1. An overview of 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).

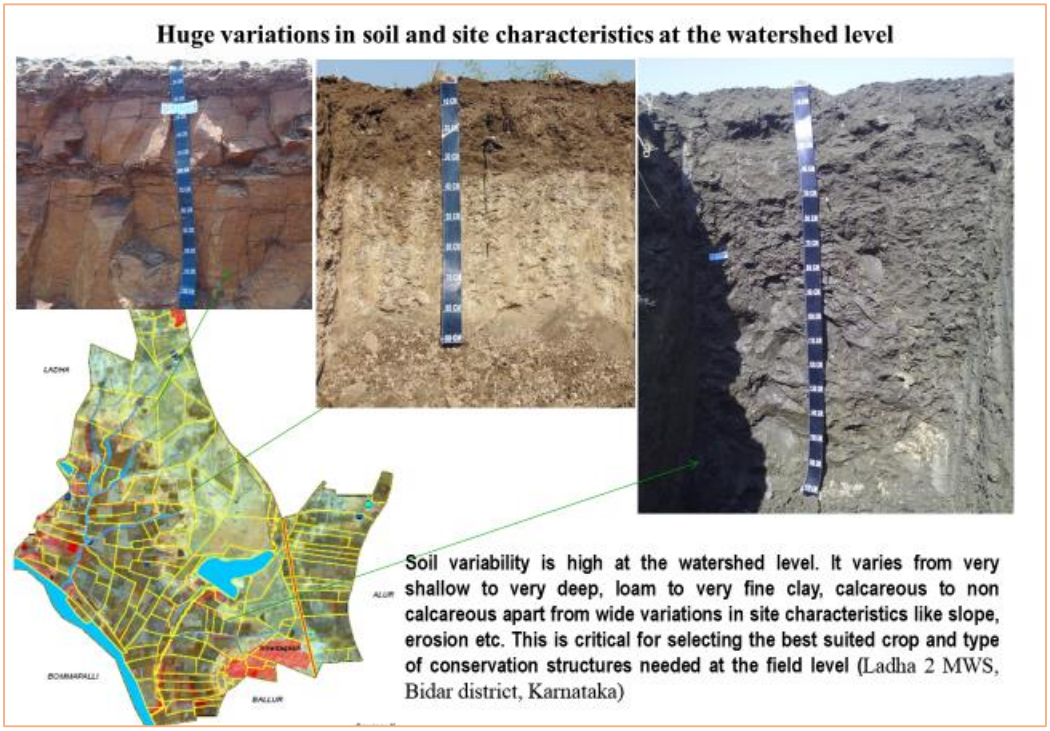
It is obvious that urgent measures are needed not only to arrest the declining health of land resources in the country but also to regenerate the degraded lands in a reasonable timeframe. Otherwise, the cost of the neglect, estimated to be about 2.5 per cent of the GDP in 2014-15, will be too high to pay in the future (TERI, 2018). Realising 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.

Why REWARD program?

As we know that the factors and processes affecting degradation, productivity and sustainability are very site and location specific, for any meaningful intervention needed for their restoration and management requires site-specific land resource information which is not available at present for major part of the country. As the land resources are not uniform and vary from field to field in any given landscape, generation of location specific information pertaining to the nature and extent of variability in soil, water availability, topography, land use, and advisories 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 past by line departments in the country. This has been highlighted by many studies/committees/working groups in the past (Planning Commission-11th Plan, 2007, NMSA 2009, Natarajan et al 2006, Natarajan 2022).

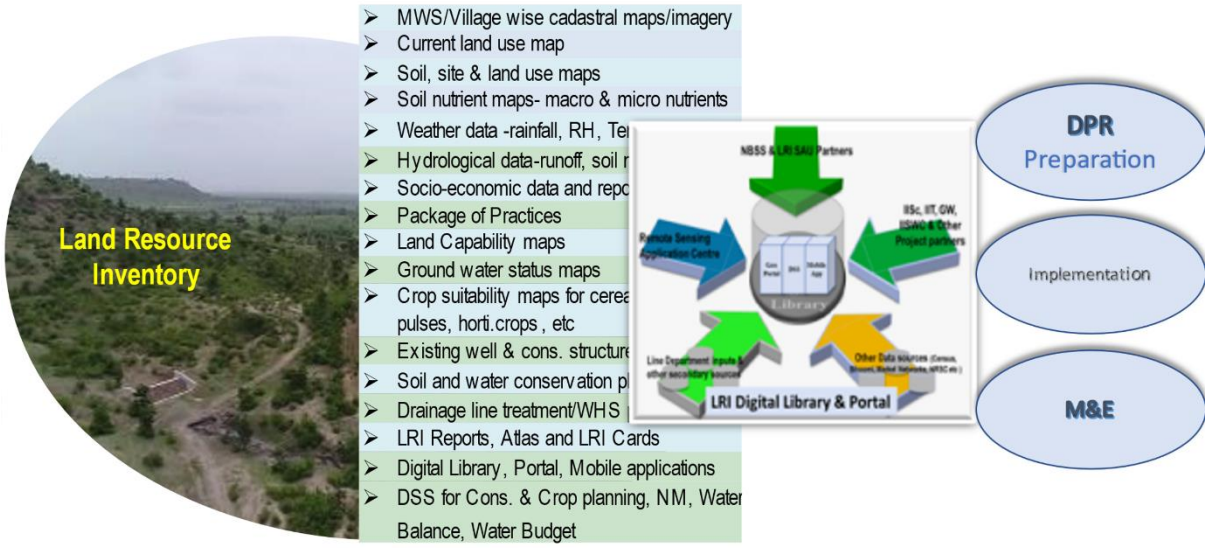
Variability in soil-site characteristics at field/landscape level



Realising the importance of site-specific soil and other information for taking up targeted interventions many States have taken up generation of such database and advisories and among them the most noteworthy initiatives have come from Tamil Nadu, Karnataka, Kerala and in few other States in the country (Natarajan 2022). The outcome of 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 in Karnataka, 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 cycle to four years, 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.

Appreciating the impact of the above program, the Government of Karnataka has extended it to cover the whole rainfed area of the state with Land resource inventory (LRI) technology. Similar initiatives are planned by other States after their visit to Sujala-3 project areas in Karnataka. To upscale the lessons learnt from Karnataka to other States and to support science-based planning, implementation, and monitoring of watershed interventions under PMSKY, the REWARD project (Rejuvenating Watersheds for Agricultural Resilience through Innovative Development (REWARD) is taken up in Karnataka and Odisha with the support of the World Bank from 2022 onwards. The REWARD project is designed to support the full range of watershed development activities in the country. This life cycle approach, piloted through REWARD, is expected to demonstrate the importance of LRI and hydrology, thematic maps and Decision support system (DSS) in planning interventions, role of digital library and portal in Detailed project report (DPR) preparation and program convergence. Further, the outcome of the REWARD is expected to consolidate and improve the existing guidelines and come up with appropriate protocols and new set of guidelines for science-based watershed planning, convergence of schemes and other interventions in the country later. The overview briefly presents the generation of cadastral level land resource information through LRI and hydrological investigations, thematic map generation, importance of DSS for planning interventions, role of Digital library (DL) and Portal for DPR preparation, dissemination of advisories and program convergence, role of partnerships and capacity building, and need for evidence-based Monitoring and impact evaluation of the interventions carried out under the REWARD program.

REWARD-A life-cycle approach to Watershed Management



Generation of LRI and hydrological data:

Though the importance of site-specific cadastral level information for planning watershed interventions is known for a long time, its effectiveness has been largely demonstrated by the outcome of the Sujala-3 program in Karnataka. Since the utility of LRI data depends on the base

map, selection of appropriate base is critical for the generation of LRI data. In our situation, with smaller holdings and fragmentation, cadastral map is the only source which can provide all the needed information like the field boundaries, survey number and other permanent features like roads, habitations, drainage lines *etc* that can help the user to orient himself without any doubt, the mapper to show the boundaries clearly and the line departments to take up the planned interventions with confidence and certainty. Fortunately, due to the initiatives of the DoLR and State Space Application Centres the cadastral maps are digitised, georeferenced and available for the entire country in a seamless manner.

Apart from this an array of high-resolution remote sensing data products (Quick bird, Worldview *etc*) are available on which the cadastral layer can be superimposed and used as a base for LRI work. The development of 2-meter contour from the Cartosat data by Karnataka remote sensing application centre (KSRSAC) will further improve the delineation of landform units. Recently, the Survey of India with the support from GoI has taken up Survey of Villages and Mapping with Improvised Technology in Village Areas (SVAMITVA, 2020) to generate ortho mosaic maps, and digital surface models at 1:500 scale by drones in the country which offers enormous scope for using it as a base for LRI in the future.

After the base map selection, the assessment of the status and changing condition of soil, water, land use and related resources at the field level is carried out by following the critical steps as indicated below (USDA, 2019, Natarajan *et al*., 2016).

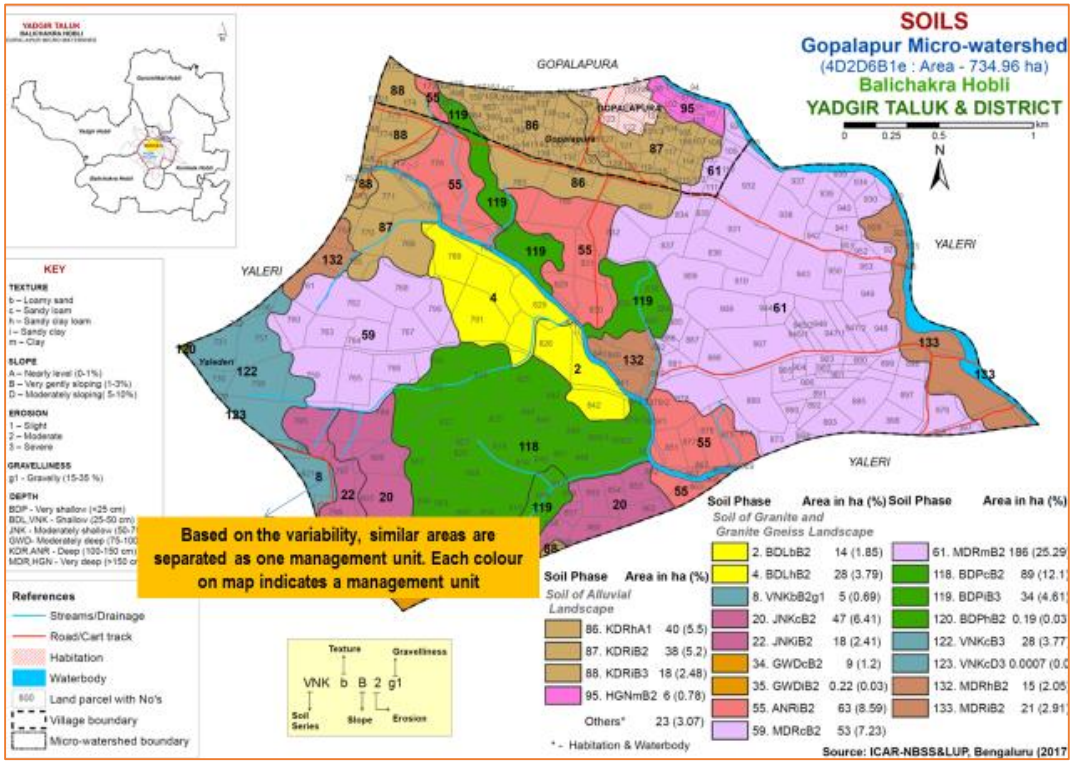
- Interpretation of the imagery and preparation of base map
- Field traversing, checking and correction of units delineated based on variations observed in rock types, landforms, land use, slope, drainage *etc.*
- Selecting transects, profiling and study of soil-site characteristics
- Grouping similar areas based on soil-site characteristics into management units
- Mapping the extend and distribution of the units on the cadastral map
- Collection of profile and grid points for analysis
- Preparation of land use and land cover map
- Well inventory
- Mapping existing conservation and water harvesting structures
- Establishing model watersheds and benchmark soils and their instrumentation
- Collection of weather and climatic data, soil moisture, ground water level, demographic, socio-economic and farmer details
- Analysis of soil samples, processing of field data and maps and finalisation of soil and other maps through the GIS

