International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459 (Online), An ISO 9001:2008 Certified Journal,Volume 3, Special Issue 2, January 2013)
National conference on Machine Intelligence Research and Advancement (NCMIRA, 12), INDIA.

Predicting Suitability of Crop by Developing Fuzzy Decision Support System

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Abstract

This paper is a summary of fuzzification aspects found in an extensive research work related to development of on line farmer assisting system. Here, the proposed DSS takes in to account all factors responsible for selection of a crop and then help farmer to take appropriate decisions regarding various aspects of Agriculture so as to minimize the losses of having less yield. This research study finds a good scope in India as Agriculture is the predominant occupation of two third of working India population for their livelihood

***Keywords*-component; DSS, Artificaial Intelligence, Fuzzy Logic , Agriculture ,Uncertaity**

I. INTRODUCTION

Agriculture is the major occupation of 75% population and contributes substantially to National Economy. About 1/3 of the total gross domestic product comes from agriculture sector alone. In export front agriculture has been contributing more than 11% of the total export. The Indian farmers have made tremendous progress in the last three decades and today they are self sufficient to feed one billion populations besides sizable exports.

Indian agriculture is mainly monsoon dependent with limited land resources. Keeping growing human population, the only way to increase crop productivity with varied farming situations, farmers' practices, thorough planning with active participation of farmers. An online agriculture decision support system is developed to assist the farmer for making a good decision in particular situation. Generally taking a good decision at proper time, directly affects the total production of the crop. Process of taking a decision is so complex as there are several factors affecting entire farming process. There are several factors which affect on yield of crops [1]. Further, Farmer has to analyze these several factors while taking decision of cropping and such decisions are changed area wise because geographical conditions differ region to region. In India, the weather is a single major limiting factor in crop production. Hence successful farming calls for appropriate decisions in the light of weather conditions have great significance.

Similarly, the monsoon depressions can be said to be a single factor that controls the distribution of the rainfall over the India [2]. A sound knowledge of the climate and an understanding of the complex processes of interaction between climate and biological processes of the plants are also essential aspects to be considered. Usually, for a good decision, one has to consider rainfall parameters, atmospheric condition, humidity, type of soil and many others factors. End user of the system is farmer and usually not more convenient with English. Since the project is intended for Marathwarda Region of Maharashtra, the local language i.e. Marathi is used for the displaying the information in web pages, so that the end user can thoroughly understand it. Above discussion highlights complexity of crop selection process. We also witness scope for fuzzy analysis as there is always uncertainty in the factors responsible for crop selection. The System design diagram is as below. Our system consists of two modules one is developed in software platform like Visual studio dot net which gives general information about the fertilizers, pesticides, insecticides, pest control for the specific crop. Second module is developed in MATLAB which is gives the information about the probable yield of the crop for the crops like cotton, Soyabean and Bajra.

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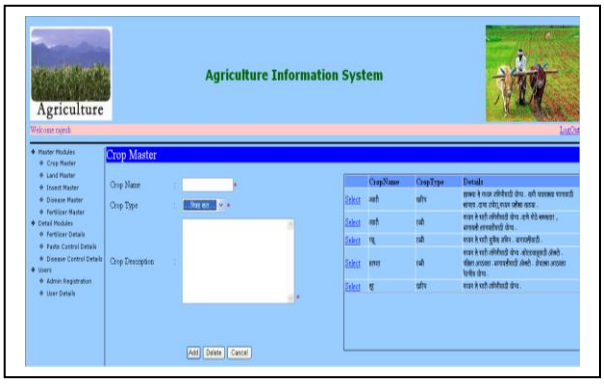

