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Decision Support System : An Essentiality for Micro Planning in Agriculture and Operating Ecosystem

S K Acharya[1], Anannya Chakraborty[2] and Chandrasekhar Chatterjee[3]*

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ABSTRACT

The agricultural production and entrepreneurship basically depends on micro level decision, macro level policy and strategy. Decision is the process to select the best alternatives in neo- modernization of agriculture and the concept of urbanization is the process that is becoming more complex and confusing. Human intuitive judgment and deci-sion making can be far from optimal, and it deteriorates even further with complexity and stress. Quality of decisions is important, aiding the deficiencies of human judgment and decision making has been a major focus of science throughout history. Disciplines such as statistics, economics, and operations research developed various methods for making rational choices. More recently, these methods, often enhanced by a variety of techniques originating from information science, cognitive psychology, and artificial intelligence, have been implemented in the form of computer programs, either as stand-alone tools or as integrated computing environments for complex decision making. Such environments are often given the common name of decision support systems (DSSs).

DSS is extremely broad and we have defined them as interactive computer-based systems that aid users in judgment and choice activities. An-other name sometimes used as a synonym for DSS is knowledge-based systems, which refers to their attempt to formalize domain knowledge so that it is amenable to mechanized reasoning. This paper traces decision support applications and research studies related to model and data-oriented systems, management expert systems, multidimensional data analysis, query and reporting tools, online analytical processing (OLAP), Business Intelligence, group DSS, conferencing and groupware, document management, spatial DSS and Executive Information Systems as the technologies emerge, converge and diverge. All of these technologies have been used to support decision making and their role in bringing about more ICT interaction with the people through E-governance. Decision support systems research and development will continue to exploit any new technology developments encouraging E-governance and will benefit from progress in very large data bases, artificial intelligence, human-computer interaction, simulation and optimization, software engineering, telecommunications and from more basic research on behavioural topics like organizational decision making, planning, behavioural decision theory and organizational behaviour.

Keywords : Decision support systems, knowledge-based systems, online analytical processing, Executive Information Systems.

[1]Department of Agricultural Extension, Bidhan Chandra Krishi Viswavidyalaya; [2]Department of Agricultural Extension, Seacom Skills University; [3](Seed Testing Laboratory, Burdwan), Govt. of West Bengal. * Email : acharya09sankar@gmail.com

Introduction :

The estimation of the global food production must be increased by 60–110% to feed 9-10 billion of the population by 2050. Thus, the sustainability of agriculture field is the key to guarantee food security and hunger eradication for the ever-growing population. In addition, due to the appearance of several food safety scandals and incidents in the food sector such as bovine spongiform encephalopathy and dioxin in poultry, a well-documented traceability system has become a requirement for quality control in the food chain. Moreover, weather and climate change conditions, together with the sustainable water management due to water scarcity, are crucial challenges in the next years. For these reasons, urgently, the establishment of a strategic shift from the current paradigm of enhanced agricultural productivity to agricultural sustainability is needed. To anticipate efficient solutions, helping farmers and stakeholders to enhance their decision by adopting sustainable agriculture practices is a crucial choice, especially the use of digital technologies including Internet of things (Iot), Artificial Intelligence (AI), and cloud computing. Additionally, the subsets of AI (machine and deep learning algorithms) combined with location intelligence technologies are extensively used. The goal of our review is to present the main applications of artificial intelligence and machine learning techniques in the agri-food sector.

Artificial intelligence and Machine Learning Approach :

