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RESEARCH PAPER

Karnataka land resource inventory portal: One stop solution for optimal resource allocation and conservation at farm level for maneuvering of agriculture

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Abstract: The watershed Development Department (World Bank supported Sujala-III project) in consortium with State Agricultural, Horticultural and Veterinary Universities, NBSS&LUP and Indian Institute of Sciences, Bengaluru has developed Land Resource Portal (2019) to strengthen the science based planning for optimal use of land and water resources, conservation practices and crop planning both at cadastral (1:7920) and watershed scales simultaneously. The portal designed and developed to host digital data base (spatial and non-spatial) and data products (climatic, soil-water – crop relations) through characterization and depiction of status of soil, geology, land slope, components of hydrological cycle, socio- economic bench mark credentials pertaining to 1.4 M ha (so far) of rainfed tracts across 11 Districts. The portal provides GIS-integrated decision support on Soil & Water conservation plan, Crop Selection, Land Capability Classification, Nutrient Management, Surface Runoff, Designing of Size & location of Farm Ponds, Crop Water Requirement, Water Balance, and Water Budgeting both at farm holding level and at watershed level benefiting in timely problem solving with improved efficiency for dealing with agricultural situations of rapidly changing variables.

Key words: Decision support system, Hydrological cycle, Nutrient

Introduction

The watersheds are natura hydrological entities that cover a specific aerial expanse of land surface from which the rainfall runoff flows to a defined drain, channel, stream or river at any particular point. The watershed with its flexible scale is widely used to denote hydrological units which vary from a few hectares (micro) to millions of square kilometres (catchment) and a micro watershed covers approximately about 500 ha. Watershed management is the holistic approach to manage the land, vegetation, and water to optimise the agricultural productivity in turn production under the sustained use of resources. Land Resource Inventory (LRI) is an investigative assessment of the site-specific status and changing condition of soil, water, land use, weather and their related phenomena and features observed and measured at ground reality at cadastral level. Assessing the field variability and grouping similar areas into one management unit is critical for taking up any site-specific interventions by the dedicated agency which are primarily monitored by the line departments. The subsequent critical analysis of the LRI data base of a given watershed provides ready to use maps, thematic outputs, Reports, Atlas, Decision Support System and advisories needed for site-specific land resource management at the watershed or farm level. The changes in the eco system thus quantified through the data analysis measures the changes with respect to its own previous status in the past sensitizing the resource managers and end user in building the strategy for further course of management.

A degraded environment can be tackled effectively through the redressal and holistic development of that natural geo-hydrological watershed. The Digital library (DL) is a repository of both spatial and non-spatial database and maps of the state of resources comprehended at different scales and resolutions though interpretation of data in the form of geo-referenced cadastral maps, imagery, LRI database, geology, geomorphology, land use and other maps, thematic maps, decision support systems (DSS), LRI and Hydrology Reports and Atlas, etc., including photographs, images, audio, video, or other digital products. In addition to storing the content, the LRI DL helps the user to search and retrieve the information stored in the DL. An expert system developed with the involvement of domain specialists to facilitate the watershed and other line departments to prepare their plans based on criteria and to provide advisories to the planners, farmers and other users on soil and water conservation, crop selection, nutrient management etc would help in comprehending and extends guidance in making better use of state of resources.

Development of decision support systems

A decision support system (DSS) is a computerized information system used to support decision-making in an organization. A GIS based **Decision Support System (G-DSS)** planned under Sujala III project comprises of a decision support system integrated with a Geographic Information System (GIS). This is an interactive system which entails use of a Database Management System (DMS), which holds and handles the geographical data; a library of potential models that can be used to forecast the possible outcomes of decisions; and an interface to aid the user interaction with the computer system and to assist in analysis of outcomes. A G-DSS typically uses a variety of spatial and non-spatial information, like data on land use, soil and water management, demographics, agriculture, climate, and other resource information (Annexure-1). Using the tools, stakeholders can investigate the effects of different scenarios, and provide information to make informed decisions. The benefits of decision support systems include more informed decision-making, timely problem solving and improved efficiency in dealing with problems with rapidly changing variables.