Development of criteria needed for interpretation and thematic map generation:

The LRI data per se is of not much use or value to the planners unless it is converted into a form or format which they can understand and use it for planning and implementation of their programs. This is a real challenge and calls for the involvement of subject matter specialists from different

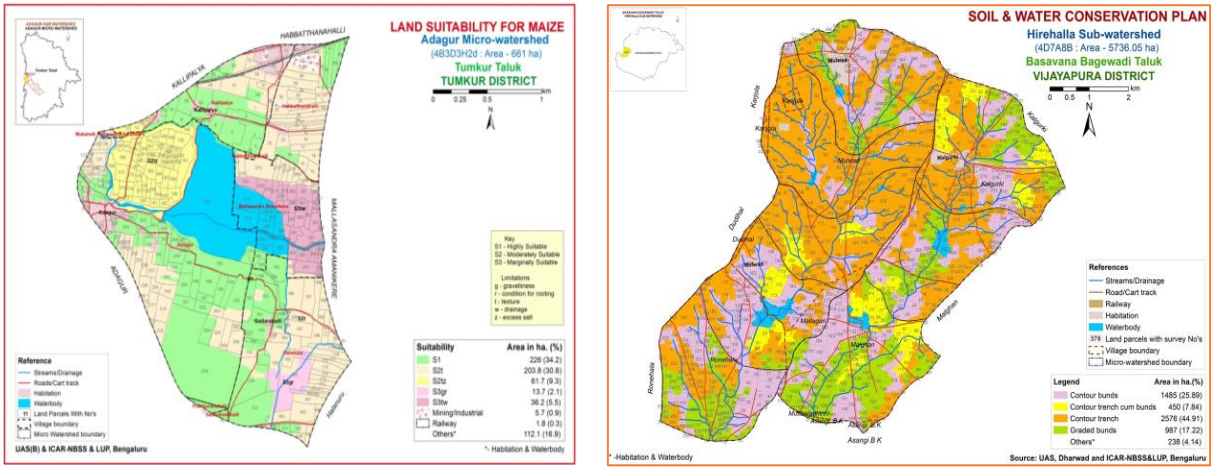
disciplines. For example, to assess the suitability of an area for a crop needs a team of specialists trained to use the LRI data who can effectively identify the constraints of the soil, weather and climate and optimum conditions required for its growth. The assessment becomes difficult when many factors and processes are considered together which is further complicated by the interaction of one factor/parameter with the other or with all of them. This calls for the development of criteria, models, algorithms, and guidelines by a team of specialists which can facilitate the assessment for crop selection, soil and water conservation interventions, nutrient management, runoff, water budgeting *etc*. It is important to remember that the criteria, models, or algorithms *etc* developed needs to be tested in the field and validated with multi location trials before they are rolled out for use. This exercise needs to be an ongoing one and as and when additional information is received necessary improvement/refinement needs to be incorporated and the models/criteria modified accordingly.

Site and Soil (profile) characterisation during LRI



LRI for grouping similar areas into management units, Gopalapur MWS, Yadgir

Based on the criteria, models, and guidelines developed and integrating the same with the LRI data, the required thematic maps on the constraints, potentials, suitability, soil and water conservation, nutrient status and their management, runoff estimation, soil moisture assessment, crop water requirement, water balance and budget *etc* can be generated for any mapped area. For example, for finding out the suitability of the land resources for a particular crop, first the soil-site-hydrology criteria for suitability assessment is developed with the involvement of domain specialists, and based on the criteria, algorithm and flow chart assessment for the selected crop is carried out and suitability map generated. Similarly, based on the criteria developed, suitability for other crops/land uses can be carried out and maps generated for use. Likewise, thematic maps for soil and water conservation, land capability, moisture availability, water balance *etc* can be developed at the farm/water shed level as per the requirement of the users.



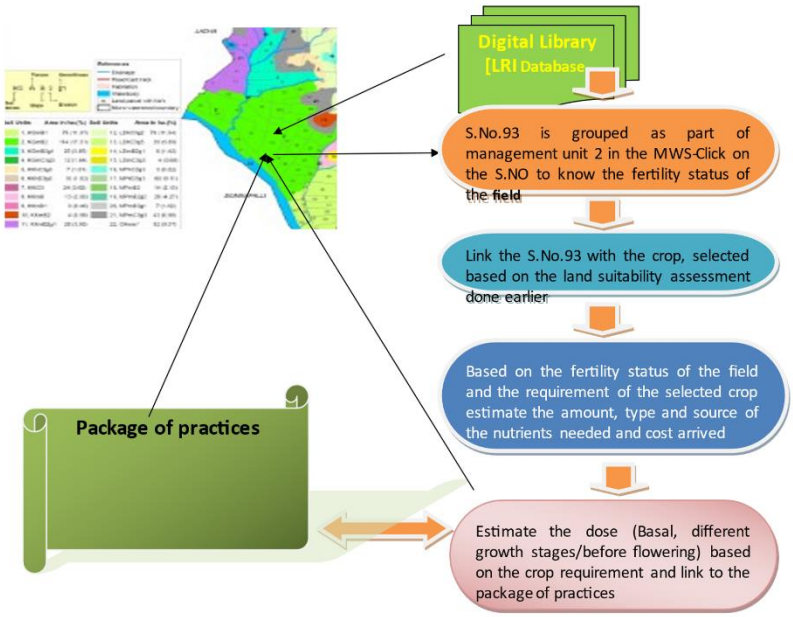
Suitability of Adagur MWS for Maize and Conservation plan for Hirehalla SWS

Development of Decision Support System (DSS) for resource optimisation:

The development of DSS, a computerized expert interactive information system, is critical to decide on the most appropriate interventions that can be taken up for implementation based on the available information. Since LRI provides all the required spatial and non-spatial information and thematic outputs needed for planning it will be of great help if appropriate DSS are developed to facilitate the decision-making process by user departments apart from bringing uniformity in their assessment. Under Sujala-3 project, an attempt has been made to develop few DSS models to facilitate watershed planning in Karnataka, as indicated below which can be further improved and new ones developed as per the user needs in new project areas in the country based on LRI coverage.

- 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 on Land Capability Classification
- DSS on crop based Nutrient Management and Soil Health
- DSS for estimating Surface runoff at farm/MWS/SWS levels
- DSS for designing the Size and location of Farm ponds and Check dams based on runoff model
- DSS for estimating the Crop water requirement at MWS/SWS levels based on the existing land use or crops that are planned to be taken up for cultivation
- DSS for estimating Soil Water balance at MWS or higher levels
- DSS for Water budgeting taking into consideration the needs of various uses/users at MWS/ Village level- crop needs, human needs, livestock needs *etc.*

It has been observed that the development of DSS has significantly reduced the time required for watershed planning, targeting of soil and water conservation investments where it is critically needed, estimation of water balance and water budgets, farmer decision-making around crop selection, precision farming, nutrient management, program convergence among the line departments and other activities at the farm and watershed levels (WDD 2020).



DSS for site-specific nutrient management

Preparation of DPR/Land use plan:

The relevance of the LRI information and their outputs depends on the extent they are used in the preparation of land use plans by the line departments and their acceptance by the farmer and other stakeholders at the grassroots level. The land use plan or the DPR should be able to capture not only the constraints, potentials, and suitability of the resource base for different crops and other uses but also include the alternatives for making choices, cost estimates for taking up the identified intervention, action plan for implementation and expected impacts of the interventions carried out in the area. This is not a standalone exercise to be carried out by any one department or agency, but a joint exercise carried out with the involvement of both data generators and data users in an iterative manner. For example, the conservation plan is prepared by the integration of the LRI data with the criteria table developed for the selection of different structures along with costs norms involved by the LRI partner and Watershed Development Department (WDD). Similarly, the plan for taking up other interventions are also developed jointly and included in the DPR, which is not a closed document but a dynamic one which gets revised as and when necessary, based on the feedback received during implementation. It is important to note that the success of the land use plan/DPR depends on the active involvement of all stakeholders in planning, validation, implementation, and monitoring stages of the program. This life-cycle approach for planning will

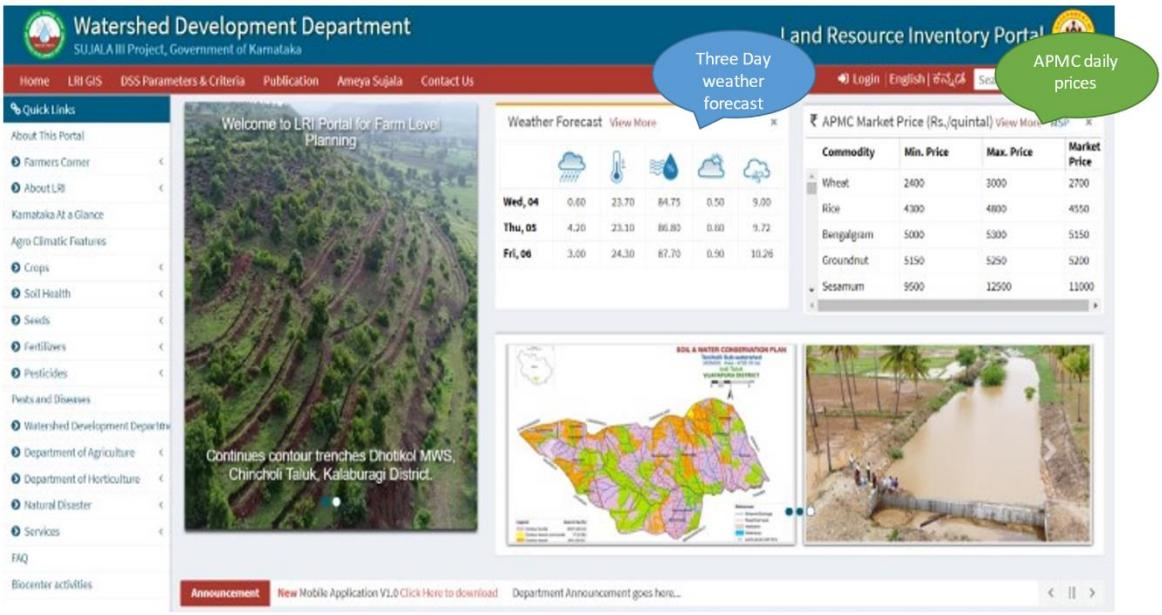
ensure the successful implementation of the programs designed at the farm or grassroots level in the country.