Fig.1 GUI of Agriculture based DSS

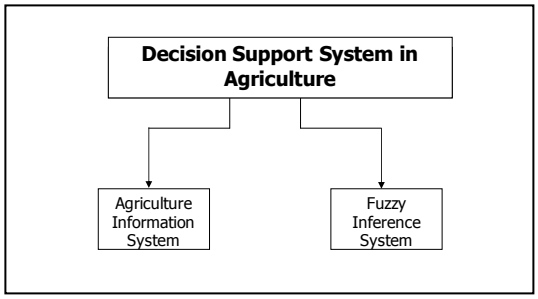

Fig.2 Anatomy of Agriculture based DSS

II. Literature Review

Literature review describes new trends of Decision Support System for effective decision making. Some efforts are seen which employs the fuzzy system that is able to organize and process all information related to make effective decision. The basic method used is inference based rules. The benefits reported from the increasing use of fuzzy include more accurate decisions, flexibility, improved quality and minimization of human inconsistencies. A rigorous analysis on the components of fuzzy system has shown that the systems in agriculture include database and knowledge bases. Some additional modules are also used for processes like optimization, simulation, decision analysis and inference It was also found that the simulation was employed to test sensitivity of the weather and market variations. Almost all of them have linear programming model used in them. The model is formed according to "if-then" type rules that are stored in knowledge base. The particular values of variable indicate what kind of crops should be grown and in what area for achieving the biggest benefit under the environmental and other conditions.

Some decision support systems perform the tasks of analysis of production efficiency, resource reserves and shortage. They also have support to internet for real time processing and provides farmer with suggestions necessary to increase the efficiency of production conforming to environmental constraints. The integration of optimization calculations and knowledge management into agriculture decision support system expands its possibilities and improve the quality of solutions.

While designing DSS, a simple approach has to be followed. Literature review shows focus on user-centered design. This can be accomplished by taking interviews and survey of growers and farmers. We witness following reasons of lack of uptake of DSS

- The complexity of the software's interaction with the user.
- The accessibility and required accuracy of inputs
- The cost benefit of using the system
- The need to answer the right questions
- The fit with the user working patterns and existing organizational structures.

III. System Planning

Many researchers have developed decision support system for various aspects related to agriculture such as use of fertilizers [5]. Some of them focus on implemented fuzzy based approach in decision support system [6] to make it more powerful. Some researchers suggest knowledge based DSS [7] and MIS based DSS [8] systems. Decision-making is a process which decision maker uses to arrive at a decision. The core of this process is described by the Herbert Simon in a model. He describes the model in three phases as a) Intelligence; b) Design and c) Choice. Management Information System follows this model in its development stage [9].

There are several websites available which provide agriculture information. Almost all of them provide the information about the specific crop. Very few from them provide all the information necessary for the users. Due to increasing awareness and use of computer in almost all the fields, use of internet is reached in rural area also. Still there is problem of language, all web sites provides information generally in English which is not understandable by most of the framers. Our attempt has solved this language barrier. Designing a web application on agriculture information system called "On-line Agriculture DSS" for providing agriculture information to the farmers is the main issue.

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It offers more flexibility in operation, provides all the necessary information to the farmers for making a appropriate decision in farming. It provides information related to the crops, fertilizers, pest controls, different types of diseases found in various crops and desired action to recover from it. In addition to this program also contains additional fuzzy based module providing information about possible yield of the crop if you provide the necessary parameters.

The feasibility study was conducted by developing the online application within a very short period of time. Few meetings were proposed to be organized with the technical experts for System Design. Minimum hardware requirement of the project is P4 or higher processor, 512MB RAM and Windows-XP or higher operating system. Prototyping was carried out which helped system designers to build an information system that intuitive and easy to manipulate for the end user. System Development Life Cycle (SDLC) was also drafted and traced. It is a structure imposed on the development of software. There are several models for such processes, each describing approaches to a variety of tasks or activities that take place during the process. An important task is documenting the internal design of the software for the purpose of future maintenance and enhancement. The various task of the system was documented to understand and work with the system. It was recommended by the expert group to design the web application by using .NET technology and SQL-Server as back end. The MVC patterns were used. The main purpose using MVC pattern is to decouple the GUI from the data. It also gives the ability to provide multiple views for the same data. MVC pattern separates objects into three important sections [19] . For example when a user is suppose to retrieve information related to pest control first it takes this data from the user interface (basically a view). Then user perform event like search and execute the actual query regarding to select operation. All these outputs are stored in data grid which is present in view of pest control. SQL Server support new data types like bigint-8-byte integer type, SQL variant. It allows the storage of data of different data types. There is also a table data type which allows application to store results temporarily for later use. It included native support for managing XML data, in addition to relational data. It has also been enhanced with new indexing algorithms, syntax and better error recovery systems. Data pages are check summed for better error resiliency, and optimistic concurrency support has been added for better performance.