The decision support systems developed by the partner institutions of the Sujala-III project namely, National Bureau of Soil and Land Use Survey, Indian Institute of Soil Sciences, State Agricultural Universities of Bengaluru, Raichur, Dharwad, State Agricultural and Horticultural University, Shivamogga and Horticultural University, Bagalkot are as follows:

1. DSS for Soil & Water conservation plan

The conservation plan includes three types of treatments: 1) bunding, 2) terracing, 3) trenching. Criteria for selection of treatment types are divided into arable-black soils, arable red and lateritic soils, and non-arable soils. Selection of conservation plan is decided based on land slope, soil depth, texture, gravel, rainfall and cost of construction. The dedicated tables have been generated for selection befitting with field conditions being described interms of variables aforesaid. The sequence of activities involved and decision rules in the selection of different structures, their size, shape and preparation of Soil and Water conservation plan for a given watershed is followed as the guidelines given in Implementation Manual for Sujala III project (WDD, 2016). The DSS estimates and displays length of bund (main and side bund), waste weir, volume of earthwork involved and cost towards earth work pertaining to location within selected watershed. In similar lines DSS leads to logical conclusions with respect to terracing and trenching.

2. DSS for Crop selection

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-site characteristics, 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 Food and Agricultural Organisation (FAO, 1976 and 1983) to assess the resources of an area for specific land use/crop. In this assessment, the specific requirements of a crop (compiled from the existing literature) are compared with the characteristics of land and suitability of the area for the crop is arrived based on the matching. If the land characteristics of an area match the requirements of the selected crop then the area is considered as suitable for the crop, otherwise it is grouped as not suitable for the crop. The site-specific land resources database generated through LRI helps to establish the suitability of the resources to any selected crop for the area in a very objective manner, which was not possible earlier with general datasets. The land unit are classified as that of no limitation for sustainable use (highly suitable, S_1), with not more than three slight limitations (moderately suitable, S_2) and as beyond three moderate limitations (marginally suitable, S_3). Again, the land are also catagorised as with severe to very severe limitations (Currently not suitable, N_1) and those having limitations that will be very difficult to correct and use (Permanently not suitable, N2) following law of minimum and internal prioritization among crops with same rank

3. DSS for delineating arable and prime farm lands (based on land capability assessment)

Land capability assessment is done to find out the general capability of the resources of an area for agricultural crops, forestry and other uses. In this assessment, the mapping units occurring in an area are grouped according to their limitations they pose for cultivation, the risk of damage if they are used for the identified use, and the way they respond to management interventions. Normally the criteria used in grouping the units don't take into consideration any major and costly reclamation measures or conservation techniques that change the slope, depth or characteristics of the soils. This system is not aimed to find out the suitability of the land resources for specific uses or crops. Though the classification was evolved originally to help the soil conservation efforts, but now this system can be used for identifying priority areas, which requires immediate attention and development within a watershed or project areas. The capability grouping is based on the inherent soil characteristics, external land features and environmental factors that limit the use of the land for different purposes (I.A.R.I., 1971 and Soil Survey Division Staff, 1993). The land and soil characteristics (depth, texture, reaction, water holding capacity, calcareousness, salinity/ alkalinity) and climate (Rainfall distribution and length of growing period) are used to group the land resources identified in an area into various classes and units. Capability subclasses (I – VIII) are formed based on the dominant limitations observed within the capability class. They are designated by adding a lower-case letter like e, w, s, or c, to the class numeral.

4. Crop based Nutrient Management and Soil Health

The fertility status of the soils, surface soil samples are collected at 250/325-meter grid intervals and analysed for the soil fertility parameters including nitrogen, phosphorous, potassium, calcium, magnesium, and Sulphur, copper, iron, zinc, manganese and boron. The ratings used to group the soils into various Soil fertility classes are based on recommended guidelines on content of macro nutrients (kg/ha) for Organic Carbon (gKg^{-1}), Available N, Available P(P_2O_5), Available K (K^2 O) and Available S ($mgKg^{-1}$) In respect of micronutrient, their recommended critical limits in the soil have been considered. The crop wise fertilizer recommendation for twenty crops has been set for decision making processes. The spatial data product on soil fertility parameters, crop wise fertilizer and micro nutrient recommendations, criteria for adjusting the fertilizer recommendations, farmers information, location information of farmers field are considered.