Development of digital library, LRI portal and mobile applications:

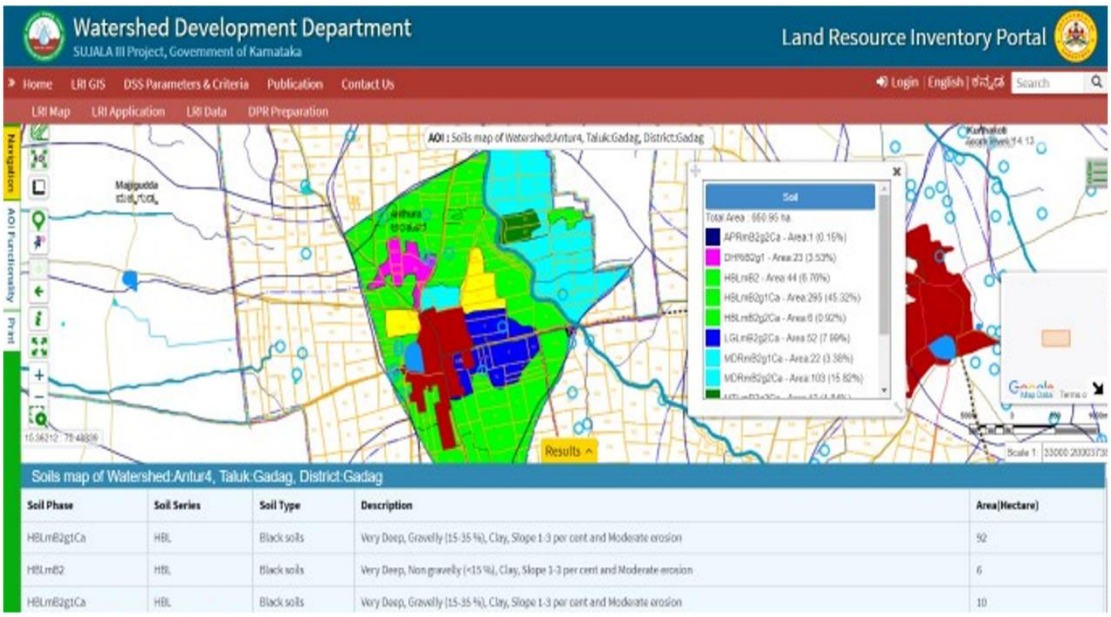
For effective dissemination of information, all the spatial and non-spatial database and thematic maps generated from LRI and hydrology and information compiled from different sources along with the Decision Support Systems developed can be migrated and integrated in a single platform (Digital Library and LRI Portal) and the same can be made available to the line departments, farmers and other users on real time basis through web and mobile applications. The availability of site-specific land resource information, thematic maps along with the Decision Support System and advisories on a single platform will be of great help to the Watershed, Agriculture, Horticulture, and other line departments to prepare science based Detailed Project Reports in a shorter span of time. The user can also generate the required maps and reports as per the area of his interest with the help of the Portal. The development of LRI portal in Karnataka has helped to automate the preparation of the DPR which used to take years earlier, watershed cycle gets reduced to 3 to 4 years which used to take 6 to 7 years and real time convergence of the programs by various line departments made possible in the state.

Partnerships, capacity building and training for upscaling REWARD program:

The generation of cadastral level LRI, hydrology and other datasets, thematic outputs and advisories is not possible by any lead institute alone or by any other organisation and hence establishing partnerships with appropriate institutions at the state and country levels is critical for executing and upscaling REWARD activities in the operating states. For effective implementation of the program, it is important that not only the partners should be on board to generate the required data but also the institutions/agencies who can add value to the data and most importantly the user departments to support the program due to the advantage they derive in using the LRI outputs and tools should be brought together for this purpose. Accordingly, a consortium of partners and user agencies/line departments is needed to take up the program on a mission mode. The successful implementation of KWDP II program in Karnataka with the establishment of a consortium of 14 partners/user agencies with defined roles and responsibilities will form the template for taking forward the REWARD program in Odisha, Karnataka, and other states in the country in the coming years. The establishment of dedicated RS, GIS, analytical and field facilities at the partner institutions with the required manpower, working capital and training will help in the generation of thematic outputs as and when needed, facilitate the preparation of DPRs for any area of interest and disseminate the information and advisories to the users on real time basis.



Landing page of the LRI Portal displaying weather and commodity prices



Viewer can select AoI, view, download, print, save or generate maps as required

Towards this, the role of the Centre of Excellence (CoE) on Watershed Management in established in Karnataka as part of the REWARD program will play a critical role in imparting training to the REWARD program states and subsequently in the operationalisation of PMKSY programs in the country in the coming years. Apart from this, the success of the program will help in the development of new generation guidelines for watershed management under PMSKY in which about 26 m ha are planned to be covered in different states by 2030.

2. An overview of LRI outputs and their application in watershed management

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.

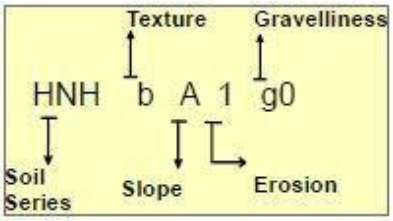
9. Location of wells map: The total number of wells (open wells and bore wells) existing in the particular watershed area will be indicated in the maps along with their location.

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 characteristics 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.

3. An overview of hydrology outputs and their application in watershed management

Hydrology outputs: 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.

The objective is that hydrological monitoring aided by advanced data & innovative models that will be used under this project will aid in producing hydrological budget at relatively higher temporal frequency (e.g. weekly/monthly) and also at the desired spatial granularity in the micro watersheds, for improved sustainable water management.

Preparation of hydrologic atlas:
Integrated Hydrological Assessment & Monitoring involves hydrological data gathering, behavior mapping & processes understanding at micro-watersheds scale. 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, number of 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 maps.

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 micro-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 the annual series.

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.

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.

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,

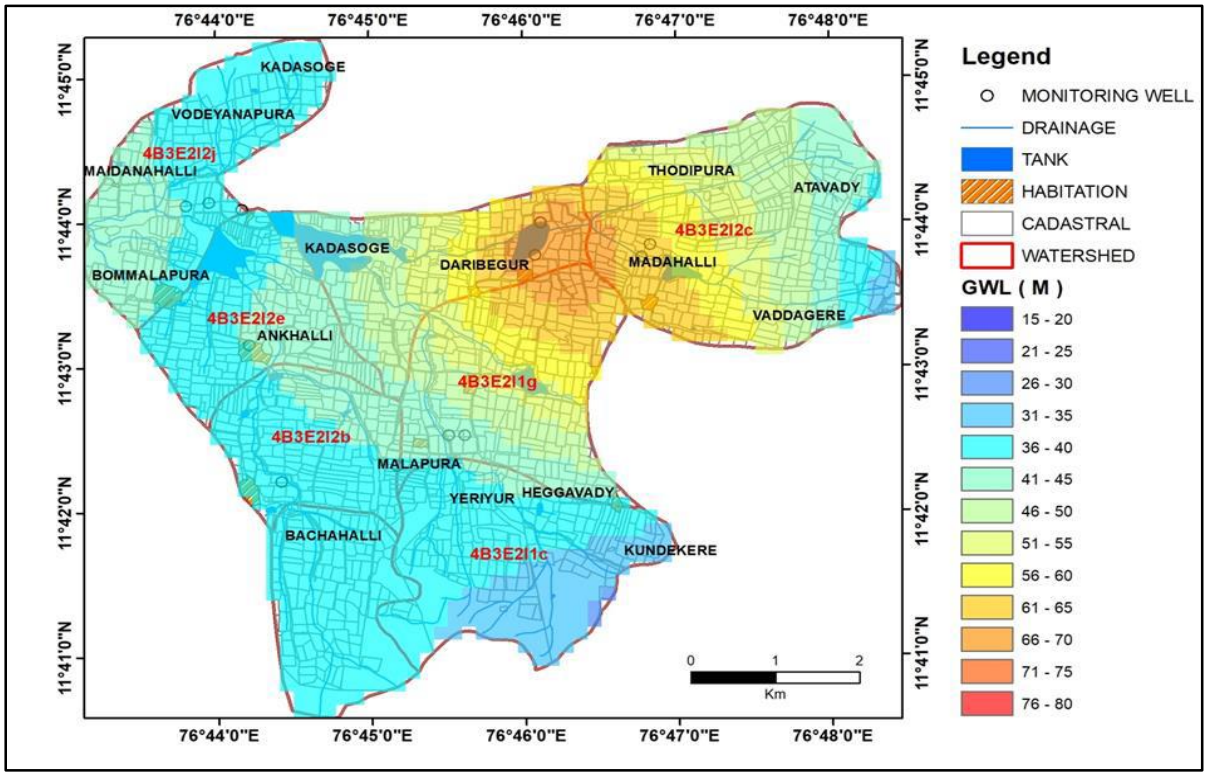
$$P=Q+AET+R+S$$

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.