The artificial intelligence (AI) is a creative tool that simulates the human intelligence and ability processes by machines, principally computer systems, robotics, and digital equipment. Several applications of the AI include natural language processing (NLP) to comprehend human verbal communication as it is spoken, computer vision to see an analogue-to-digital conversion such as video, and speech recognition and expert systems to simulate the judgment. The AI encoding is based on learning (acquire data and then create algorithms to turn them into actionable information), reasoning (choose the right algorithm to reach a preferred result), and self-correction (continually adjust designed algorithms and ensure that they provide the most accurate results) as three cognitive skills. The AI technique is being used in several sectors which are seeing the fastest growth in the recent years such as finance, healthcare, retail, pharmaceutical research, intelligent process automation, and marketing. Machine learning (ML) is one of the central themes of AI and helps people to work more creatively and efficiently. In ML, statistical and mathematical methods are used to learn from datasets to make data-driven predictions/decisions. Several different methods exist for this. General distinction can be made by two systems; the first one is the symbolic approaches (the induced rules and the examples are explicitly represented) and the second one is the subsymbolic approaches (artificial neuronal networks: ANN). The ML approach is classified into three major tasks: supervised, unsupervised, and reinforcement learning. According to the supervised learning, the aim of this approach is to map the variables to the preferred output variable. The predictive model is created using the labelled data with the prior knowledge of the input and the desired output variables. Algorithms used under supervised learning techniques are numerous, particularly, decision trees, Bayesian networks, and regression analysis. Concerning the unsupervised learning, it includes algorithms such as Artificial Neural Networks (ANNs), clustering, genetic algorithm, and deep learning and uses unlabeled datasets without prior knowledge of the input and output variables. In fact and as mentioned by Jordan and Mitchell , this case of unsupervised machine learning method establishes the hidden patterns by using the unlabeled dataset and is primarily used for dimensionality reduction and exploratory data analysis. According to the third category of ML task named the reinforcement learning, numerous algorithms are used for machine skill acquisition, robot navigation, and real-time decision making such as Q-learning and deep Q-learning. In this case of ML task, the learner interacts with the environment to collect information and the two steps of training and testing datasets are combined. The learner gets awarded for his actions with the environment leading to an exploration versus exploitation dilemma. The learner must explore new unknown actions to gain more information as compared to exploiting the information already collected. Recently, AI technology has opened the doors of its implementation in the agri-food sector. In fact, AI approaches offer significant contributions and assistances to understanding a model's identification, service creation, and the decision-making processes as support to the different agri-food's applications and supply chain stages. The principal goal of AI in agriculture is to provide precision and forecasting decision in order to improve the productivity with resource preservation (4); through this, AI tools propose algorithms to evaluate performance, classify patterns, and to predict unexpected problems or phenomena in order to solve comprehension problems in the agricultural field and for the identification of pests and its suitable method of treatment, as well as the management of the irrigation process and water consumption by setting up smart irrigation systems. Abiotic and biotic factors are being assessed through remote sensing and sensors in order to optimize crop and livestock management. In addition, the AI implementation and applications have enormous advantages which could revolutionize the agri-food sector and its related business. Firstly, AI provides more efficient ways to produce, harvest, and sell crops products as well as emphasis on checking defective crops and improving the potential for healthy crop production and also AI is being used in applications such as automated machine adjustments for weather forecasting and disease or pest identification with 98% accuracy. In fact, recently, the performance of machine learning (ML) and deep learning (DL) methods was compared to detect and identify the citrus plant leaf disease. They showed that the VGG-16 deep learning method gave the best result in terms of disease classification accuracy. Secondly, the progression in the AI technique has reinforced agro-based businesses to run more proficiently by improving crop management practices, thus helping many tech businesses invest in algorithms that are becoming useful in agriculture as well as by solving the contrasts farmers face such as climate variation and an infestation of pests and weeds that decreases yields. Indeed, scientist developed a novel modeling approach for augmenting parametric statistical models with deep neural networks, which we term semiparametric neural networks (SNNs), and by using data on corn yield from the US Midwest, they showed the outperformance of this approach in predicting yields of years withheld during model training compared to classical statistical methods and fully nonparametric neural networks. Thirdly, by using AI tools, farmers could be able to remain updated with the data related to weather forecasting and, therefore, predicted weather data help farmers to increase yields and profits without risking the crop, and as a result, after analyzing the generated data, AI allows the farmers to better understand and learn and then to take the precaution by implementing practices in order to make a punctual smart decision. In fact, collected different weather parameters (temperature, precipitation, wind speed, pressure, dew point visibility, and humidity) from the Indian climate data center and implemented a weather forecasting model by using a Recurrent Neural Network (RNN) with the long-short-term memory (LSTM) technique. They concluded that the used technique gave high-accuracy results compared to other weather forecasting approaches. Fourthly, AI approaches are capable of monitoring soil health and management by conducting and identifying the possible defects and nutrient deficiencies in the soil either by image captured with the camera recognition tool or by deep learning based tool to analyse flora patterns in farms and to simultaneously understand soil defects, plant pests, and diseases. In fact, Suchithra and Pai classified and predicted the soil fertility indices and pH levels of Kerala north central laterite Indian region soil by using the Extreme Learning Machine (ELM) technique with different activation functions such as hard limit, sine-squared, triangular basis, hyperbolic tangent, and gaussian radial basis. They revealed that the maximum performance (80% of the accuracy rate calculations in every problem) for four out of five problems was obtained with the Gaussian radical basis function followed by hyperbolic tangent Fifthly, an important functional benefit of the AI technology employment is the environmental protection by decreasing pesticide usage. For example and in order to manage weeds faster and with greater accuracy, AI techniques by implementing robotics, computer vision, and machine learning could help farmers to spray chemicals only where the weeds are; thus, this directly reduced the use of the chemical substance spraying on the whole field. Consequently, AI tools are helping farmers find more efficient actions to protect their crops from weeds. Finally, the practice of the advanced AI-based technologies has other advantages on the agri-food supply chain such as reducing employee training costs, reducing the time needed to solve problems, reducing the amount of human errors, reducing human intervention, and offering an automated good, accurate, and robust decision-making on the right time with low cost .

Decision Support System (DSS) : The concept of DSS is extremely broad, and its definitions vary, depending on the author's point of view. To avoid exclusion of any of the existing types of DSSs, we will define them roughly as interactive computer-based systems that aid users in judgment and choice activities. An-other name sometimes used as a synonym for DSS is knowledge-based systems, which refers to their attempt to formalize domain knowledge so that it is amenable to mechanized reasoning. For the last twenty years, different kinds of information systems are developed for different purposes, depending on the need of the business. Transaction Process Systems (TPS) function in operational level to process large amount of data for routine business transactions of the organization, Office Automation Systems (OAS) support data workers and Knowledge Work Systems (KWS) support professional workers. Higher-level systems include Management Information Systems (MIS) and Decision Support Systems (DSS). Expert System (ES) applies the expertise of decision makers to solve specific, unstructured problems. At the strategic level of management, there is Executive Support Systems (ESS). Group Decision Support Systems (GDSS) and the more generally described Computer Supported Collaborative Work (CSCW) systems aid group level decision making of a semi structured or unstructured decision. In the present article the authors discuss two kinds of information systems, namely, MIS, and DSS, and then their characteristics, interrelationship and their relations with decision-making process in an organization. Computerized decision support systems became practical with the development of minicomputers, timeshare operating systems and distributed computing.

The history of implementation of such systems begins in the mid-1960s. In a technology field as diverse as DSS, chronicling history is neither neat nor linear. Different people perceive the field of Decision Support Systems from various vantage points and report different accounts of what happened and what was important (cf., Arnott & Pervan, 2005; Eom & Lee, 1990b; McCosh & Correa-Perez, 2006; Power, 2003; Power, 2004a; Silver, 1991). As technology evolved new computerized decision support applications were developed and studied. Researchers used multiple frameworks to help build and understand these systems. Today one can organize the history of DSS into the five broad DSS categories explained in Power (2001; 2002; 2004b), including: communications-driven, data-driven, document driven, knowledge-driven and model-driven decision support systems. Varieties of DSS have been postulated for describing the characteristics of DSS. These frameworks are helpful in organizing and identifying the relationships of DSS.

The identification of DSS applications is important in planning organization strategy for the deployment of information technology. DSS is defined as the use of computer to: (i) Assist managers with their decision process in semi-structure tasks; (ii) To support, rather than replace managerial judgment, and (iii) To improve the effectiveness of decision making rather than its efficiency. While definitions of e-government by various sources may vary government involves using information technology, and especially the Internet, to improve the delivery of government services to citizens, businesses, and other government agencies to interact and receive services from the federal, state or local governments twenty four hours a day, seven days a week. E-government involves the use of information and communication technologies (ICTs) to support government operations and provide government services. There is a relation between E-government and DSS where E-government encourages citizen participation in the decision- making process and making government more **accountable**, **transparent** and **effective**. The problem focuses on where is the decision support system into the e-government components/ layers and how to utilize the useful of DSS into e-government. No explicit e-government framework includes DSS into its components. So the proposed framework used to solve this problem. In this work, DSS framework for e-government is presented by integrating its components into the e-government framework layers. The aim is to utilize its components to help decision-makers within the e-government.