5. DSS for estimating Runoff at farm and micro watershed levels

Runoff is a critical factor in deciding the type of conservation needed, number and location of water harvesting and recharge structures, formulation of appropriate cropping pattern and crop

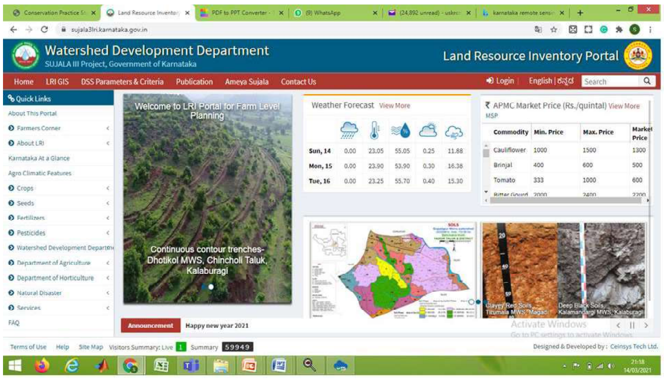

Fig. 1 The Dash board details of web Portal of Watershed Development Department

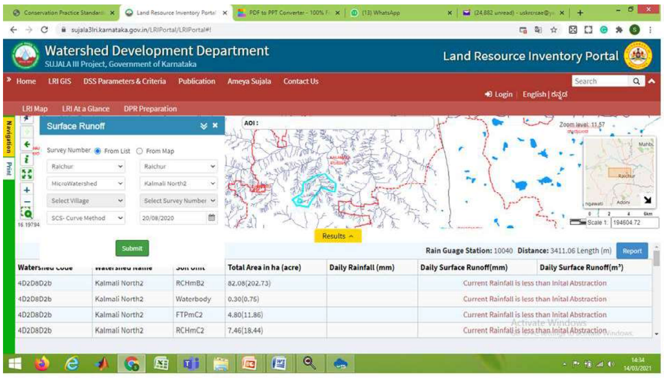

Fig. 2 DSS functionalities in estimation of surface runoff

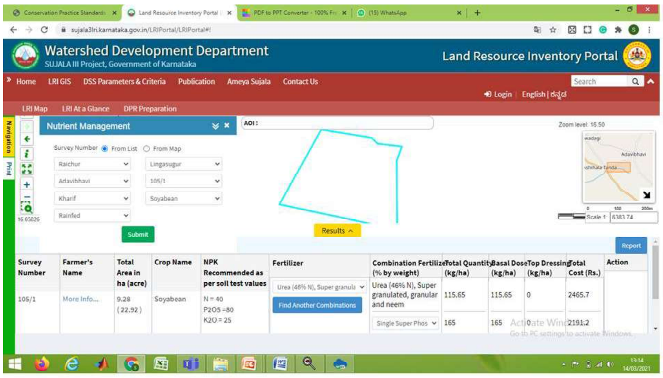

Fig. 3 DSS functionalities in estimating requirement of fertilizer

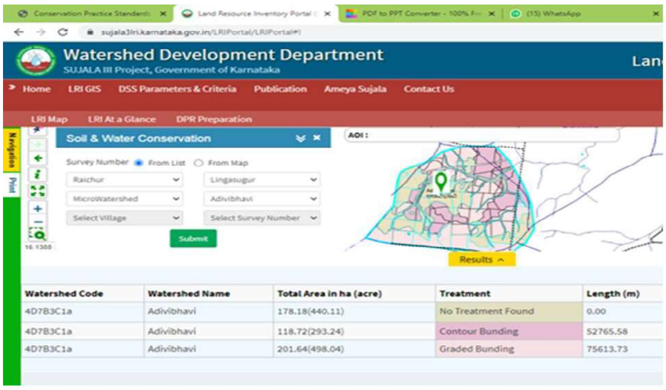

Fig. 3 DSS functionalities in deciding quantity contour bunding per ha of land parcel

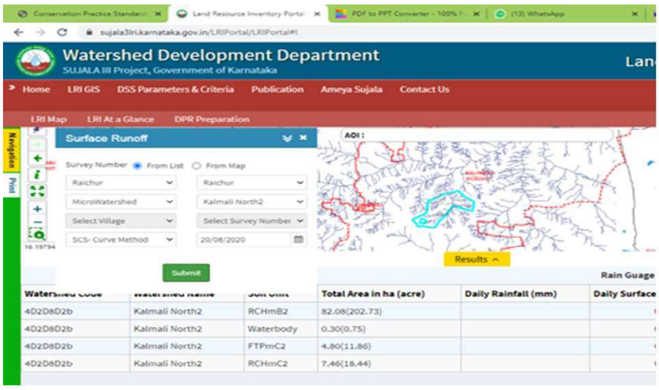

Fig. 5 DSS functionalities in deciding quantity surface runoff per ha of land parcel