Spatial distribution of depth to groundwater:

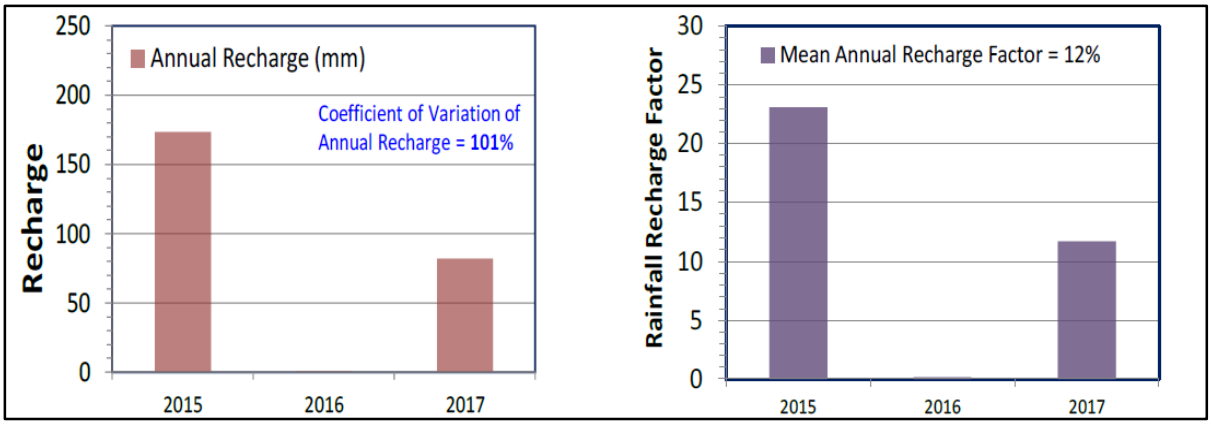
DGW is point data and needs to be interpolated to prepare the spatial maps. Any of the following approaches can be used to convert the point data into spatial maps:

- 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 behavior 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.



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

Ground water recharge:



Sample plot showing annual recharge and mean annual recharge factor 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.

Water quality maps:

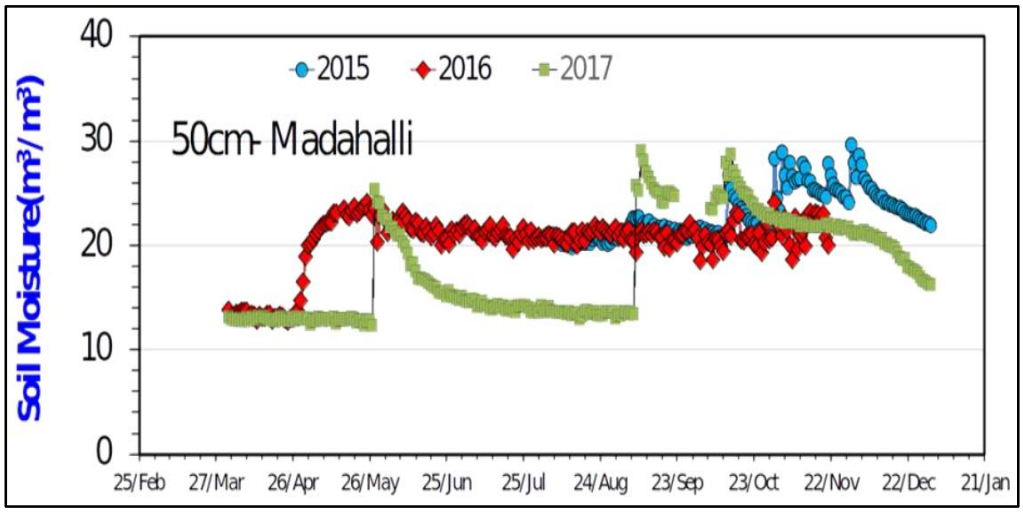
Prepare the map of groundwater quality parameters following the IDW or Kriging method of interpolation.

Depiction of 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:
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.
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.



Root zone soil moisture time series plot at the particular location in the study watershed

Depiction of 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 10 cm, up to the depth of 80 cm.

4. An overview of DSS modules developed under Sujala-3

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*
Group 1 (Soil & Water conservation plan, Crop selection, Land Capability Classification and Nutrient management)	
1	DSS for **Soil & water conservation plan**-to identify the type of structures, their design and estimate, for both arable and non-arable lands/areas
2	DSS for **Crop selection** (Based on physical suitability and cost benefit ratio)
3	DSS for delineating prime farmlands/arable and non-arable lands based on **Land Capability Classification**
4	DSS on crop based **Nutrient management** and **soil health**
Group 2 (Surface Runoff, Size and location of Farm Ponds and Check Dams, Crop water requirement, Soil Water balance and Water budgeting)	
5	DSS for estimating **Surface runoff** at farm/MWS/SWS levels
6	DSS for designing the **Size and location of Farm ponds and Check dams** based on runoff model
7	DSS for estimating the **Crop water requirement** 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 **Soil water balance** at MWS or higher levels, considering the RF, crop requirement, Runoff, evaporation and other losses, soil moisture and ground water.
9	DSS for **Water budgeting** 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.

Exercise - 1

Delineation of arable and prime lands based on land capability assessment

Based on the soil characters presented in the atlas, group each soil phase into various land capability classes and sub classes.

The parameters to be considered are given below and the criterias to be used in grouping the land parcels into land capability units are given in DSS book (Table 4.1, Page: 110). To understand soil characteristics and soil-site characteristics, refer Annexure-2 page: 219.

Climate, soil and site parameters/features affecting LCC		***Land capability ratings***							
		Suitable for Agriculture				***Suitable for forestry, silvipasture, wildlife etc.***			
		Class I	***Class II***	***Class III***	***Class IV***	***Class V***	***Class VI***	***Class VII***	***Class VIII***
Climate	Humid with well distributed rainfall								
	Humid with occasional dry spells								
	Sub humid-yields frequently reduced by droughts								
	Semi-arid								
	Arid								
Slope	**Red soils**								
	A (<1%)								
	B (1-3%)								
	C (3-5%)								
	D (5-10%)								
	E&F (10-25%)								
	G,H&I (25>50%)								
	Black soils								
	A (<1%)								
	B (1-3%)								
	C (3-5%)								
	D (5-10%)								

Climate, soil and site parameters/features affecting LCC		***Land capability ratings***							
		Suitable for Agriculture				***Suitable for forestry, silvipasture, wildlife etc.***			
		Class I	***Class II***	***Class III***	***Class IV***	***Class V***	***Class VI***	***Class VII***	***Class VIII***
Erosion	Slight (e_1)								
	Moderate (e_2)								
	Severe (e_3)								
	Very Severe (e_4)								
Drainage	Excessive								
	Well drained								
	Mod.WD								
	Imperfect								
	Poor								
	Very Poor								
Soil depth	> 100 cm								
	50 –100 cm								
	25-50 cm								
	10-25 cm								
	< 10 cm								
Texture	sl, scl, cl, loam, silty clay loam								
	sandy clay, silty clay								
	clay								
	loamy sand								
	sand								
Gravels	< 15 %								
	15-35 %								
	35-60 %								
	> 60 %								

Climate, soil and site parameters/features affecting LCC		***Land capability ratings***							
		Suitable for Agriculture				***Suitable for forestry, silvipasture, wildlife etc.***			
		Class I	***Class II***	***Class III***	***Class IV***	***Class V***	***Class VI***	***Class VII***	***Class VIII***
Rockout crops (%)	<2								
	2-10								
	10-50								
	50-90								
	>90								
Salinity EC	<2								
	2-4								
	4-8								
	8-16								
pH	Favorable Reaction (6.5-7.5)								
	Unfavorable reaction (easy to modify) (5.5-6.5 & 7.5-8.5)								
	Unfavorable reaction (difficult to modify) (4.5-5.5 & 8.5-9.5)								
	Unfavorable reaction (exceedingly difficult to modify) (<4.5 & >9.5)								
Permeability	Very slow								
	Slow								
	Mod. slow								
	rapid								
	Very rapid								

Final land capability class:

5. Preparation of soil and water conservation plan

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^2 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^2.

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.

Exercise - 2

Soil and Water conservation for arable and non-arable lands

Step-by-step execution of Conservation Plan

Steps	***Description***
1	Select two distinct soil phases and study their land characteristics
2	Select treatment for land characteristics based on decision rules (Table 2.6: Page No. 14 of DSS book)
3	Select vertical and horizontal interval based on decision rules (Table 2.9: Page No. 29 of DSS book)
4	Select cross-section of structure based on the decision rules (Table 2.10: Page No. 30 of DSS book)
5	Estimate length of Bunding per hectare (m) = 10000 x S/(VI x 100)
6	Estimate cost of conservation structure based on decision rules (Table-2.11: Page No. 31 of DSS book for Contour Bunding, Table 2.12: Page No. 33 of DSS book for TCB and Table 2.13: Page No. 34 of DSS book for Graded bunds.

6. Preparation of crop suitability plan

The land resources are finite and under stress due to the increased demand for food, fiber, fodder *etc*. from growing population. The population growth is leading to unfavorable man to land ratio. In India, per capita cultivable land holding has been declining from 0.48 ha in 1951 to 0.16 ha in 1991 and it is likely to decline further to 0.11 ha in 2025 and less than 0.09 ha in 2050 (NAAS, 2009). Although, the food production has increased from 52 m tons in 1950's to almost 311 m tons in 2020-21 (GOI, 2022), this increase has been largely as a result of expansion in cultivated and irrigated area and high chemical (fertilizer) inputs. The significant growth of agriculture has been at the cost of decline in soil quality and risk of soil degradation. We are now facing the serious threat of ensuring sustainability in our production systems. In many of the so-called first green revolution areas, a whole range of second-generation problems are posing serious challenges to the sustainable agricultural production. About 57 per cent of soils are under different kinds of degradation and these are getting further deteriorated with risk of jeopardizing our food security (Sehgal and Abrol, 1994). In addition to this, many issues concerning environmental sustainability, carrying capacity of our land resources, *etc*., are also cropping up and adversely affecting soil and human health. These problems demand a systematic appraisal of our soil and climatic resources to recast and implement an effective and appropriate land use plan at local level. Soil survey interpretation and land evaluation precede land use planning. Standard survey information can be interpreted for several purposes like suitability for agriculture through technical classification of soils, hydrological groupings, suitability for sewage disposal, trafficability, building construction, *etc*.

Land evaluation is the process of estimating the potential of land for alternative kinds of use. These uses can be productive such as i) arable farming, ii) livestock production, iii) forestry or other uses such as, a) catchment protection, b) recreation, c) tourism, d) wild life conservation. It involves interpretation of surveys, climate, soils, and vegetation and other aspects of land with the requirements of alternative land use.

Land evaluation procedures

The land evaluation activities undertaken and the order in which the work is done depend on the type of approach adopted, whether parallel or two-stage.

The main activities in a land evaluation are as follows:

- Initial consultations, concerned with the objectives of the evaluation and the data and assumptions on which it is to be based
- Description of the kinds of land use to be considered, and establishment of their requirements
- Description of land mapping units, and derivation of land qualities
- Comparison of kinds of land use with the types of land present
- Economic and social analysis

- Land suitability classification (qualitative or quantitative)
- Presentation of the results of the evaluation

It is important to note that there is an element of iteration, or a cyclic element, in the procedures. Although the various activities are here of necessity described successively, there is in fact a considerable amount of revision to early stages consequent upon findings at later periods. Interim findings might, for example, lead to reconsideration of the kinds of land use to which evaluation is to refer, or to changes in boundaries of the area evaluated.