Objectives :

- Sensitization of the concept of Decision support system
- Analysis of the methodology of decision support system
- Identification of the area of DSS application
- Issues and challenges faced by DSS
- The present status of DSS application in agriculture and allied sectors.

Review of literature :

In 1960s, researchers began systematically studying the use of computerized quantitative models to assist in decision making and planning (Raymond, 1966; Turban, 1967; Urban, 1967, Holt and Huber, 1969). Ferguson and Jones (1969) reported the first experimental study using a computer aided decision system. They investigated a production scheduling application running on an IBM 7094. In retrospect, a major historical turning point was Michael S. Scott Morton's (1967) dissertation on field research at Harvard University.

Scott Morton's study involved building, implementing and then testing an interactive, model-driven management decision system. Fellow Harvard Ph.D. student Andrew McCosh asserts that the "concept of decision support systems was first articulated by Scott Morton in February 1964 in a basement office in Sherman Hall, Harvard Business School" (McCosh email, 2002) in a discussion they had about Scott Morton's dissertation. During 1966, Scott Morton (1971) studied how computers and analytical models could help managers make a recurring key business planning decision. He conducted an experiment in which managers actually used a Management Decision System (MDS). Marketing and production managers used an MDS to coordinate production planning for laundry equipment. The MDS ran on an IDI 21 inch CRT with a light pen connected using a 2400 bps modem to a pair of Univac 494 systems.

The pioneering work of George Dantzig, Douglas Engelbart and Jay Forrester likely influenced the feasibility of building computerized decision support systems. In 1952, Dantzig became a research mathematician at the Rand Corporation, where he began implementing linear programming on its experimental computers. In mid-1960s, Engelbart and colleagues developed the first hypermedia —groupware system called NLS (OnLine System). NLS facilitated the creation of digital libraries and the storage and retrieval of electronic documents using hypertext. NLS also provided for on-screen video teleconferencing and was a forerunner to group decision support systems. Forrester was involved in building the SAGE (Semi-Automatic Ground Environment) air defence system for North America completed in 1962. SAGE is probably the first computerized data-driven DSS. Also, Professor Forrester started the System Dynamics Group at the Massachusetts Institute of Technology Sloan School. His work on corporate modelling led to programming DYNAMO, a general simulation compiler.

In 1960, J.C.R. Licklider published his ideas about the future role of multi-access interactive computing in a paper titled "Man-Computer Symbiosis." He saw man-computer interaction as enhancing both the quality and efficiency of human problem solving and his paper provided a guide for decades of computer research to follow. Licklider was the architect of Project MAC at MIT that furthered the study of interactive computing.

By April 1964, the development of IBM System 360 and other more powerful mainframe systems made it practical and cost-effective to develop Management Information Systems (MIS) for large companies (cf., Davis, 1974). These early MIS focused on providing managers with structured, periodic reports and the information was primarily from accounting and transaction processing systems, but the systems did not provide interactive support to assist managers in decision making.

By 1970, business journals started to publish articles on management decision systems, strategic planning systems and decision support systems (cf., Sprague and Watson 1979). For example, Scott Morton and colleagues McCosh and Stephens published decision support related articles in 1968. The first use of the term decision support system was in Gorry and Scott-Morton's (1971) Sloan Management Review article. They argued that Management Information Systems primarily focused on structured decisions and suggested that the supporting information systems for semi-structured and unstructured decisions should be termed "Decision Support Systems".

T.P. Gerrity, Jr. focused on Decision Support Systems design issues in his 1971 Sloan Management Review article titled "The Design of Man-Machine Decision Systems : An Application to Portfolio Management". The article was based on his MIT Ph.D. dissertation. His system was designed to support investment managers in their daily administration of a clients' stock portfolio.

John D.C. Little, also at Massachusetts Institute of Technology, was studying DSS for marketing. Little and Lodish (1969) reported research on MEDIAC, a media planning support system. Also, Little (1970) identified criteria for designing models and systems to support management decision-making. His four criteria included: robustness, ease of control, simplicity, and completeness of relevant detail. All four criteria remain relevant in evaluating modern Decision Support Systems. By 1975, Little was expanding the frontiers of computer-supported modelling. His DSS called Brandaid was designed to support product, promotion, pricing and advertising decisions. Little also helped develop the financial and marketing modelling language known as EXPRESS.

In 1974, Gordon Davis, a Professor at the University of Minnesota, published his influential text on Management Information Systems. He defined a Management Information System as "an integrated, man/machine system for providing information to support the operations, management, and decision-making functions in an organization. (p. 5)." Davis's Chapter 12 was titled "Information System Support for Decision Making" and Chapter 13 was titled "Information System Support for Planning and Control". Davis's framework incorporated computerized decision support systems into the emerging field of management information systems.

Peter Keen and Charles Stabell claimedthat the concept of decision support systems evolved from "the theoretical studies of organizational decision making done at the Carnegie Institute of Technology during the late 1950s and early '60s and the technical work on interactive computer systems, mainly carried out at the Massachusetts Institute of Technology in the 1960s. (Keen and Scott Morton, 1978)". Herbert Simon's books (1947, 1960) and articles provide a context for understanding and supporting decision making.

In 1995, Hans Klein and Leif Methlie noted "A study of the origin of DSS has still to be written. It seems that the first DSS papers were published by PhD students or professors in business schools, who had access to the first time-sharing computer system: Project MAC at the Sloan School, Dartmouth Time Sharing Systems at the Tuck School. In France, HEC was the first French business school to have a time-sharing system (installed in 1967), and the first DSS papers were published by professors of the School in 1970. (p. 112)."

What Is Decision Support System (Dss)?

A **decision support system** (**DSS**) is a computer-based information system that supports business or organizational decision-makingactivities. DSSs serve the management, operations, and planning levels of an organization and help to make decisions, which may be rapidly changing and not easily specified in advance.

Operational concept :

The concept of a **Decision Support System (DSS)** emerged in the 1970s following developments in IT which allowed the interactive use of computer technology. The DSS concept reflected dissatisfaction with previous inflexible modelling approaches which did not allow management intervention in problem solving.

