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RESEARCH ARTICLE

Development of decision support system for land suitability evaluations for crops using ICT tools

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ABSTRACT

Agricultural sector is the most important sector for Indian economy, as majority of Indian population is engaged in agricultural occupation. The demand of food in India has increased because of rapid growth of population in recent. The land is either over used or under used without considering its potential and constraints for growing crops in India. This consequence brings a set of different problems like under agriculture production, land degradation, land use conflicts, etc. Population of the India is growing dramatically so farming community has to produce more in order to meet the growing demand of food under limited land recourses. Choosing the most suitable crop to be cultivated for high agricultural production is most difficult task for farmers. To produce more crop, selection of crop for particular land is very difficult task for farmers. Number of factors like climate, soil, topograpy, moisture and nutrient availability, rooting conditions and soil toxicity make farmer's task further tough. Therefore, an attempt has been made to develop a decision making tool for farmers to select the appropriate crop for their land. National Bureau of Soil Survey Land Use Planning (NBSS-LUP) Criteria and Analytical Hierarchy Process (AHP) technique is used to develop this tool. The interface engine of formulated tool has been developed using Microsoft Visual Basic.NET programming language. This tool helps in classifying crops in four suitability classes viz. highly suitable, moderately suitable, marginally suitable and not suitable according to NBSS-LUP criteria. The system covers 46 varieties of crops covering Cereals, Pulses, Oil seeds, Fibre crops, Commercial crops, Plantation crops, Fruit crops, Medicinal and Aromatic plants and Spices. It is proposed to facilitate farmers for selecting crops as per availability of local climatic condition and soil fertility.

KEY WORDS : Decision support system, Land suitability evaluations, Crops using, ICT tools

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INTRODUCTION

Agriculture is the prime sector in India, having huge impact on GDP, export and employment. The size of agriculture sector reflects that it is the wheel of social and economic growth of nation but the current condition is not relatively good due to increasing food demand and declining land resources. To meet the demand various advanced methods and techniques like precision farming, sustainable farming, organic farming etc. can be adopted which can shift the agriculture community more on selection of the most appropriate crop for their land. Various factors affect the land suitability of any crop like climate regime, land quality, moisture availability, nutrient availability, root condition, soil toxicity and erosion hazard. Based on these factors, National bureau of soil survey and land use planning (NBSS and LUP), India has developed criteria for selection of suitable crop by considering local conditions. There is a need

to develop user friendly decision support system for farmers to select appropriate crop.

Various attempts have been made to develop agricultural and farmer friendly tools all around the world. Land evaluation computer system (LECS) developed by Wood and Dent (1983) in Indonesia based on food and agriculture organization (FAO) framework. LECS has provided specific crop recommendation for land parcel on the basis of economic factors. Kalogirou, 2002 developed land suitability evaluation model, LEIGIS software, which allows user for physical and the economic evaluation of land based on 17 land characteristics for five crops (wheat, barley, maize, seed cotton, sugar beet). The development of information technology and spatial/numerical tools during the last twenty years has enabled researchers to make rapid progress in the analysis of interactions between land resources and agriculture land use. Multi criteria analysis (MCA) based GIS technique has capability to provide a coherent and nonbiased decision making in agriculture land suitability (Ceballos and Blanc, 2003). Agroecological decision support system, MicroLEIS (Mediterranean land evaluation information system) has been developed for Mediterranean region by integrating databases, statistics, expert systems, neural networks, Web and GIS applications and other information technologies (Rosa *et al.*, 2004). Jayasinghe and Machida (2008) developed an interactive web-based GIS online consulting system with crop-land suitability analysis, which provides information on tomato and cabbage cultivation. This system is limited to two crops only however, it is available online for users.

There is a need for user friendly interface for flexibility in the system that allows the user to identify and change the crop requirements based on local condition and also to add new crop in the system if required in future. An attempt has been made to develop automated decision making tool for farmers to select the appropriate crop for their land. Automated land suitability for crops in developing country like India where the information technology is in its very early stages, should be more user friendly and accessible for farmers having limited computer knowledge. Therefore, for a common man of India, simple and flexible automated land evaluation tool is needed to be developed. This study highlights the development of new decision support system for assessing land suitability for different type of crops considering the local land characteristics and local climatic condition. It helps the farmers and policy makers to determine the suitable crop based on quality of land to increases the food production thereby improve the economic condition of farmers.