Data set requirements for land evaluation

The land units and their homogeneity form the basic requirement for proper land evaluation. The land units selected for land evaluation have no scale limitation. The information on the land units is generated through different kinds of soil surveys.

The land characters and land qualities considered in defining the land units are as under:

Land characters: Land characteristics used in land evaluation are measurable properties of the physical environment directly related to land use and are available from the soil survey. These characteristics are

Bio-physical characteristics: factors like topography (t)-slope length and gradient; wetness (w)-drainage and flooding

Physical soil characteristics: Texture, soil depth and intensity of acid sulphate layer and gypsum or kankar layer

Fertility characteristics (f): Cation exchange capacity of the clay as an expression of weathering stage, base saturation and organic matter content

Salinity and alkalinity (n): Salinity status and alkalinity status

Climatic database: Factors such as temperature, potential evaporation, the temporal and spatial variability of rainfall, specific to an area are considered as database for estimation of growing period.

There are a number of other important properties, which co-vary with changes in the property; however, these properties are of great value in interpreting the various uses. Soil classification systems very much rely extensively on quantitative composition of soils and these compositions are selected on their assumed importance in understanding the genesis of the soil.

Land qualities: It is a complex attribute of land which acts in a distinct manner, its influence on the suitability of land for a specific kind of use. They may be positive or negative. They are in fact

practical consequences of land characteristics. They could be segregated in to two groups: FAO (1976) suggests three comprehensive land qualities:

Internal qualities: Water holding capacity; oxygen availability; availability of foot hold to roots; tolerance to iron induced chlorosis; nutrient availability; resistance to structural degradation of top soil; absence of salinity and alkalinity.

External qualities: Correct temperature regime; resistance against erosion; ability for layout of farm plan and workability.

Land Evaluation Approaches

Land evaluation is the ranking of soil units on the basis of their capabilities (under given circumstances including levels of management and socio-economic conditions) to provide highest returns per unit area and conserving the natural resources for future use (Van Wambeke and Rossiter, 1987). Several systems of land evaluation have been recognized (Storie, 1954; Requier *et al*., 1970; Sys, 1985; Sehgal *et al*., 1980). There are both qualitative and quantitative approaches in vogue.

A. Qualitative evaluation

i) Land Capability Classification (Klingbiel & Montgomery, 1961).
ii) Land Irrigability Classification (Soil Survey Staff, 1951; USBR, 1953).
iii) Fertility Capability Classification
iv) Crop Suitability Classification (FAO, 1976; Sys, 1985; Sys *et al*. 1993)
v) Prime Land Classification (Ramamurthy *et al*., 2012)

B. Quantitative evaluation

i) Soil index rating (Shome and Raychaudhari, 1960; Storie, 1978)
ii) Actual and potential productivity (Riquier *et al*., 1970)
iii) Soil suitability classification- statistical approach (Sehgal *et al*., 1989)
iv) Land use planning and analysis system (LUPAS) (Laborte *et al*., 2002):
v) Land suitability assessment by parametric approach (Rabia and Terribile, 2013)
vi) Land suitability by fuzzy AHP and TOPSIS methods (Mukhtar Elaalem *et al*., 2010)
vii) Land suitability by integrated AHP and GIS method (Ramamurthy *et al*., 2020)

Land Suitability Evaluation

Each plant species requires specific soil-site conditions for its optimum growth. The land suitability assessment provides the suitability or otherwise of the various land resources occurring in an area for major crops grown. This helps to find out specifically the suitability of the land

resources like soil, water, weather, climate and other resources and the type of constraints that affect the yield and productivity of the selected crop.

This assessment is based on the model proposed by the FAO (1976 and 1983) for land evaluation and suggested the classification of land in different categories: Orders, Classes, Sub-classes and Units. The soil-site characteristics are expressed in terms of degree of limitation (0, 1, 2, 3 or 4); the limitation of 2 is considered critical at which the expected yield declined significantly and the cultivation is considered marginally economical. The final soil-site evaluation/suitability is based on the number and degree of limitation (s). Modern approaches involve simulation model predicting yield as a measure of suitability. Although very well refined, yet these approaches are largely based on local experience of farmers or of the researchers.

Land evaluation involves the assessment of land and soils for their potential for different uses involving matching the land qualities and requirements for the land use. For rationalizing land use, soil-site suitability for different crops need to be determined to suggest the models for guiding the farming community to grow most suitable crop(s), depending on the suitability/capability of each soil unit mapped.

The adaptability of crops in one or the other area is the interaction between existing edaphic conditions and fitness of the cultivar under these conditions. Although, lot of data on crop production through experimentation have been generated by the SAU's and Crop Research Institutes, yet it has not been correlated with sufficient data base on the soil-site conditions in order to work out soil-site suitability models for optimizing land use in the country.

In the land evaluation, there are four steps namely (i) characterization of existing soil, climatic and land use conditions (ii) development of soil site criteria or crop requirements (iii) matching of crop requirements with existing soil and climatic conditions and (iv) choosing of the best fit among the crops and the selecting the same as the alternative crop strategy.

Among the above four steps, the formulation of the soil site criteria to meet the crop requirements forms a vital and important step. For the development of crop requirements, one has to do either experimentation at each well characterized growing environment or take the help of published literature. Naidu *et al*. (2006) have compiled the soil-site requirement of major crops of India by reviewing published literature and consulting crop specific researcher teams.

Matching of crop requirements consists of comparing existing climate, soil and physiographic conditions with the soil-site criteria with respect to individual crop. On the basis of the degree and the number of limitations identified, the suitability class is established, *viz*., highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and unsuitable land (N1 & N2) for specific kind of land use. Land suitability subclasses are divided into land suitability units based on specific management requirements. The ratings used for defining each class are based on the number and degree of limitations present. The S1 classes correspond to areas, which have a yield potential

above 80% of the maximal attainable harvest within the climatic region of the area. This figure drops to 60% and 40% for classes S2, and S3, respectively.

Simple limitation method: In assigning the overall suitability class to any area, the limitation approach or law of the minimum is followed. According to this approach, even if all other factors are favorable for the crop and only one factor is likely to be a limitation, then that factor is given precedence in assigning the suitability class. The suitability classes and sub-classes are directly assigned to land units based on suitability criteria. A brief description of the orders, classes and subclasses used in the suitability assessment of major crops is given below:

Order S (Suitable)

Class S1	:	(Highly suitable) Land unit having no limitation for sustainable use or with not more than three slight limitations.
Class S2	:	(Moderately suitable) Land with more than three slight limitations but with not more than three moderate limitations.
Class S3	:	(Marginally suitable) Land with more than three moderate limitations but with not more than two severe limitations.

Order N (Not Suitable)

Class N1	:	(Currently not suitable) Land with severe or very severe limitations that may be overcome in time but cannot be corrected with existing knowledge at current acceptable cost
Class N2	:	(Permanently not suitable) Land having limitations that will be very difficult to correct and use

There are no sub-classes within the suitability class S1. Classes S2, S3 and N1 are divided into subclasses based on the specific limitations encountered in an area for the selected land use. The specific limitations that are likely to affect crop production at the watershed or village level are indicated below with their symbols to be used.

Erratic rainfall and its distribution and short growing period	c
Erosion hazard (Slope and erosion)	e
Soil depth (rooting conditions)	d

Soil texture (lighter or heavy texture)	t
Coarse fragments (gravelliness or stoniness)	g
Soil fertility constraints, calcareousness, sodicity hazard, salinity problem etc.	n
Drainage problem	w
Moisture availability	m
calcareousness	z
Topography	l

Limitations are indicated in lower case letters after the suitability class symbol. For example, marginally suitable land with low rainfall or short growing period as a limitation is designated as S3c. Normally two and sometimes three limitations are included at subclass level. Land suitability units are indicated by the Arabic numbers after the limitation symbol.

Based on the suitability classification, land resources of any watershed or area can be evaluated to find out their suitability for various crops, like cereals and millets, oil seeds, pulses, commercial crops like cotton, sugarcane, spices and horticultural crops. The assessment can be done for the existing crops that are under cultivation at present or for some of the promising crops and varieties from other places before they are recommended for cultivation in the area.

The process involved in the crop suitability assessment is elaborated below.

- Selection of the crop and the survey number or land parcel to be assessed for suitability evaluation
- Finalisation of suitability criteria for the crop or crops to be assessed. The criteria table developed for each crop will show the soil-site and other land characteristics on one side and the range of values assigned to each of the land characteristics for different suitability classes like Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), Currently Not Suitable (N1) and Not Suitable (N2) on the other side
- Run the system to match the crop suitability criteria with LRI, Hydrology and other resource information pertaining to the farm/survey number stored in the system
- After the matching process, the system displays the degree of suitability for the crop with constraints if any as subscripts after considering the following criteria/logic
- Law of Minimum/Limitation approach in assigning the degree of suitability

- Internal prioritization among crops with same rank
- Displaying the suitable crops (on prioritization basis) with all limiting factors as sub-script
- Based on the soil, site, climate and other datasets, the system calculates the number of S1s, S2s and S3s against the parameters provided with each crop matrix. Then the crop is placed into a suitability class/category based on the law of minimum as illustrated below.

Example:

Sorghum: 4S1 + 3S2 + 4S3 ~ will be placed in to S3 (Internal prioritization based on the Law of Minimum approach)

Maize: 1S1 + 10S2 + 0S3 ~ will be placed in to S2 (Internal prioritization based on the Law of Minimum approach)

Red gram: 15S1 + 0S2 + 0S3 ~ will be placed in to S1 (Since there is no limitation for the crop)

Maize S2, Groundnut S2-Selection of the most suitable crop among the two will be based on B:C Ratio as the score for both crops are same.

Benefit cost ratio: is decided based on standard cost of cultivation, yield and dynamic market prices. The standard cost of cultivation for any crop is available with the Department of Agriculture. Market prices can be obtained from Agmarketnet web API. Using the above the B:C Ratio can be calculated as (Yield X Market Price) / Cost of Cultivation.

The Crop suitability choices arrived for an area need to be shared to the concerned agricultural office/stakeholders and vetted before the same is recommended to the farmer. This assessment can help greatly in identifying the best suited areas and the areas having limitations in the watershed area. Similar assessments can be made for other areas and for other crops for the same area.