The early definitions of **DSS** emphasised the role of DSS as flexible systems combining database and model components aimed at less structured decisions. These modelling and database components are under the control of the user through an interface or dialogue system.

DSS includes knowledge-based systems. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge, or business models to identify and solve problems and make decisions.

Typical information that a decision support application might gather and present are :

- Inventories of information assets (including legacy and relational data sources, cubes, data warehouses, and data marts),
- Comparative sales figures between one period and the next,
- Projected revenue figures based on product sales assumptions.

DSS help executives make better decision by using historical & common data from internal information systems & external sources. By combining massive amounts of data with sophisticated analytical models & tools,& by making the system easy to use ,they provide much better source of information to use in decision making process. DSS are a class of computerised information system that support decision making activities. DSS are interactive computer-based system & subsystem intended to help decision makers use communications technologies, data, documents, knowledge or models to successfully complete decision process task.

A decision support system or DSS is a computer based system intended for use by a particular manager or usually a group of managers at any organizational level in making a decision in the process of solving a semi structured decision (Figure 7). The DSS produces output in the form of periodic or special report or the results of mathematical simulations (Raymond, 1990). It is difficult to pinpoint that are completely structured or unstructured. The vast majorities are semi structured. This means that the DSS is aimed at the area where most semi structured decision is needed to be made.

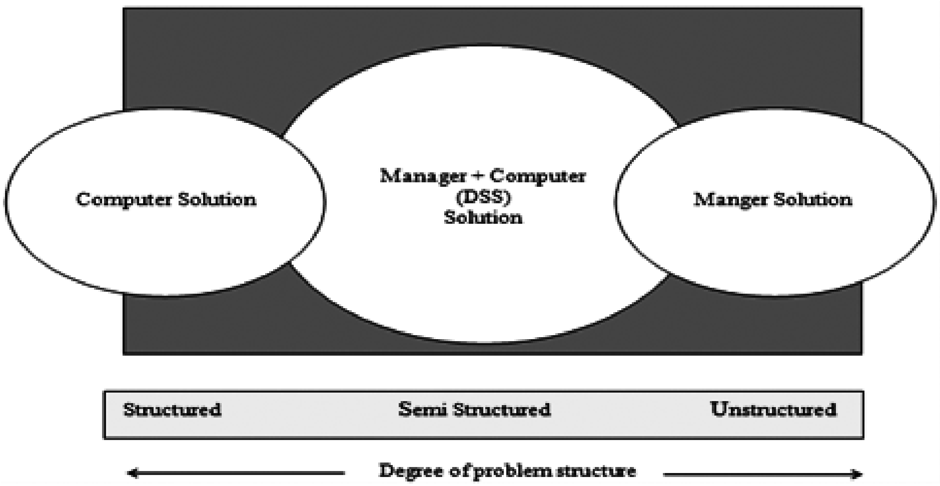
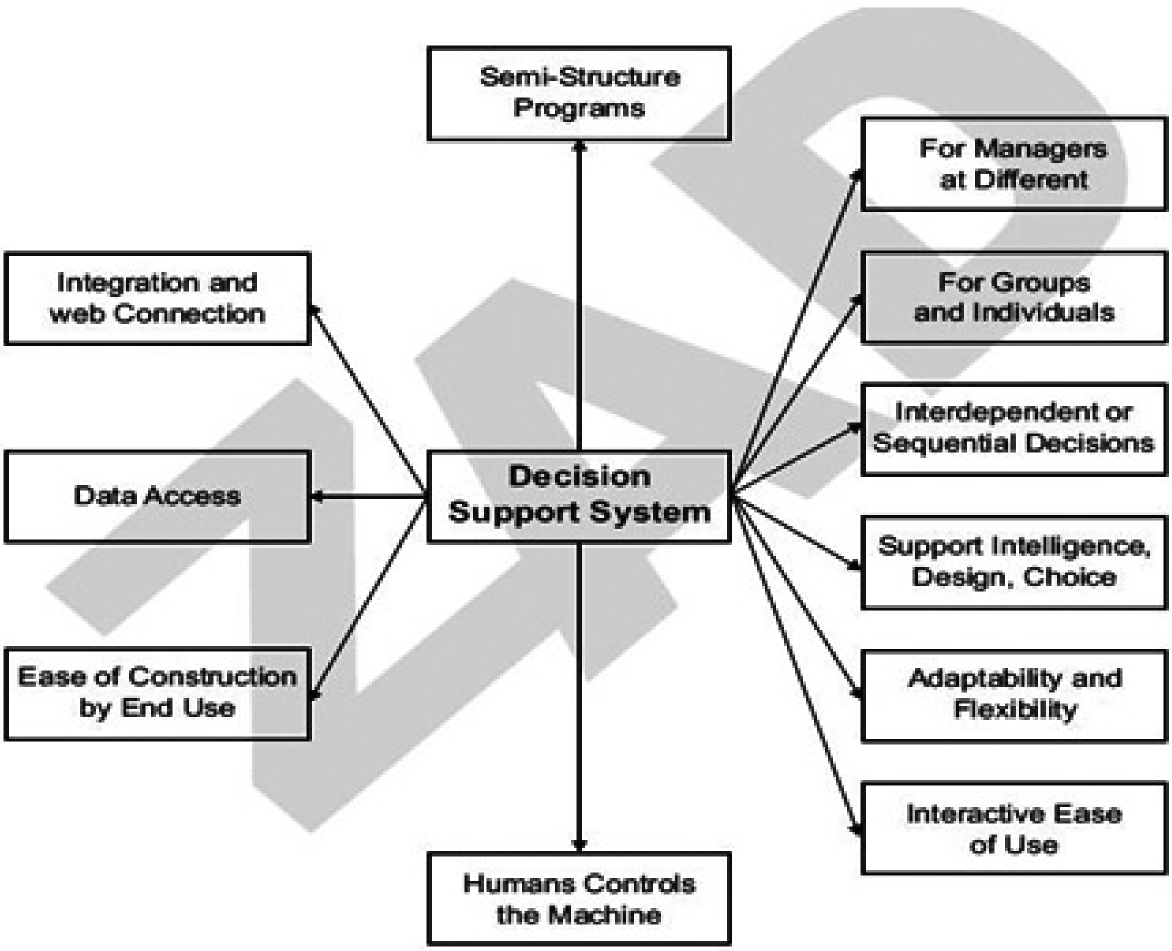


Fig. 1 : The DSS focuses on semi structured problems (Raymond, 1990)

Characteristics of DSS : The characteristics of the DSS are as follows :

- DSS focus on towards providing help in analyzing situations rather than providing right information in from of various types of reports.
- DSS is individual specific. Each decisions maker can incorporate his own perceptions about the problem and analyze its effect.
- DSS incorporate various mathematics, statistical and operations research models.
- DSS is only supportive in nature decisions makers still retain their supremacy. It does not thrust its outcomes on the decision maker.
- DSS is effective in providing assistance to solve semi-structured problems at all levels. It is used at first line, middle level and top level management.
- DSS needs an effective database management system. It is extensively uses database.
- DSS helps decision makers to carry out **'what- if'** analysis.