EXPERIMENTAL PROCEDURE

Under this project, decision support system is developed for farmers to identify suitability of crop based on various climatic and land characteristics. Analytical and mathematical approaches have been adopted to develop the decision support system. A software model is formulated by combining VisualBasic.NET programming language and advanced Microsoft excel. The primary objective of this work is to build a genuine, robust and intact computer software platform to help the farmers. The following points were considered for building the intended decision support system (DSS):

– Farmers use this decision support system to analyze the suitability of specific crop for his agricultural land without having knowledge of computer programming language.

– The DSS should have an ability to recommend the suitable crop to user out of 46 prescribed *Kharif* and *Rabi* crops.

– This recommendation will help to improve agricultural productivity thus, to enhance the economic condition of farmer.

– In this developed DSS, new crop can be added in future if required.

The developed tool is simple, easily operated by non-GIS users and well equipped with flexible user interface. The system requires input data such as climate regime, land quality, moisture availability, nutrient availability, root condition, soil toxicity and erosion hazard. The output of the system will be the suitability classes from non-suitable to highly suitable based on input parameters. MS excel is used for database management and visual basic is used for building tool interface. Crop land suitability is made by integrating crop evaluation criteria and weights derived from saaty's method (add content for saty). Final suitability index is calculated by multiplying criteria rank value as shown

in Eq. 1. Two excel sheets for every crop is prepared. First excel sheet contains evaluation criteria based on NBSS-LUP and criteria rank for every parameter which is termed as crop parameter sheet and other comprise of mathematical calculation of criteria rank and weightage derived from saaty's method is termed crop evaluation sheet. In crop parameter sheet, criteria rank for every parameter is defined based on suitability criteria class based on FAO, 1976. Highly suitable, moderately suitable, marginally suitable and not suitable are given ranks 4, 3, 2 and 1, respectively. In crop evaluation sheet, rank is multiplied by the individual weight derived from saaty's method of specific parameter of crop parameter sheet. The product of rank and weight gives individual suitability index. The sum of individual suitability index of each parameter leads to final suitability index as shown in Eq. 2. and Fig. 1 shows the methodology for tool development.

Individual suitability index= $S_i = \sum R_i \times W_i$ .....(1)

Ri = Rank of individual parameter
Wi = Weightage factor of individual parameter

Final suitability index $s_f = \Sigma s_i$ .....(2)