Permissions and access control have been made more granular and the query processor handles concurrent execution of queries in a more efficient way. Partitions on tables and indexes are supported natively, so scaling out a database onto a cluster is easier. SQL CLR (Common Language Runtime) was introduced with SQL Server 2005 to let it integrate with the .NET Framework [23].

Experiments are carried out on the medium sized farms mainly for different types of atmospheric and others conditions. If one parameter such as a soil type is considered the average yields for different crops are tested. It was found that the system runs successfully. Our decision support system correctly provides information about the pesticides, the proper use of fertilizers according to the type of soil. The fuzzy inference system also provides the approximately correct results of the possible yield. Data is collected from different sources such as agriculture experts from Agriculture Department of Government of Maharashtra, Krushi Vidnyan Kendra (KVK). Some of the data was collected from the farmers directly because farmers can provide actual on site information. In addition , data from different books and news papers like Agro- One was also cited. We have developed a fuzzy based inference system that gives idea about the productivity of the crop i.e. the possible yield of the crop. This is a rule based system. If we provide necessary parameters then the system provides possible yield of the chosen crop. The DSS system was developed in Dot Net Platform with SQL Server 2005 as back end. The particular Fuzzy Component is developed in MATLAB. This development was carried out in following steps

- First step to develop agriculture based fuzzy inference system is to find out the important parameters. We have chosen such parameters where the vagueness is often encountered. As the output of system is the percentage of yield, the important parameters considered are mainly the type of soil and rainfall. Our System is developed around those parameters. Uncertainty is more common in both these parameters.
- Second step is design membership function of the selected parameters. The careful design of membership function gives the correct output.
- Third step is to write the rules for the fuzzy inference system.

Three important crop were selected i.e. Bajra, Soyabean and Cotton and for each crop separate fuzzy inference systems are developed.

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The general flow diagram of the system is as follows,

a) Crop Selection → Identification of input and output parameters → Selection of proper parameters → Data Collection →Design of Membership Functions → Rule base Design → Implementation and Testing

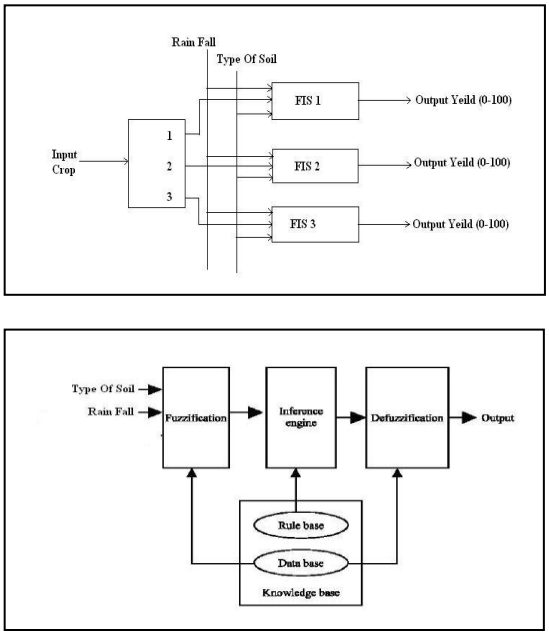

Fig.3 a) General diagram of Fuzzy system and b) Block diagram of FIS

The FIS designed works as per the input parameters. Once input is given by the user, appropriate rule will get fired and the output is given by the system. For designing of the fuzzy inference system the fuzzy logic tool box is used from the software MATLAB. For all the three crops, the input selected includes mainly,

- *Soil type :* Normally , soils are of three different types namely Low quality (more percentage of rock), Medium quality soil and High quality soil (black cotton), so three different parameters are taken i.e. low, medium and high. The membership function assigned to it is triangular (trimf).
- *Rainfall :* This is most uncertain in nature. Most of land in the selected region is dry land. Hence this parameter is greatly affecting the entire farming system.

In Marathwada region the average rainfall is 835 mm per annum. Following table shows the classification of low, average and high values of rainfall.