Objective of DSS : The objectives of the DSS are stated below :-

1. Provide assistance to decision makers in situations which are semi-structured.
2. Identify plans and potential actions to resolve problems.
3. Rank among the solution identified, those which can be implemented and provide list of viable alternatives.

Needs of DSS : DSS have become necessary for today's manger because of following reasons :-

1. ***Fast computation* :** A decision maker can perform a large number of computations very quickly and that too at a low cost with the help of computer support systems.
2. ***Enhanced productivity* :** Decision support system can enhance the productivity of support staff and also enable the group members to discuss the problems among themselves as a distance.
3. ***Better decisions* :** Computer support system can help a decision-maker in arriving at a better decision. For examples, more alternatives can be evaluated, risk analysis be perform quickly, and views of experts from differ places can be collected quickly and at a lower cost.
4. ***Data transmission* :** Sometimes the data, which may be stored at different locations, may be required to be transmitted quickly from distant locations. Computer support system can search, store and transmitted the required data quickly and economically.

DSS benefits : That said, even if DSS do not necessarily result in quantifiable, tangible benefits, they do provide identifiable ones. The following list is derived from about 30 DSS studies. Only benefits mentioned in at least five case studies are included. A few typical illustrations or quotes are given for each category on the list :

1. Increase in number of alternatives examined
2. Better understanding of the business
3. Fast response to unexpected situations
4. Ability to carry out ad hoc analysis
5. New; insights and learning
6. Improved communication
7. Control
8. Cost savings
9. Better decisions
10. More effective teamwork
11. Time savings
12. Making better use of data resource

These categories add up to a concept of productivity. It is these often qualitative aspects of effectiveness that managers value. The operating assumption of Decision Support is that improving communication, flexibility,' learning and responsiveness leads to better decision making.

DSS in farm system : The model will help the farmers in increasing their productivity by raising the yield/hectare in food grains: thus, leading to their economic growth. This system has been developed to keep track of farmers all type of information related to crops.

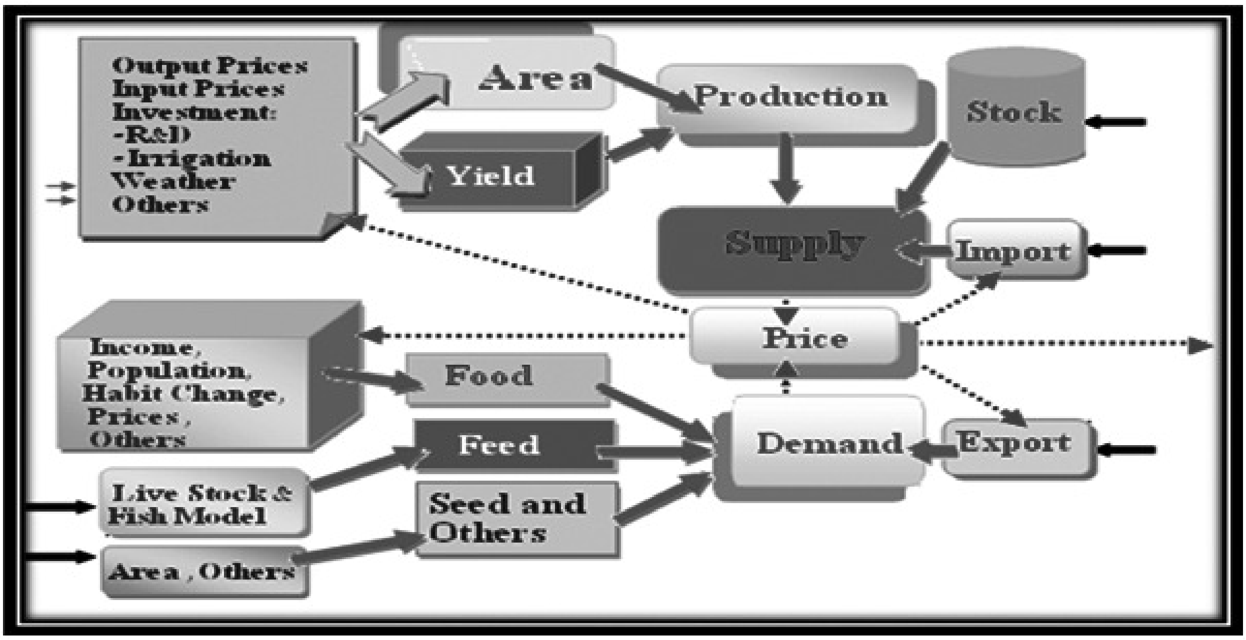
Certain applications that are successfully developed using this database are :

- Farmers can manage their cash flow through the DSS system in a more predictable and efficient way. It is a more common problem with the farmers to manage the cash received at time of harvesting the crop.
- They can avail full benefit of their cash management by co-relating it with the loans and advances.
- The administrator can add information to the database without stopping the application.
- If implemented at Village, District and State level, the model will provide valuable information to other agencies and panchayats in particular.

Growing population and demands for improved watershed management, there is an obvious need to implement sustainable resource use that best serves the communities and the nation. To satisfy this need, the DSS is developed to aid decision – makers and various stakeholders in identifying and assessing options for resource uses. The DSS applies an integrative approach, combining biophysical data, perceptions and socioeconomic conditions of the farmers in the given area. The DSS attempts to stimulate the farmer's behaviour in selecting farming systems given relevant constraints and then aggregating up to the node.

A large number of database queries can be generated according to Crop, Water Availability and Requirement, Socio-economic constraints and so on. Design and Development of this database is purely based on Relation Database Management System Model, so the large volume of queries can be easily handled.