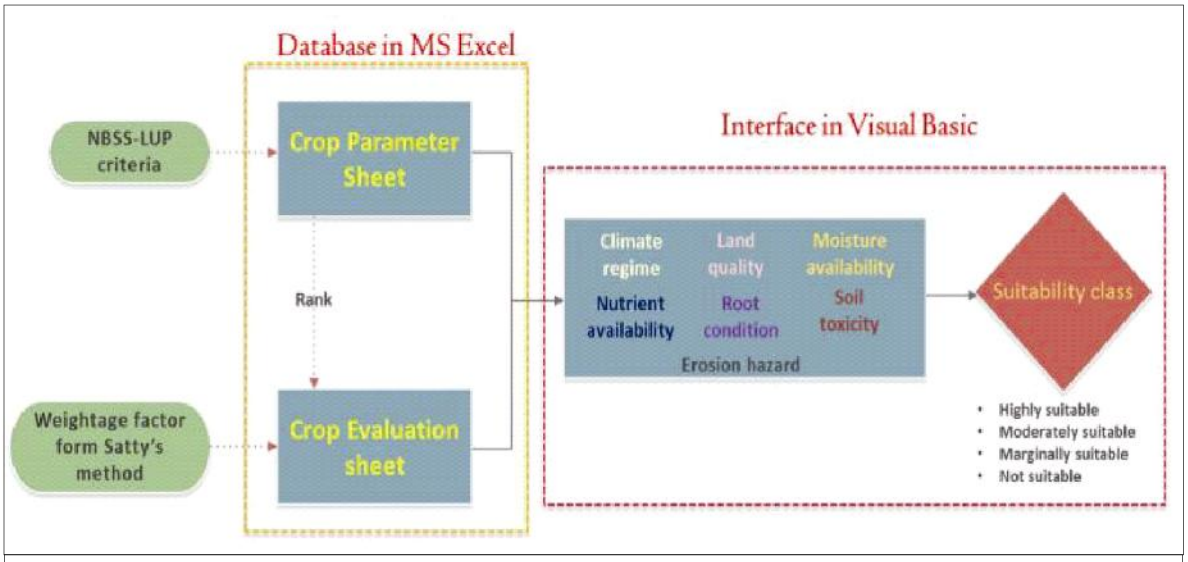

Fig. 1 : Methodology for tool development

Data base management system :

The user is required to provide the information like crop to be cultivated, climatic parameters (Rainfall, temperature and relative humidity), land quality parameters (soil drainage class, water depth level, days of water logging in growing season, elevation), moisture availability parameters (available water capacity), slope of land, nutrient availability parameters [Texture, sub surface texture, pH, organic carbon, cation exchange capacity, available nutrients (NPK)], root condition parameters (Soil depth, stoniness) and soil toxicity parameters (Salinity and solidity). The database of this system is comprised of total 46 major Indian crops based on NBSS-LUP criteria. The crop types in the data base are the major Indian agricultural crops such as cereals (Rice, wheat, sorghum, maize, pearl millet, finger millet, minor millets), pulses (Pigeonpea, bengal gram, field bean, cluster bean), oil seed crops (Groundnut, rapeseed and mustard, sunflower, soybean, castor, sesamum), fibre crops (Cotton, jute), commercial crops (Sugar cane, potato, chilli, tobacco), plantation crops (Tea, coffee, coconut, arecanut, rubber, cashew, oil palm), fruit crops (Mango, grapes, citrus, banana, sapota, guava, pomegranate), Medicinal and aromatic plants (Ashwagandha, mucuna, davana, lemongrass) and spices (Vanilla, pepper, ginger, turmeric, cardamom). The limiting criteria adopted from NBSS-LUP is formulated MS Excel. Fig. 2 shows a synoptic view of data base management system used for development of this tool.