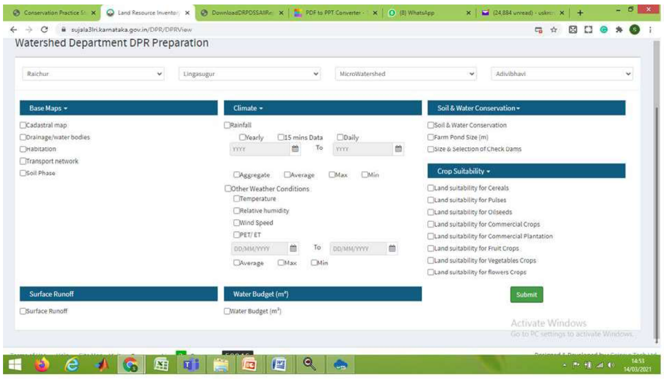

Fig. 6 DSS functionalities in deducing the Detailed project Preparation

selection and the water balance and water availability at the watershed scale. The algorithm for estimation of runoff has been depicted in the methodology followed in SCS-curve number method, Rainfall intensity- Infiltration method and Rational method (peak discharge).

6. Determination of the Size of farm ponds

Farm ponds are manmade water storage structures (ponds) which facilitate to harvest runoff in excess of conservation and stored water could be used during stress period of crop to ensure its life saving through irrigation. Farm ponds are constructed by excavating the soil, by depositing the soil on the bunds. These ponds may be lined with impermeable membrane such as HDPE sheet to avoid infiltration of water into soil. However, unlined ponds contribute towards groundwater recharge. The DSS would be instrumental in deciding optimal size, its dimensions, storage capacity following procedure of balancing between spatial and temporal pattern of runoff excess generated from land holding vis-a-vis demand that needs to be met out of stored water per unit lifesaving irrigation and other peripheral uses including animal husbandry.

7. Estimation of Crop water requirement

Crop water requirement has been estimated using FAO 56 method. The input parameters are land parcel size, its land management status, potential evapotranspiration estimated based on modified Penman- Montieth's weather-soil regimeaerodynamic model, crop management terms (type, date of sowing and crop duration) and crop growth indicator (crop coefficient, K_c). The DSS tree leads to net crop water requirement (mm) against prevailing situations.

8. Estimation of Soil-Water (Moisture) balance at micro-watershed scale

Soil Water (Moisture) balance equation at micro-watershed scale is defined as the change in soil moisture storage pertaining to the spatial land parcel in a given period would be arithmatics of the water balancing components namely, Rainfall, Irrigation, Surface runoff, Evapotranspiration, and deep percolation. As a continuation to the DSS on water requirement, the soil moisture deficit against maximum holding capacity of soil on daily basis would be the basis to decide quantity of water to be supplied (irrigation) on an eventuality to tide over water stress during crop growth period.

9. Water budgeting

It envisages at accounting the water available on watershed scale from different sources including rainfall, ground water and surface storage and allocating the available quantity to the different demands including agriculture, cottage industry and domestic usage considering variability supply positions and demands on different time scales.

Credentials of Web Portal

The portal designed and developed to host digital data base (spatial and non-spatial) and data products (climatic, soil-water –crop relations) through characterization and depiction of status of soil, geology, land slope, components of hydrological cycle, socio- economic bench mark credentials pertaining to 1.4 M ha (so far) of rainfed tracts across 11 Districts. The 66 thematic derived for each 2533 micro watersheds through analysis of spatially inventoried data on remote sensing (Cartosat-I) and GIS platforms using advanced toolkits and temporal analysis using validated models and algorithms. The vital data used from repository of important source institutions namely, Karnataka State Natural disaster Management center (KSNDMC), Bhoomi and Karnataka State Remote Sensing Applications centre (KSRSAC) and State line Departments. The web based portal accepts query on the 66 thematic and provides solution or data product both in visual and report formats. Portal is hosted at Karnataka State Data Center equipped with modern IT infrastructure which enables data sharing and collaboration with Universities. This is a platform used to search and access geographic (geospatial) data products and associated services (display, editing, analysis, etc.) via the Internet providing access to populate and publish data and metadata and discover / explore metadata through catalogue service.

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