DSS with all the ready information help the farmers in a very useful manner. The farmers can get all the information at just at click of the mouse, and they need not to travel to Agricultural Universities for that.



DSS for agro-technology transfer :

- The Decision Support System for Agro-technology Transfer (DSSAT) is a software package integrating the effects of soil, crop phenotype, weather and management options that allows users to ask "what if" questions and simulate results by conducting, in minutes on a desktop computer, experiments which would consume a significant part of an agronomist's career. It has been in use for more than 15 years by researchers in over 100 countries.
- DSSAT is a microcomputer software product that combines crop, soil and weather data bases into standard formats for access by crop models and application programs. The user can then simulate multi-year outcomes of crop management strategies for different crops at any location in the world.
- DSSAT also provides for validation of crop model outputs; thus allowing users to compare simulated outcomes with observed results. Crop model validation is accomplished by inputting the user's *minimum data,* running the model, and comparing outputs. By simulating probable outcomes of crop management strategies.
- DSSAT offers users information with which to rapidly appraise new crops, products, and practices for adoption.The release of DSSAT Version 4 incorporates changes to both the structure of the crop models and the interface to the models and associated analysis and utility programs.
- The DSSAT package incorporates models of 27 different crops with new tools that facilitate the creation and management of experimental, soil, and weather data files. DSSAT v4 includes improved application programs for seasonal and sequence analyses that assess the economic risks and environmental impacts associated with irrigation, fertilizer and nutrient management, climate change, soil carbon sequestration, climate variability and precision management.
- DSSAT is one of the principal products developed by the International Benchmark Sites Network for Agro-technology Transfer (IBSNAT) project supported by the U.S. Agency for International Development from 1983 to 1993. It has subsequently continued to be developed through collaboration among scientists from the University of Florida, the University of Georgia, University of Guelph, University of Hawaii, the International Centre for Soil Fertility and Agricultural Development, Iowa State University and other scientists associated with ICASA.

Minimum data : The minimum data set (MDS) refers to a minimum set of data required to run the crop models and validate the outputs. Validation requires :

1. Site weather data for the duration of the growing season,
2. Site soil data, and
3. Management and observed data from an experiment.

A. ***MDS Weather Data* :** The required minimum weather data includes :

- latitude and longitude of the weather station,
- daily values of incoming solar radiation (MJ/m^2-day),
- maximum and minimum air temperature (°C), and
- rainfall (mm).

Accessory data sets, such as daily dry and wet bulb temperatures and wind speed, are optional.The period of weather records for validation must, at a minimum, cover the duration of the experiment and preferably should begin a few weeks before planting and continue a few weeks after harvest so that "what-if" type analyses may be performed as desirable.

B. ***MDS Soil Data*** **:** Desired soil data includes soil classification (e.g. USDA/NRCS), surface slope, soil colour, permeability, and drainage class. Soil profile data by soil horizons include :

- Upper and lower horizon depths (cm),
- Percentage sand, silt, and clay content,
- 1/3 bar bulk density,
- Organic carbon,
- Ph in water,
- Aluminium saturation, and
- Information on abundance of roots.

C. ***Management and experiment/ observed data*** **:** Management data includes information on planting date, dates when soil conditions were measured prior to planting, planting density, row spacing, planting depth, crop variety, irrigation, and fertilizer practices. This data are needed for both model validation and strategy evaluation. In addition to site soil and weather data, experimental data includes crop growth data, soil water and fertility measurements. This data are needed for model validation.

System requirements :

- Personal Computer running MS-Windows
- Pentium2 with 128MB RAM minimal
- Pentium4 with 512MB RAM recommended
- CD-Rom Drive
- Hard Disk Space requirement 300MB of free space

Components **:** The Cropping System Model (CSM) released with DSSAT Version 4 represents a major departure from previously released crop models in DSSAT, not in function, but in design. The computer source code for the model was restructured into a modular format in which components separate along lines of scientific discipline and are structured to allow easy replacement or addition of modules. CSM now incorporates all crops as modules using a single soil module and a single weather module. The new cropping system model now contains models of 17 crops derived from the old DSSAT CROPGRO and CERES models.

The major modules are :

- **Land Module**
- **Management Module**

- ***Soil module* :** A soil water balance sub-module and two soil nitrogen / organic matter modules.
- ***Weather module* :** Reads or generates daily weather data
- ***Soil-Plant-Atmosphere module* :** Deals with competition for light and water among the soil, plants, and atmosphere
- ***CROPGRO plant growth module* :**
  - o Grain Legumes - Soybean, peanut, dry bean, chickpea, cowpea, velvet bean, and faba bean
  - o Vegetables - Pepper, cabbage, tomato
  - o Grassws-Bahia, brachiaria

Problems with DSS development and adoption : Although these systems seem to have many benefits to producers, they have not widely been taken up by them (Wilde, 1994; Lynch et al., 2000). Cox (1996), Campbell (1999), and Lynch et al. (2000) have examined reasons behind the low adoption of DSS and other intelligent support systems within agriculture.

Some of the reasons they suggest are as follows :

- ➢ Limited computer ownership among producers,
- ➢ Lack of field testing,
- ➢ No end user input preceding and during development of the DSS,
- ➢ DSS complexity and possibly considerable data input,
- ➢ No reason seen for changing current management methods,
- ➢ Distrust for the output of a DSS because producers do not understand the underlying theories of the models,
- ➢ Mismatch of the DSS output with the decision-making style of the producer because the producer's conceptual models are excluded, and unclear definition of the beneficiaries (e.g., scientists, primary producers, and technology transfer agents).
- ➢ Availability of back up & software.