Table 1
Table showing rainfall values

Rainfall in mm	Range
500	Low
835	Average
1131	High

If the inputs are common, their membership functions are also same. By taking this table into consideration, three parameters are taken for the rainfall i.e. low, medium and high. The membership function assigned to is triangular (trimf). The output generated is based on the experiment carried out in the following sections.

IV. SYSTEM DEMONSTRATION

A. FIS1: Bajra

This fuzzy inference system developed of the crop Bajra. This crop is most commonly found in the Beed District. This system has two inputs viz. type of soil and rainfall. The rules designed for this FIS are as shown in table below.

Table 2
RLES USED FOR FIS1:BAJRA

Soil Type	Rainfall	Yield
Low	Low	Very Low
Low	Average	Average
Low	High	High
Medium	Low	Low
Medium	Average	Average
Medium	High	Very High

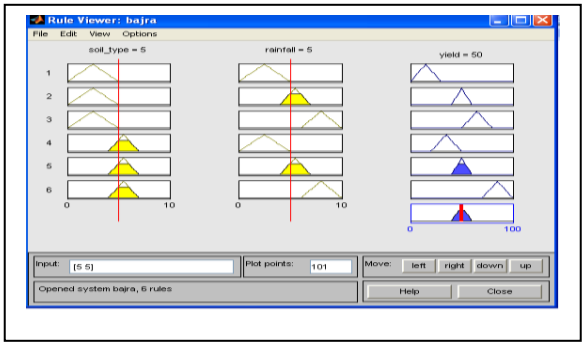

Fig.4 Screen showing rules used for FIS1:Bajra

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B. FIS Soyabean

This fuzzy based inference system is developed for crop Soyabean. The input and their membership function are same as that of the crop Bajra . Only the rules are different and output we get is as per the following rules.

Table.3
ULES USED FOR FIS2:SOYABEAN

Soil Type	Rainfall	Yield
Low	Low	Very Low
Low	Average	Average
Low	High	Average
Medium	Low	Low
Medium	Average	Average
Medium	High	High
High	Low	Low
High	Average	High
High	High	Very High

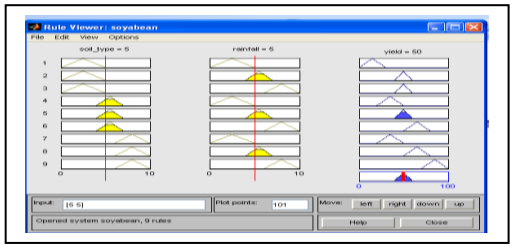

Fig.5 Screen showing rules used for FIS2:Soyabean

C. FIS Cotton

This system is for most common cash crop i.e. cotton. As the inputs i.e. type of soil and rainfall are common in all systems so their membership function and same as described above. The rules for this system are given in the following table.

Table.4
RULES USED FOR FIS3:COTTON

Soil Type	Rainfall	Yield
Medium	Low	Low
Medium	Average	Average
Medium	High	High
High	Low	Low
High	Average	Average
High	High	Very High

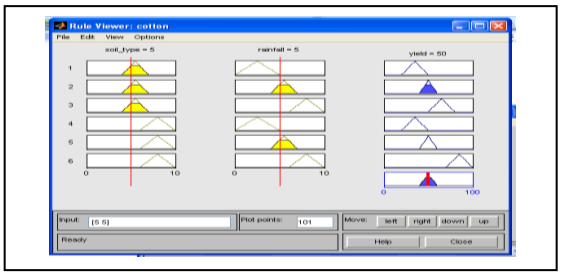

Fig.6 Sreen showing rules used for FIS3:Cotton

D. Output of FIS :

The output of all the FIS is percentage of yield of the specific crop. The membership function assigned to is also triangular (trimf). System will fire the appropriate rule from the particular FIS and finally it gives the desired output. The output variable 'yield' has five different values i.e. very low, low, average, high and very high. The average values of the selected crops are as follows,

Table.5
TABLE SHOWING AVERAGE YIELD VALUES

Crop Name	Average Yield Per Hector (in 100kg)
Bajra	45-55
Soyabean	55-60
Cotton	50-60

V. DISCUSSIONS

A review of experimental work carried out highlights that, the fuzzy component worked properly. The success rate is also high. Figure No.7, is the output of FIS: Soyabean. Here input given i.e. soil type Medium (value 5), Rainfall Average (value 6) and output we get is 85% of yield. This out put of DSS strongly recommends crop Soyabean, for medium type of soil and average rainfall.