Exercise - 3

Crop wise soil characteristics for deciding suitability of crops

Description		***Ragi***	***Redgram***	***Mango***	***Areca***
Depth (cm)					
Very shallow	<25	N	N	N	N
Shallow	25-50	S3	N	N	N
Moderately shallow	50-75	S2	S3	N	S3
Moderately deep	75-100	S1	S2	S3	S2
Deep	100-150	S1	S1	S2	S1
Very deep	>150	S1	S1	S1	S1
Gravels (%)					
g0	<15	S1	S1	S1	S1
g1	15-35	S2	S2	S2	S2
g2	35-60	S3	S3	S3	S3
g3	60-80	N	N	N	N
Slope (%)					
A	0-1	S1	S1	S1	S1
B	1-3	S1	S1	S1	S1
C	3-5	S2	S2l	S2	S2
D	5-10	S3	S3l	S3l	S3
E	>10	N	N	N	N
Texture					
Loamy sand (b)	ls	S3	S3	N	S3
Sandy loam (c)	sl	S1	S2	S2	S2
Sandy clay loam (h)	scl	S1	S2	S1	S1
Clay loam (f)	cl	S1	S2	S1	S1
Sandy clay (i)	sc	S1	S1	S1	S1
Clay Red (m)	c	S1	S1	S1	S2
Clay Black (m)	c	S3	S2	S3	S3
Drainage					
Well		S1	S1	S1	S1
Moderately well		S1	S2	S2	S2
Poorly		S3	S3	S3	N
Very poorly		N	N	N	N

Considering the above crop suitability criteria, for the given soil phases indicate suitability of Ragi, Redgram, Areca and Mango as S1/S2/S3/N

Soil Phase	***Characters***					***r***	***t***	***g***	***l***	***w***	***Suitability class***
	Depth	***SSG***	***SST***	***Slope***	***Drainage***	***Depth***	***Texture***	***Gravels***	***Slope***	***Drainage***	
Ragi											
TDHhB1	50-75	0	sc	1-3%	mod. well						
APHiA1St1	<25	33	sl	0-1%	well						
CKMiC1g1	75-100	0	ls	3-5%	poor						
Redgram											
KMHiB1g1	100-150	23	c(r)	1-3%	well						
BPRiB1	25-50	32	scl	1-3%	poor						
JDGcA1	50-75	8	sc	0-1%	mod. well						
Arecanut											
GLRiD1	100-150	40	c(r)	5-10%	well						
NDLhC1	>150	50	s	3-5%	well						
BDKcB1	25-50	14	c(b)	1-3%	very poor						
Mango											
RTRiB2g1	25-50	10	c(b)	1-3%	well						
TSDiA1	75-100	17	scl	0-1%	poor						
TDGiC1	>150	37	s	3-5%	well						

7. Preparation of nutrient management plan

The importance of soil fertility and plant nutrition to the health and survival of all life cannot be understated. As human population continue to increase, human disturbance of the earth's ecosystem to produce food and fiber will place greater demand on soils to supply essential nutrients. The practice of intensive cropping with hybrid varieties for boosting food production in India caused nutrient depletion in soil, consequently macro and micro nutrient deficiencies are reported in soils of India. If we do not improve and/or sustain the productive capacity of our soils, we cannot continue to support the food and fiber demand of our growing population. Maize is gaining importance as a commercial food grain crop in Karnataka. High fertilizer responsiveness together with preference for cultivation under irrigation, maize crop is known to remove nutrients exhaustively. It is therefore important to monitor the nutrients status of soil from time to time with a view to monitor the soil health.

In the recent past, concept of watershed based holistic development has emerged as one of the potential approach in rainfed areas, which can lead to higher productivity and sustainability in agriculture. Hence, assessing the fertility status and nutrient mapping of soils is needed to identify extent of nutrient deficient area for site specific recommendations. Micronutrient deficiency in soil has become wide spread in recent years and has resulted in low crop yields, more so after the introduction of high yielding crop varieties coupled with the use of high analysis fertilizer and increased cropping intensity. The information regarding the status of available micronutrients and nutrient mapping of soils is needed to realize the concept of watershed approach successfully.

Many of the soils in different ecosystems are fragile and miss management can rapidly lose whatever capability they have for sustained productivity. If we do not improve and/or sustain the productivity capacity of our fragile soils, we cannot continue to support the food and fiber demand of our growing population. Therefore, it is critical that we increase our understanding of the soil nutrient status and relationships in the soil-plant atmosphere continuum that control nutrient availability.

Hence, geo-referenced information on the location, extent, quality of land display of spatial data is a must for advisory purposes. Geographic information system (GIS) is a powerful set of tool for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world. Geographic information system (GIS) can be used in producing a soil fertility map of an area, which will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. This is an important technique for formulating site specific recommendation of nutrients.

Available Nutrients mapping

Surface (0-20/30 cm) soil samples are to be drawn in grid sampling from the area at 320-meter grid intervals. Soil samples are to be processed and analyzed for the soil fertility parameters like organic carbon, nitrogen, phosphorous, potassium, calcium, magnesium, Sulphur, copper, iron, zinc,

manganese and boron by standard analytical techniques. Thematic maps are to be prepared for the analysis data using GIS tools.

DSS on Nutrient Management

Inputs data required for the DSS: GIS layers of all soil fertility parameters, crop wise NPK fertilizer and micro nutrient recommendations, criteria for adjusting the fertilizer recommendations, information of the farmer and location details of the farmer's field.

Soil fertility criteria for adjusting the recommended fertilizer doses for macro nutrient application (NPK)

Nutrient	*Very Low*	*Low*	*Medium*	*High*	*Very High*
Nitrogen	Recommended dose x 1.67	Recommended dose x 1.33	Recommended dose x 1.00	Recommended dose x 0.67	Recommended dose x 0.33
P_2O_5					
K_2O					

Note: For example, if the recommended dose of N for irrigated maize is 150 kgs/ha and if the nutrient content of the soil is very low, then we need to add 250 kg/ha (150 x 1.67), for low 200 kgs/ha (150 x1.33), for medium 150 kgs/ha (150 x 1.0), for high 100 kgs/ha (150 x 0.67; 2/3 general recommendation as per POP) and for very high 50 kgs/ha (150 x 0.33; 1/3 general recommendation as per POP). Similarly, for phosphorus and potassium, the fertilizer requirements are calculated using the above formula.

Step by Step Process

Step	*Description*
1	Read farmers information (Contact number, land parcel, crop sown, area, ACZ, dry or irrigated)
2	Read soil fertility status with respect to land parcel from LRI information
3	Select nutrient recommendation from selected crop
4	Adjust nutrient recommendation with respect to soil fertility status
5	Read nutrient content in fertilizers
6	Estimate amount of fertilizer required for the crop
7	Estimate the dose at different stages of plant growth (Basal dos and top dressing)
8	Send the advisory to the farmer-dosage of fertilizer and cost at different stages of growth along with package of practices to be followed
9	Based on the nutrient status of the soil in the watershed/sub watershed area estimate the amount of fertilizers required for the area.

Apart from the display of the nutrient status maps, the amount of nutrients required for the Micro watershed/sub watershed area can be estimated and shown as an output as per the requirement.

Exercise - 4

Nutrient Management Plan

1	Select a micro watershed atlas
2	Select three 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
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) (table - 5.3a to 5.3h Page No. 119-142 of DSS book)		
Adjusted nutrient as per soil nutrient status (table - 5.4: Page 143 of DSS book)		
Type and quantity of fertilizers recommended		
Combination 1		
Urea		
SSP		
MOP		
Combination 2		
DAP		
17-17-17		
Urea		
MOP		
Cost of fertilizers (Rs.) (table - 5.7: Page 148 of DSS book)		

8. Preparation of drainage line treatment plan

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 lie 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 cm, 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 slit.
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 of 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.

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 - 5

DSS for estimating runoff and designing of water harvesting protocol

1. In the hydrology atlas, soil phase wise runoff figures are indicated. Correlate the contributing soil characteristics of different phases to understand the extent of runoff.

Exercise - 6

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

1. Suggest the size of the farm pond for a given condition with cost estimates - Refer page - 181 in DSS book for details
   Catchment area -1ha
   Runoff - 30mm
   Soil type - Red

9. Crop water requirement and water budgeting

Water is a basic and most essential natural resource for existing of life. Although, 70% of the earth is covered with water, 0.3% is only available for human welfare satisfying domestic, agricultural and industrial needs. The per capita water availability of water in India is reduced from 5177 m^3 during 1951 to 2500 m^3 during 1980 to the present (2020) 1700 m^3 and expecting to decline further to 1140 m^3 by 2050 against the safe limit of 1800 m^3. NITI Aayog (2018) report 'Composite water management index' mentions that India is undergoing the worse water crisis in its history and nearly 600 million people are facing high to extreme water stress. The report also mentions that India is placed in 120th position among 122 countries in water quality index, with nearly 70% of available water being contaminated.

In India, agriculture being the major sector consuming around 82% of the fresh water, will lose its share with increasing demand from domestic and industrial share. Sustaining agriculture production to achieve food security of the burgeoning population in the country demand efficient use of available water, necessitating water budgeting.

Water budgeting at watershed scale is essential in the present context in India considering its greater dependence on rainfed farming. The purpose of water budgeting at watershed scale is

- To promote sustainable water management (Surface & groundwater) through participation of stake holders for higher water productivity.
- To create awareness among the water users within the watershed.
- To facilitate a shift in cropping systems considering water availability.
- To develop wise water use protocols.

Steps in Water Budgeting

Water balance is the difference between source / supply and utilization / demand. The source of water / supply side in the watershed include rainfall, surface water if available (canal / lift irrigation / tanks) and ground water. The demand side of water in the watershed includes domestic, agricultural and industrial (if exist in watershed) needs besides water subjected for evaporation from the storage structures. The steps involved in working water budget are

1. Estimation of water availability (rainfall, surface, groundwater etc) within the watershed.
2. Estimation of storage potential of rainfall in different forms (Soil moisture, Runoff, Surface and Ground water storage)
3. Estimation of total water use demand for human, livestock, crop and industries with in the watershed Area.
4. Finding out Water Balance (Available Water – Water Requirement as per proposed water use pattern).

Step 1: Water supply Assessment.

Rainfall: The quantity of rain water received in a watershed is calculated by multiplying the amount of rainfall with the geographical area

$$\text{Rain water availability } (m^3) = \text{Total Rainfall (mm)} \times \text{Watershed area (acre)} \times 4$$

Eg: The quantum of water received in a watershed with 500 ha area (1250 acre) with 700 mm annual rainfall is

$$\text{Rain water availability } (m^3) = 700 \times 1250 \times 4$$

$$= 35,00,000\ m^3$$

$$= 350,00,00,000\ \text{ltr} \quad (\textbf{Note}\ 1\ m^3 = 1000\ \text{ltr})$$

Other sources: If the watershed receives water from other surface (Canal, lift irrigation, runoff from the upper catchment etc.) or groundwater (to be calculated based on the number of bore wells and their water yield) also to be considered.

Step 2: Assessment of Stored Water (existing) using GEC (Groundwater Estimation Committee) Norms

As per GEC guidelines, the rainfall proportion utilized for different components include

A. Soil moisture and evaporation : 70%
B. Runoff : 20%
C. Ground water storage : 10%

Step 3: Water Demand Assessment (based on water use pattern)

The data on Human and Livestock population including birds for calculating domestic needs, crop are data for calculating agricultural needs and Industrial needs if any within the watershed area to be considered in demand analysis using the following information.