Some of these issues are discussed in the following sections :

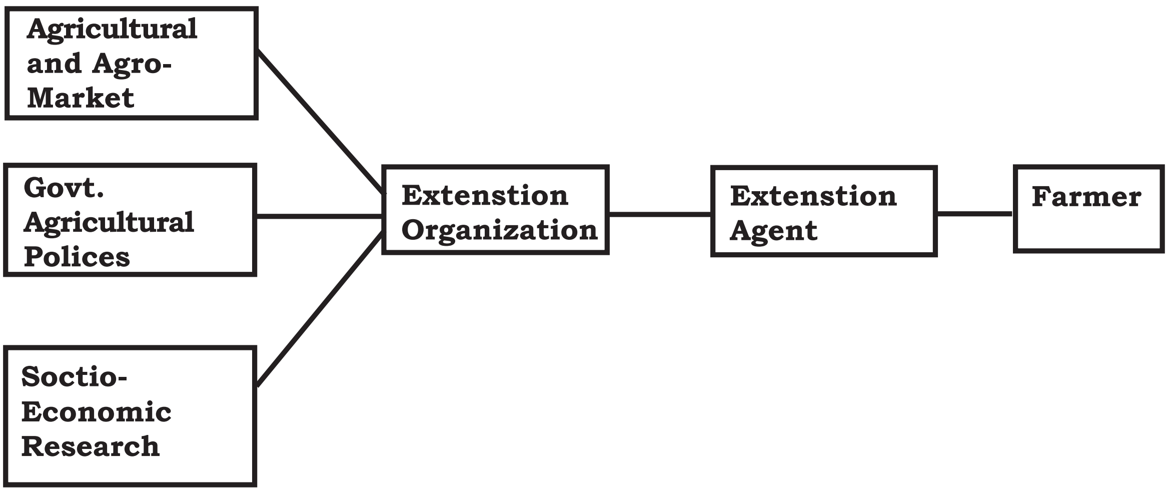
Ease of use : Features of the DSS will affect adoption (i.e., that DSS are not useful to the user and are not easy to use). Perceived ease of use and perceived usefulness issues has been discussed by Keil *et al.* (1995) and are best described through Figure 1. Perceived usefulness is a measure of how well the DSS will enhance a user's decision-making capability, that is, the count of time it might take to perform a certain task. Alternatively, perceived ease of use is a measure of the reduction (or increase) in physical or mental effort to use the DSS. It is important to balance emphasis and effort between ease of use and usefulness. Keil *et al.* (1995) suggested that software that rates low in ease-of-use and low in usefulness will be rejected. Software that is high in ease-of use and low in usefulness they term "toys." Users may embrace this software initially but there is little chance of lasting acceptance. Software that is low in ease of use but high in usefulness will only be used by what they term "power users," very competent computer users. Most users will avoid this type of software because the time and effort required to learn how to use it outweighs the potential benefits. The aim is to develop software that rates high in ease of use and high in usefulness. They also suggest that designing for ease of use "must begin with some type of task analysis that goes beyond the typical considerations of ergonomics and user interface."

Problem statement and solution methodology : The timely information to the farmers is closely linked to the Agricultural Development and well being of the rural communities. Quick information transfer between the researchers and the farmers has specific importance. Hence this research work is focused on the problem of developing a decision support system for farm entrepreneur. As the sharing of programme is beneficial, if used through Internet, hence the project is planned to be web based.

The additional advantages that will accrue are :

- Low cost of operation.
- Quick access to all relevant information.
- Direct and personalized.
- Integrated.

The present work will provide the platform for the farmers to make the use of internet technology to take farm management decisions. With the help of present model, the farmers can access online interactive and flexible information for their farm management.



The proposed flow system for farm management is shown in Proposed Flow System

The farmers will be able to access the necessary information regarding the various government policies for agriculture, the ongoing socio-economic research and the different benefits for the entrepreneur for investing in particular area of farm management. The Farmers can acquire this information from :

- Farmer's organizations.

- Researchers.
- Other Farmers.
- Farm journals, radio, television, Government, Departments and agencies.

The primary and the basic fundamental of any project involving the database is the collection of data and information. This project also requires the collection of information from various sources. The main source of the data is the service published by the state or center Government. The present model will help the farmers to take interactive, flexible and quick decisions. This will also help them in increasing their productivity by raising yield per hectare in food grain, thus leading to their economic growth. It will keep track of farmer's all type of information related to crops.

The additional advantages that will accrue are :

a) Low cost of operation.

b) Quick access to all relevant information.

c) Direct and personalized.

d) Integrated.

DSS with all the ready information, help the farmers in a very useful manner. The farmers can get all the information at just at click of the mouse, and they need not to travel to Agricultural Universities for that.

A. *Sitemap :* Sitemap gives us the complete description of how the control flows through the site. The main page that links to all the pages is called the Home Page. This page shows the introduction about the Farm Entrepreneur System, the objective of the system and the principles of activity.

B. *Information retrieval system :* The main advantage of this model to the farmer is that they can retrieve the dynamic information for their farm management decisions. DSS Framework being an agent for the driving force behind the changes in highland resource uses, the farm or household is considered to be the center of this analysis. The decisions on agricultural land and water uses are made in response to resource endowments, economic conditions and socio-cultural norms of the household or communities.

C. *Resource management unit :* Farms or households are classified into different types, called resource management units or RMU.

D. *Modeling at the node level :* The term node is defined, conceptually, as 'water balance unit'. Its implication depends much on the aspect from which a node is looked at. From hydrological view point, a node represents a village and a network of nodes. Hence each node has a physical domain, which has to conform to that of the village it represents. Within this physical domain exist other biophysical attributes such as soil type, climate type etc. These biophysical attributes constitute a process, which determines the amount of water that flows in and out of the node.

From a socio-economic viewpoint, the characteristics of farm households, alternative land use options and farmers' priorities and constraints characterized by RMU types may differ from node to node. The different set of socio-economic conditions would influence the decisions on how they should manage their available resources to their optimal level of production [4].

From a modeling viewpoint, a node plays a major role in the whole Decision Support System. A node is the level at which all modeling Engines are activated and linked together. The main outputs from modeling process, although initialized at farm or plot level, are reflecting interaction between human and resource availability at the node level.

E. ***Outputs and implication*** : The simulation system provides the output on land and water allocation that can maximize gross margin to the communities and Farm Entrepreneur within the node by taking into account the biophysical and socio economicconstraints specific to the area. The effects of a partial change in the land uses, prices, investment and other developments plans on farm gross margin, labor and capital requirements can be easily assessed and the results can be presented both at the non-aggregated RMU (household) level and the aggregated level (node or village).

The economic and environmental tradeoffs of various plans can be determined for improving welfare. Since water is basically a very important shared resource with lack of true ownership, the Decision Support System, can aid assessing management options to help resolving or avoiding land and water use conflicts. Although the output is quantitative in its nature, this DSS is aiming towards providing the trend of resource use options rather than quantifying the amount of resources being used. The workflow overview of the DSS is shown in Workflow of DSS.