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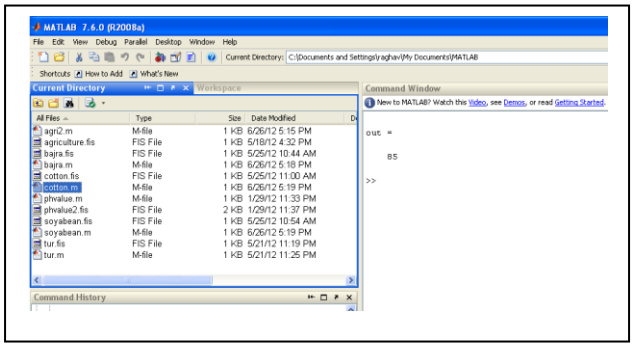

Fig.7 Results for Soyabean

Figure No.8 , is the output of FIS: cotton, here input given i.e. soil type High (value7), Rainfall High(value 8) and output we get is 85% of yield. This out put of DSS strongly recommends crop cotton, for higher quality of soil and high rainfall is predicted. In this situation if farmer goes with this particular crop, he may get maximum benefit.

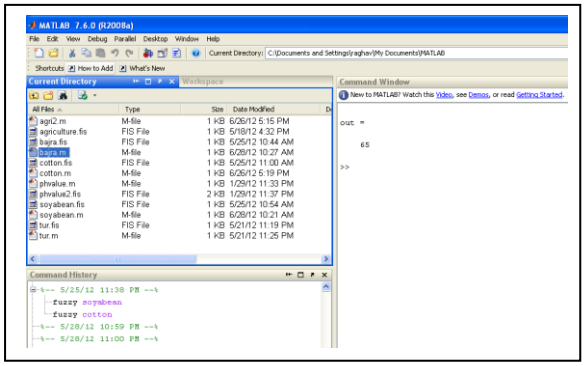

Fig.8 Results for Cotton

Figure No.9, is the output of FIS:Bajra, here input given i.e. soil type Low (value 3), Rainfall High (value 8) and output we get is 65% of yield. Here DSS suggest that the Bajra is crop suitable for low type of soil and Average rainfall. Here the output is Average(i.e. 65%) because the rainfall input is high (8). If farmer want to have maximum yield in low quality soil he may go for some other crop, when high rainfall is predicted. Maximum output of Bajra is possible in low soil and medium rainfall. (note :- the rules are given in tables for each FIS)

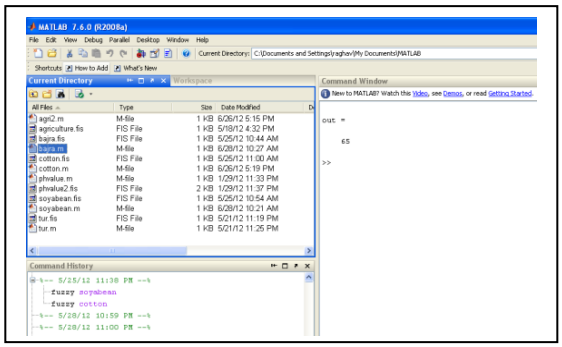

Fig.9 Results for bajra

Purpose of choosing the crops as cotton, Soyabean and Bajra is that they are more commonly found in the selected region. Study of the FIS related to them, clearly highlights that the cotton is the crop most suitable for the high quality soils, Soyabean for medium quality soil and Bajra for low quality soils.

The Agriculture DSS thus developed, help and assist farmers for making good decisions for better production output. The decision process, no doubt, is very complex and involves uncertainty handling. Hence Fuzzy logic effectively used for dealing with this uncertainty. The said system can be very easily developed and gives output as per the human agriculture expert. The system can be further enhanced by considering additional parameters.

VI. CONCLUSION

Taking on site decision without consulting the expert is the major problem farmers in India have to face. This is mainly because the decisions depend on several factors including climatic conditions, nature of crop, type of soil etc. Decision support system thus developed, provides the frame work to improve the decision making process. The paper draws its conclusions from the experiences of a practically developing an online DSS system.

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