Domestic demand: The total water demand for domestic needs to be calculated using the per capita water demand (ltr per day) for different population as detailed below

Human: 135 ltr	Local cows: 100 ltr	Crossbreed cows: 150 ltr
Buffalo: 150 ltr	Sheep & Goat: 10 ltr	Horse: 32.5 ltr
Donkey: 20 ltr	Pig: 10 ltr	Poultry: 0.25 ltr
Dog: 5 ltr	Rabits: 0.64 ltr	

Agricultural crop water demand: The area under different crops in the watershed need to multiply with the crop water requirement to workout agricultural demand, the water requirement of crops is detailed below for the said calculation

Sl. No.	Name of the crop	Water requirement					
		Irrigated			Rainfed		
		cm	Ltr / acre	m^3 / acre	cm	Ltr / acre	m^3 / acre
1	Paddy	150	6000000	6000	100	4000000	4000
2	Jowar	55	2200000	2200	50	2000000	2000
3	Bajra	40	1600000	1600	35	1400000	1400
4	Maize	60	2400000	2400	55	2200000	2200
5	Ragi	45	1800000	1800	40	1600000	1600

6	Wheat	55	2200000	2200	45	1800000	1800
7	Minor Millets	35	1400000	1400	30	1200000	1200
8	Bengal gram	45	1800000	1800	40	1600000	1600
9	Red gram	70	2800000	2800	65	2600000	2600
10	other pulses	40	1600000	1600	35	1400000	1400
11	Groundnut	60	2400000	2400	50	2000000	2000
12	Castor	70	2800000	2800	65	2600000	2600
13	Sunflower	60	2400000	2400	50	2000000	2000
14	Soybean	55	2200000	2200	45	1800000	1800
15	Sesamum	45	1800000	1800	35	1400000	1400
16	Mustard	45	1800000	1800	35	1400000	1400
17	Safflower	45	1800000	1800	35	1400000	1400
18	Linseed	50	2000000	2000	40	1600000	1600
19	Niger	40	1600000	1600	30	1200000	1200
20	Sugar cane	200	8000000	8000	170	6800000	6800
21	Cotton	85	3400000	3400	75	3000000	3000
22	Tobacco	50	2000000	2000	45	1800000	1800
24	Mulberry	120	4800000	4800	80	3200000	3200
25	Mango	60	2400000	2400	60	2400000	2400
26	Banana	220	8800000	8800	220	8800000	8800
27	Lemon	90	3600000	3600	90	3600000	3600
28	Guava	60	2400000	2400	60	2400000	2400
29	Sapota	50	2000000	2000	50	2000000	2000
30	Pomogranate	60	2400000	2400	90	3600000	3600
31	Papaya	90	3600000	3600	60	2400000	2400
32	Grapes	90	3600000	3600	90	3600000	3600
33	Other fruits	60	2400000	2400	60	2400000	2400
34	Potato	60	2400000	2400	50	2000000	2000
35	Tomato	70	2800000	2800	70	2800000	2800
36	Brinjal	70	2800000	2800	70	2800000	2800
37	Beans	50	2000000	2000	50	2000000	2000
38	Onion	60	2400000	2400	50	2000000	2000
39	Green chillies	60	2400000	2400	60	2400000	2400
40	Ladies finger	50	2000000	2000	50	2000000	2000
41	Radish	30	1200000	1200	30	1200000	1200
42	Carrot	40	1600000	1600	40	1600000	1600
43	Water melon	30	1200000	1200	30	1200000	1200
44	Leafy vegetables	30	1200000	1200	30	1200000	1200
45	Total gaurds	40	1600000	1600	40	1600000	1600

46	Other vegetables	45	1800000	1800	45	1800000	1800
47	Pepper	100	4000000	4000	100	4000000	4000
48	Cardamum	100	4000000	4000	100	4000000	4000
49	Dry Ginger	90	3600000	3600	90	3600000	3600
50	Turmeric	90	3600000	3600	90	3600000	3600
51	Garlic	60	2400000	2400	60	2400000	2400
52	Dry chilli	50	2000000	2000	65	2600000	2600
53	Coriander	60	2400000	2400	60	2400000	2400
54	Coconut	-	700000	700	-	700000	700
55	Cashew	50	2000000	2000	50	2000000	2000
56	Total flower crops	70	2800000	2800	70	2800000	2800
57	Medicinal plants	70	2800000	2800	70	2800000	2800
58	Coffee	100	4000000	4000	100	4000000	4000

Industrial demand: The annual water demand for industries in water watershed to be accounted if they exist.

Step 4: Calculation of Water Balance

The difference between water supply and demand gives water balance. If the difference is negative, planning to be made either to source water externally or by adjusting cropping system with low water demanding crops. If positive, alternative means viz., cropping intensification (multiple cropping), high water demanding crops of other activities may be planned to use the excessive water.

For more details, refer the DSS book supplied as part of training kit.

Exercise - 7

Estimation of crop water requirement

Steps in estimation of crop water requirement

#	***Description of the steps involved***
1	Define land use class/ cropping system and its management details
2	Estimate day after sowing
3	Estimate crop coefficient based on days after sowing and crop growth parameters
4	Estimate potential evapotranspiration requirement using measured weather parameters on daily time scale
5	Estimate crop water requirement using crop coefficient (Table 8.3) and potential evapotranspiration (Multiply crop coefficient with PET)
6	Display crop-wise water requirement **at parcel level**. (Aggregate crop water requirement at soil unit, MWS and SWS levels based on the crop cultivated)
7	Display crop-wise water requirement to the farmer/other stakeholders

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

Refer table-8.3, page: 194 for crop coefficient (Kc) values compiled for major crops (FAO, 1998)

Crop	***Area (ha)***	***Crop water requirement***
Maize	7	
Sorghum	14	
Soybean	3	
Groundnut	10	
Sunflower	9	
Cotton	12	

10. Draft DPR guidelines

DRAFT GUIDELINES FOR INTERNAL USE ONLY

Government of Karnataka
Watershed Development Department

DRAFT

GUIDELINES

FOR

DETAILED PROJECT REPORT (DPR) GENERATION USING LRIDATA AND COMMUNITY CONSULTATION PROCESS

REWARD Program

(Rejuvenating Watersheds for Agricultural Resilience through Innovative Development)

CONTENTS

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 managementpractices. 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.

Plate-1: Frequently drought affected taluks in Karnataka

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 agriculturalproductivity 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 micro watersheds covering 14 lakh ha. Eleven pilot watersheds developmentprojects were

taken up 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 organizingfarmers 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 totechnology, 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.

Plate-2: 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 LRIinputs. Advanced equipment's were procured by the Karnataka State Remote Sensing and Application Centre (KSRSAC) 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 Bankfor 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 programis 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 counterpartfinancing 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 theWDC-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 planningand 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 21rainfed 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 24th March 2022 to 30th 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)
NBSS&LUP						
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
TOTAL				**68**	**613**	**3,25,303.12**
UAS Bangalore						
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
TOTAL				**68**	**654**	**3,60,678.67**
UAS Dharwad						
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
TOTAL				**74**	**667**	**3,60,180.88**
UAS Raichur						
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
TOTAL				**56**	**495**	**2,87,266.74**

Sl No	District	Taluka	Area Details	No. of SWS	No. of MWS	Area for LRI (ha)
UHS Bagalkot						
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
TOTAL				**89**	**558**	**3,43,998.91**
UAHS Shivamogga						
12	Chitradurga	Challakere	New area	26	159	1,13,841.86
13	Shivamogga	Shikaripura	New area	17	153	78,811.16
14	Chikkamgalur	Kadur	New area	20	142	1,04,377.41
15	Chikkamgalur	Kadur	Sujala -III balance area	1	5	3,645.08
16	Chikkamgalur	Tarikere	Sujala -III balance area	4	15	9,361.46
17	Davengere	Channagiri	Sujala -III balance area	6	19	11,126.48
TOTAL				**74**	**493**	**3,21,163.45**
GRAND TOTAL				**429**	**3480**	**19,98,591.78**

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 hectares 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 inengaging 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 accountabilitymechanisms 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 ofgeneration 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 ofDPR
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 PRAexercise

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 theDPR 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 byState 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 placedin 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 basictraining 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 resourcemanagement 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 andNGO to ensure proper estimate, following guidelines and execution based onbudget 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 watershedplanning and demonstration of generating draft DPR using DSS modules inLRI 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;

Participants	**Individual / Private lands**	**Common lands and Drainage lines**	**Vulnerable Groups**
Field NGO	• Field Guide and Community organizer • Technical Staff if any	• Field Guide and Community organizer • Technical Staff if any	• Field Guide and Community organizer
Assistant Agriculture Officer (AAO)	AAO assigned to that micro-watersheds	AAO assigned to that micro-watersheds	AAO assigned to that micro-watersheds

Participants	Individual / Private lands	Common lands andDrainage lines	Vulnerable Groups
Watershed Developmen tTeam (WDT)	Specialist in • Horticulture • Livestock • Agriculture • Forestry	Specialist in • Horticulture • Livestock • Agriculture • Forestry	Optional
SWS Executive Committe e(WEC)	Preferably the entirecommittee and • President • Secretary • Treasurer • Gram Panchayat Representatives Compulsorily: Representatives fromAGs and SHGs	Preferably the entirecommittee and • President • Secretary • Treasurer • Gram Panchayat Representatives Compulsorily: Representatives fromAGs and SHGs	• President • Secretary • Treasurer • all SHG representatives
Area Groups	All members belonging to the area	All members belonging to the area	
SHGs	Representatives of theWEC	Compulsorily: All members of the SHGs dependent on CPRs in the mini-micro-catchment and the micro-watershed Representatives to WEC	All members of the concerned SHG, especially representatives of all the SHGs
Individua lfamilies	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 anyconcern/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 activitieson 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 neighbour farmers should be recorded.
7. Prioritize the interventions over time line and prepare tentative year wise action planwith 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 neighbours/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 of3 photos while planning for CPRs from different angles/sides should be capturedand 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 upto 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 consolidatedat 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 withthe 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 helpin 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 transact in all the Area groups area, on 4th day the Task Teamwith 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 duringtransect done for planning.

- For seeking clarifications on any issue that might have arisen duringtransact.
- For finalising the activities to be taken in the watershed on individual andcommon lands.
- For discussing implementation strategies, cost sharing aspects, labouravailability for the works, etc.
- For carrying 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 andplace before GS.

