire project period                 |
| 23 | Take up pilot studies to develop rapid and accurate soil characterisation using NIR/MIR spectrometer. Validate and Calibrate method of soil characterisation and cost effectiveness of using NIR/MIR spectrometer as against traditional method on sample basis in REWARD area. | By the end of 42 <sup>nd</sup> Month. |

### Financial support

The required budget will be provided as per the program activities planned and executed by the Institute. The budget support will be towards the (1) Cost of Equipment and Goods (2) Cost of Manpower and (3) Operational costs (4) Institutional charges and any other contingency expenses likely to be incurred during the program period.

### Services and facilities to be provided by the watershed development department

The WDD will support ICAR-NBSS&LUP, Regional Centre, Bengaluru by assisting in the following activities -

- a) It will provide a framework and guidelines, required maps to facilitate effective implementation of the REWARD-SUJALA IV Program
- b) It will provide Financial support, and Equipment needs as per the program needs
- c) It will liaison with District JDAs, ZPs, PRIs, NGOs and communities for effective implementation of LRI base line data collection and for effective programme convergence
- d) It will enable conducive working environment for collaboration between various stakeholders involving Line Departments and Project Partners of the Project and also involve in State level workshops
- e) It will undertake periodic review of Project Progress and consultation processes with various groups of Stakeholders and Project Partners for mid-course corrections and as and when the need arises
- f) It will provide both hard and soft copies (Geo-coded) images, Base maps, DEM, LULC and other essential products needed for LRI.

### Composition of review & co-ordination committee

A Review & Co-ordination Committee consisting of members from the WDD, Department of Horticulture/Agriculture including representatives from NBSS&LUP, SAUs, SHU, KVAFSU, KRSRAC, KSNDMC and IISC and M&E agency will be formed to monitor project progress and undertake mid-term review and to suggest modifications and refinements if any as and when required.

### List of key personnel

List of key persons from NBSS&LUP with their field of specialization and years of experience to be provided as indicated below. In case required expertise is not available in the institute then how the planned work will be managed needs to be elaborated.

| # | Name and Designation | Qualification/Field of Specialization & experience  |
|---|----------------------|---|
| 1 | Lead Scientist       | Ph.D. in Soil science/Agronomy with at least 15 years of experience in Soil survey, land evaluation, LUP etc. |
| 2 | NRM                  | Minimum of 10 years experience in NRM/Watershed Management  |
| 3 | Soil Science         | Minimum of 10 years experience in Soil Science/NRM/Watershed Management                                       |
| 4 | GIS Expert           | Minimum of 10 years experience of GIS/RS particularly in watershed Management                                 |

### Terms (Period of MOU)

The services of the institute are for the WDC-REWARD Program duration of about five years from 2021-22 to 2025-26. However, the service period could be extended on mutual consent as per the progress and need of the program.

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