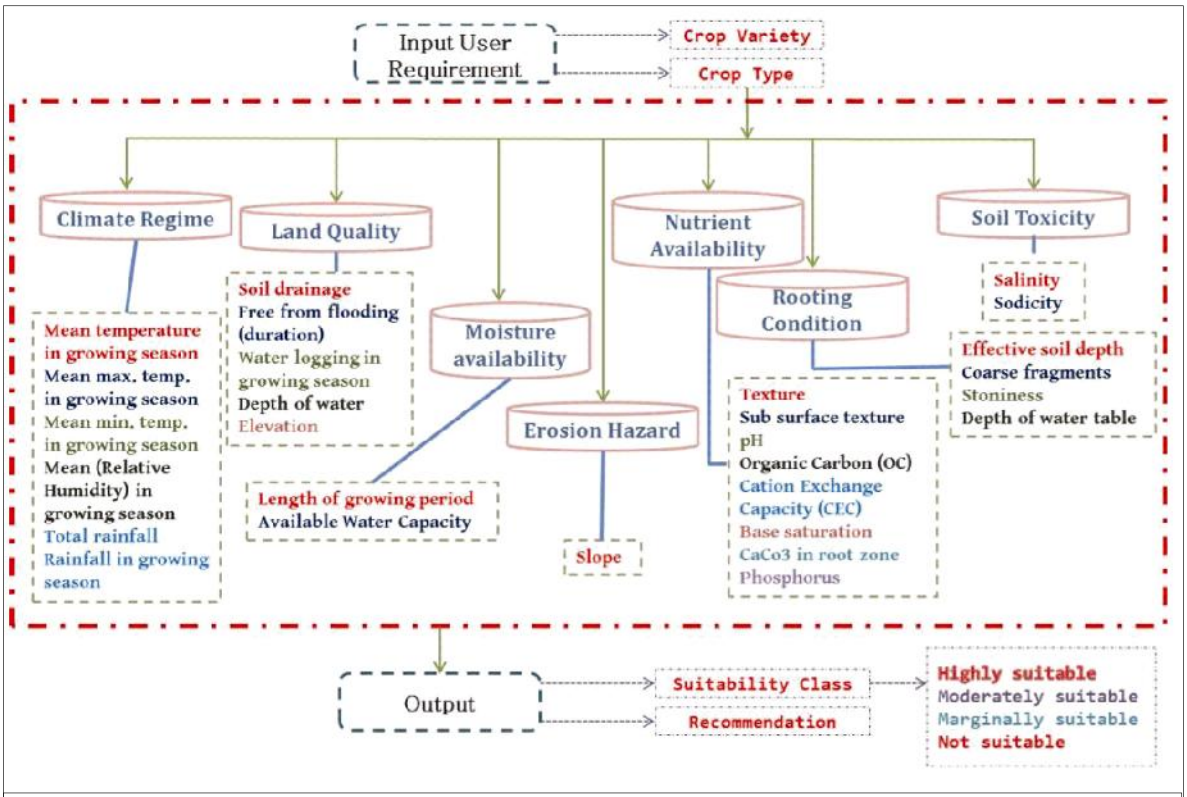

Fig. 2 : Database management system

EXPERIMENTAL FINDINGS AND ANALYSIS

This study presents an intelligent decision support system for the evaluation of farm land suitability of various agricultural crops using the soil and climatic parameters. In particular, Farmers find difficulty in selecting suitable crop

Fig. 3 : Graphic user interface of crop land suitability tool

Fig. 4 : User friendly features in tool

for their land. This system is developed using visual basic and MCDM technique, which allow user to select most suitable crop for their land. Visual basic makes the tool user friendly as compared to other decision support systems. In addition to that, the operation of the system is through graphic menus which avoid the mathematical calculation during the process of crop selection. This tool would be helpful to the decision makers as well as local agricultural authorities for suitability of land for various crops in order to increase the yield and to increase the profitability. The selection of most appropriate crop not only increase the production but it also helps in reducing the unnecessary use of fertilizers, which ultimately degrades the soil and crop productivity. In this tool, database for 46 Indian crops are available and more number of crops can be added in future if required. Moreover, other parameters responsible for crop productivity can be incorporated. Efforts have been made to make this tool as user friendly as possible. Help menu is provided at right corner of tool. Help menu provided basics of each and every parameter, how to determine the parameters, significance of parameter. This helps user to carrying out respective test as per standards and specifications for crop land suitability. User can also get brief information about each parameter by clicking on respective field. In addition to this user can also request for adding a new crop in the tool. These features make this tool more users friendly and lucrative. The snapshot of developed decision making tool is shown in Fig. 3 and 4.

Conclusion:

Indian is an agriculture based economy and having large impact on GDP however no computer based automated decision support system available to farmers and Indian farmers are still using conventional method of cultivation. Hence, attempt had been made to develop the automated decision support system for crop land suability evaluation for major Indian crops based on local evaluation criteria. The evaluation criteria are adopted from national bureau of soil survey (NBSS)- Land use planning (LUP), Nagpur, India. The suitability classes are defined according to the FAO method of land evaluation. Analytical hierarchy process (AHP) is used as multi criteria decision making method. MS Excel and Visual basic is used for development of this tool. A window based user-friendly computer software package is developed for land suitability evaluation. Using this system, users can evaluate land suitability for 46 type of crops faster than with conventional method. This tool is designed for Indian farmers with less computer knowledge and may have commercial and research application. This system is flexible enough to incorporate more crops as well as diverse criterion. The system is able to print hardcopies of the evaluation report. This study helps farmers for improving long-term agricultural productivity in an effective and

sustainable way.

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