The model will help the farmers in increasing their productivity by raising the yield/hectare in food grains thus, leading to their economic growth. This system has been developed to keep track of farmers all type of information related to crops.

Certain applications that are successfully developed using this database are :

- Farmers can manage their cash flow through the DSS system in a more predictable and efficient way. It is a more common problem with the farmers to manage the cash received at time of harvesting the crop.
- They can avail full benefit of their cash management by co-relating it with the loans and advances.
- The administrator can add information to the database without stopping the application.
- If implemented at Village, District and State level, the model will provide valuable information to other agencies and panchayats in particular.

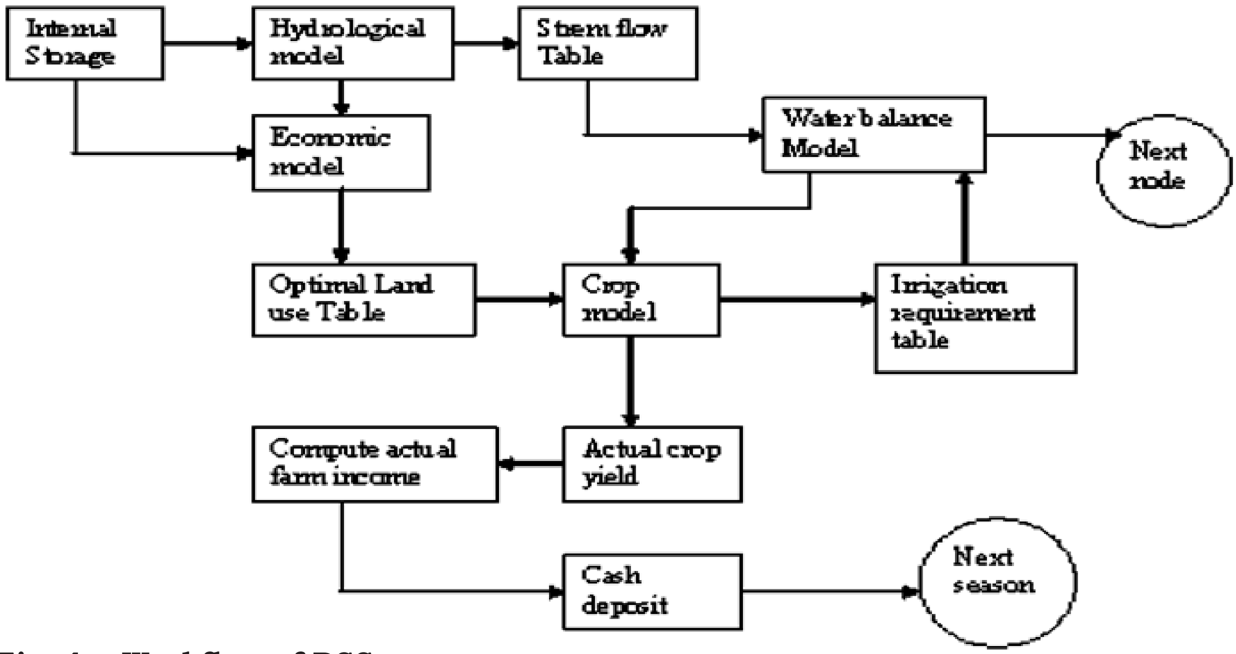


Fig. 4 : Workflow of DSS

With growing population and demands for improved watershed management, there is an obvious need to implement sustainable resource use that best serves the communities and the nation. To satisfy this need, the DSS is developed to aid decision – makers and various stakeholders in identifying and assessing options for resource uses. The DSS applies an integrative approach, combining biophysical data, perceptions and socioeconomic conditions of the farmers in the given area. The DSS attempts to stimulate the farmer's behaviour in selecting farming systems given relevant constraints and then aggregating up to the node.

A large number of database queries can be generated according to Crop, Water Availability and Requirement, Socio-economic constraints and so on. Design and Development of this database is purely based on Relation Database Management System Model, so the large volume of queries can be easily handled.

DSS with all the ready information help the farmers in a very useful manner. The farmers can get all the information at just at click of the mouse, and they need not to travel to Agricultural Universities for that.

Future scope : The Scopes for the future research are :-

- The Farm Entrepreneur System can be made more useful for the farmers by converting the language of the system to the local language.
- Further development of the economic model is required in order to address more complicated resource management patterns effectively.
- Market information relating to prices of the crop, particularly if quoted higher than the maximum support price offered by the government.

- Information transfer to the farmers can be increased substantially by providing email, news groups, messenger services, online chatting, and discussion groups.
- Voice support in local language can be provided for illiterate or semi-literate farmers.

  Research on growing different crops in protected environments.

Conclusion :

DSS practice, research and technology continue to evolve.. Decision support systems research and development will continue to exploit any new technology developments and will benefit from progress in very large data bases, artificial intelligence, human-computer interaction, simulation and optimization, software engineering, telecommunications and from more basic research on behavioural topics like organizational decision making, planning, behavioural decision theory and organizational behaviour. Trends suggest that data-driven DSS will use faster, real-time access to larger, better integrated databases. Model-driven DSS will be more complex, yet understandable, and systems built using simulations and their accompanying visual displays will be increasingly realistic. Communications-driven DSS will provide more real-time video communications support. Document-driven DSS will access larger repositories of unstructured data and the systems will present appropriate documents in more useable formats. Finally, knowledge-driven DSS will likely be more sophisticated and more comprehensive. The advice from knowledge-driven DSS will be better and the applications will cover broader domains.

Current researchers should remember that Decision Support Systems pioneers came from a wide variety of backgrounds and faced many challenges that they successfully overcame to demonstrate the value of using computers, information technologies and specific decision support software to enhance and in some situations improve decision making. The DSS pioneers created particular and distinct streams of technology development and research that serve as the foundation for much of today's interest in building and studying computerized decision support systems. The legacy of the pioneers must be preserved.

The association with e-governance is very important for government to interact with people and business transactions. E-government proffers a huge potential to find innovative way to satisfy need of people.This can be helpful to the farmers as well. Progress of new technologies allows electronic services to be applied in e-government. So, DSS must be integrated with e-government managerial levels. DSS is a very helpful tool for all e-government enterprises.

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