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

Steps	Details
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. The map should contain the following features: • Drainage lines • Existing soil and water conservation structures •Various types of land with survey boundaries (common lands and individual lands) • Major land features• Vegetation etc.
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 theREWARD and budget coming from the convergence with other schemes etc. Technical appropriateness of the intervention need to be discussed.

e) Discuss broad implementation issues	**Discuss the following issues in great detail:** • 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? • Will the labour required for all the works come from the vulnerable families in the micro watershed? • Do the land treatment activities accommodate the livelihoods needs of the vulnerable groups? • Are there special activities with usufruct sharing mechanisms to support thevulnerable groups? • 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. • Discuss the mechanisms to collect people's contributions for work and document the same
f) Environmental and Social Safeguard Strategies	Any physical treatment activity is having any adverse impact on environment and social systems? If yes, how to manage those?

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 finalised by FNGO and submitto 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 approvalforward 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 ontheir 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 maleand 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 towomen 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.

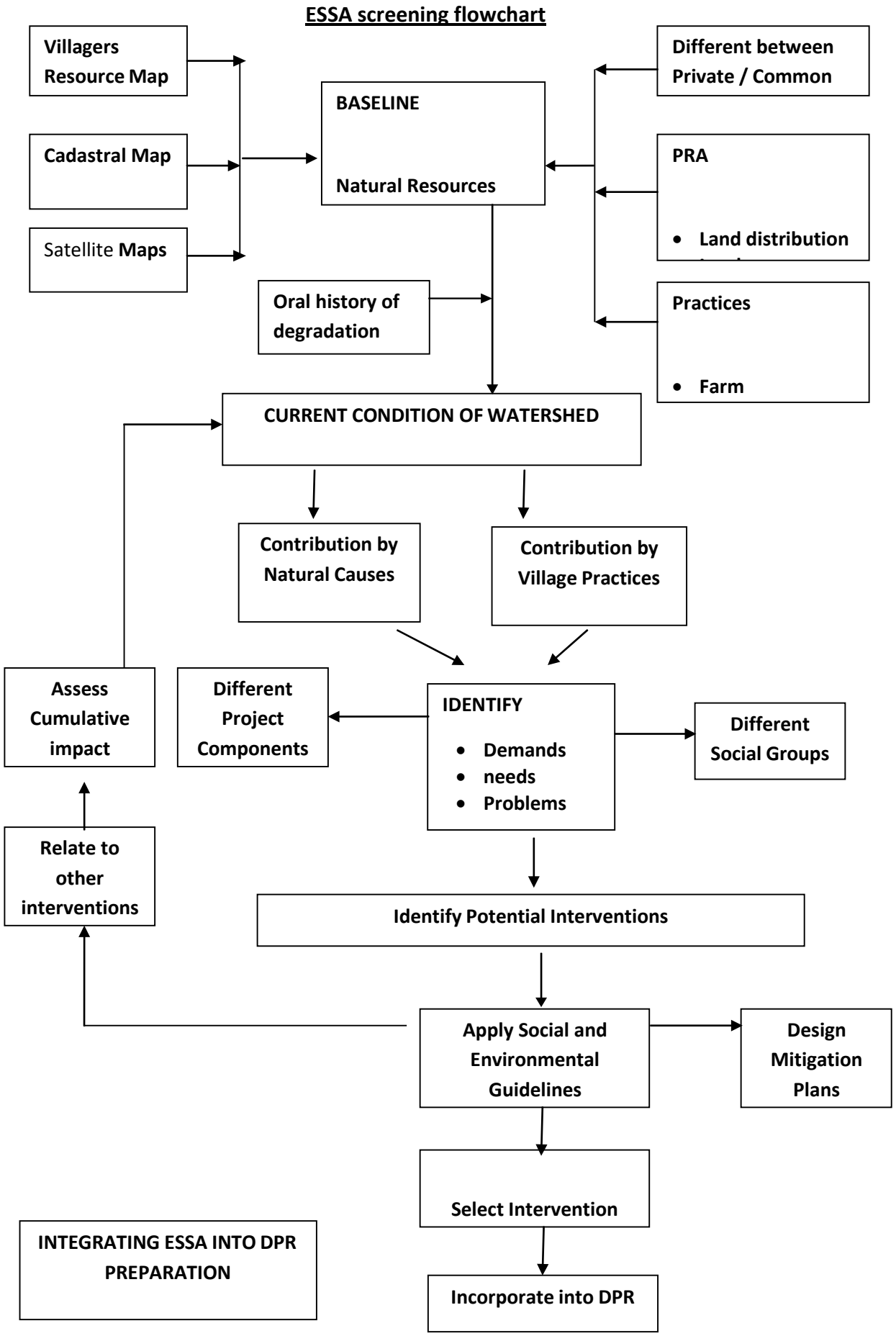
J. Integrating Environment and Social Issues into DPR Preparation

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 withdifferent 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 KSRSAC.
3. The social baseline including different traditional practices followed by different sections of the village (farming, livestock, and non-farmactivities), 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 differentsocial groups (landowners, marginal farmers, landless), what are the needs ofthe 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 potentialinterventions, they become an analytical tool for selecting the most optimum set of interventions that would enhance the productivity as wellas 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 oractivity.
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.


ESSA screening flowchart
Villagers Resource Map
Cadastral Map
Satellite Maps
BASELINE
Natural Resources
Different between Private / Common
PRA
Land distribution
Practices
Farm
Oral history of degradation
CURRENT CONDITION OF WATERSHED
Contribution by Natural Causes
Contribution by Village Practices
Assess Cumulative impact
Different Project Components
IDENTIFY
Demands
needs
Problems
Different Social Groups
Relate to other interventions
Identify Potential Interventions
Apply Social and Environmental Guidelines
Design Mitigation Plans
Select Intervention
INTEGRATING ESSA INTO DPR PREPARATION
Incorporate into DPR

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	Helps to understand the history of the village
Trend and Seasonality analyses	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.	• 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. • area impacted with salinity (Ece=>4.0) & sodicity (ESP=>25), waterlogged area, designated wet lands as per Ramsar classification etc.	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	:	
		District	:	
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**
2. Resources			
2.1	**Forest Land**		
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	**Grazing Land**		
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	**Biodiversity**		
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 meditational 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	**Agriculture** 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	Soil Quality		
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	**Ground Water**		
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	**Surface Water**		
2.7.1	No of ponds		

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	**Common Property Resources**		
2.8.1	Is there any common property resource area located within the watershed		

Annexure-II

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 andprovide 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 rulesare 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 alsorequest 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 oron-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 WE 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 thesame 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 came 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 technicalsupport 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.

a) To ensure active partnership of the project community in planning and implementation.

b) 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.

ANNEXURE-III a

Trainings for CBOs

I. SHG Trainings:

Project Phase	Module	Topic
Preparatory Phase	S1	Orientation on REWARD Program, functions, roles and responsibilities, ESSA compliance and participatory planning.
Implementatio nPhase	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):

Project Phase	Module	Topic
Preparatory Phase	AG1	Overview of REWARD, formation, functions, roles and responsibilities, ESSA compliance, gender & social inclusion, participatory planning and DPR preparation.
Implementatio nPhase	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):

Project Phase	Module	Topic
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

ANNEXURE-III b

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

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 Subwatershed in each DATC	EC members	45	2	1080	12	2 days

ANNEXURE-IV

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.

- 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.

ANNEXURE-V

DPR Training

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

#	Subject	By	Timings
	Day-1		
1	**Introduction about REWARD program**, Program objective, Uniqueness, Activities & Implementation methodologies, Institutional arrangements, M&E etc.,	District Joint Director of Agriculture	10.00 am to 10.30 am
2	**Land Resource Inventory (LRI) and Hydrological studies under REWARD**: 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
	Tea Break: 11.30 am to 11.45 am		
3	**Orientation about Preparation of draft Detailed project reports (DPR**) for watershed treatment using LRI & Hydrological data/atlases & 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	**Orientation to Watershed development team (WDT)** 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
	Lunch Break: 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
	Tea Break: 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
	Day-2		
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

Annexure VI

Private Land Treatment Plan Format:

Sl No	MWS_CODE	Hobli	G.P Name	Village	Survey_hiss	Acr	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 FORT)	Size / Section	Quantity	Actual RMT / HA / NO	Unit Cost	Total Activity Cost	Total Beneficiary Cost	S1	S2	S3
																		19									
1																											
2																											
3																											

Annexure - VII

Drainage Line and Common land treatment details

	District :	
	Taluk :	
	Sub Watershed Name :	**Sub Watershed Code :**
	Micro Watershed Name :	**Micro Watershed Code:**

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 inview of existing condition of the soil and topography
- Ensure complying key recommendations of LRI and ESSA principles

Annexure X.

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 thecommunity, 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? 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 itacquired with acceptance of the legal owner and compensation paid?
5.	Indigenous Peoples and Vulnerable Groups	Are there indigenous people in the watershed area? Aretheir 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

References:

Borrowers Completion Report, 2020, Sujala-3 Project, KWDP-II, Watershed Development Department, Government of Karnataka

Desertification and Degradation Atlas of India, 2021, Ministry of Environment and Forests.

Economics of Desertification, Land Degradation and Drought in India, 2018, TERI.

GOI. 2022. Directorate of Economics and Statistics.

Handbook for Land Resource Inventory, REWARD Project, Karnataka, 2022, National Bureau of Soil Survey and Land Use Planning and Watershed Development Department, Government of Karnataka.

High level committee report on Wasteland Development, 1995, Ministry of Rural Development, Government of India.

http://www.sujala3lri.karnataka.gov.in

MSVAMITVA, 2020, Survey of Villages Abadi and Mapping with Improvised Technology in Village Areas, Ministry of Panchayat Raj, GoI.

NATARAJAN, A., 2006, Land Resources of Sivagangai Block, Soil Survey and Land Use Organisation, Department of Agriculture, Tamil Nadu

NATARAJAN, A., Land Resource Inventory for Climate Smart Agriculture, 2022, Dr S. V. Govindarajan Memorial Lecture, Nat. Seminar on Managing Soils in a Changing Climate, NBSS&LUP, Nagpur

NATARAJAN, A., R. S. REDDY, K. V. NIRANJANA, RAJENDRA HEGDE, R. SRINIVASAN, S, DHARUMARAJAN, S. SRINIVAS, B. A. DHANORKAR AND VASUNDHARA, R., 2016, Field Guide for Land Resource Inventory, Sujala III Project, Karnataka, National Bureau of Soil Survey and Land Use Planning, Nagpur, India.

National Mission for Sustainable Agriculture (NMSA-9) -Sub-Group -4 for Promoting Data Access of the NMSA under the National Action Plan on Climate Change (NAPCC), 2009, Department of Agriculture and Co-operation, GoI.

Our Farmers are toiling on decaying Soil, Coverage of Sujala-3 Project, 2018, The Hindu, dated Aug 6, 2018

Report of the working Group on Rainfed areas for formulation of 11^{th} five-year plan, 2007, Planning Commission, Government of India.

Soil Survey Manual, Handbook No.18, 2019, United States Department of Agriculture, USA