2.0 Review of Related Literature

2.1 Review of Related Business Concepts

2.1.1 Decision Support System

A decision support system (DSS) is a computer application that is used for helping in making business decisions in management, operations, and planning. It makes use of organized and analyzed data for making quality decision making. By using DSS analysis, organizations can help not just in decision making but to identify and solve problems as well. DSS can be applied to different fields, such as medical diagnosis, engineering projects, business management, and agricultural production at farm and policy levels. ("Decision Support System (DSS)", n.d.)

Decision support systems can either be computerized, human or a combination of both. According to Larson (1982), decision support system success is influenced by 11 factors. Technical system factors include: execution time; versatility of the system; quality of help provided; adaptability; and unity of commands and interface. Human factors include: learning time; ease of recall; errors made by end users; concentration required; fatigue or work level from using the system; and the fun the user has while operating the system.

2.1.1.1 Types of Decision Support Systems

Decision support system can be separated into different classifications. Although there is no universally-accepted taxonomy of DSS, different authors propose different classifications. One example proposed the classification using the relationship with the user as a criterion. Another example, used the scope of the DSS as the criterion to classify DSS. The most commonly used and well known categorization was created by Daniel Power who used the mode of assistance as the criterion. Power differentiates DSS into five categories

2.1.1.1.1 Communication-driven DSS

Communication-driven DSS supports more than one person working on a shared task. The common target users of this

DSS are internal teams and the purpose of this DSS is to conduct a meeting or help users collaborate.

2.1.1.1.2 Data-driven DSS

Data-driven DSS emphasizes on access to and manipulation of a time-series of internal company data. It is used to query a database to get specific answers for a specific purpose. The target users of this DSS are managers, staff and new suppliers.

2.1.1.1.3 Document-driven DSS

Document-driven DSS that manages, retrieves and manipulates unstructured information in a variety of formats. The purpose of this DSS is to find documents and web pages on specific set of keywords and this DSS has a broad base of user groups.

2.1.1.1.4 Knowledge-driven DSS

Knowledge-driven DSS provides problem solving expertise stored as facts, rules, or procedures. This DSS covers users within an organization and may also include others interacting with the organization.

2.1.1.1.5 Model-driven DSS

Model-driven DSS emphasizes access to and manipulation of statistical, financial, optimization, or simulation model that assist decision makers in analyzing the situation or choosing between different options. This DSS is used by managers, staff members or others interacting with the organization.

2.1.2 Precision Agriculture

Precision Agriculture makes use of real-time data on weather, soil, air, crop maturity, equipment, labor costs, and availability. To make better decisions, predictive analysis can be used. In order to help farmers optimize in planting, fertilizing, and harvesting crops, control centers collect and process data.

Decisions made in fertilizing and maintaining the crops are influenced by the weather and depends on the time. For example, farmers don't put fertilizer to a plant if they know that it will get washed by the rain the next day. Irrigation of the fields will also depend on whether it will rain or not. Weather also affect harvesting and transportation of crops. For example, soil has to be dry for the harvesting equipment to support the weight. The equipment can destroy the crop if it is humid and the soil is wet.

Large companies use precision agriculture since they have a robust IT infrastructure and resources used for monitoring. But a researcher, named Ulisses, anticipates a time when small farms can make use of mobile devices to optimize their farms. The farmer could take a photo of a crop and upload it in order for an expert to assess the crop's maturity. And people can provide temperature and humidity as a substitute for sensors.

With precision agriculture, farmers can make the right decisions based on weather forecasts, models, and simulations. (Melo, n.d.)

2.1.3 Crop Productivity

Crop productivity is the quantitative measure of crop yield in a given area of field. Another definition of crop productivity is the quantity of returns from arable land. There are different methods that have been developed to measure productivity. Land quality is a major component of natural resources and has a clear effect on crop productivity. (Lyon,june 14 2012).

Sampling sugarcane crop for yield estimation provides many challenges. A method for determining the yield would be with the use of sampling method, the idea is to count the number of stalks in each plot and the weight of a subsample of stalks. This method provides an efficient and accurate method of estimating final yield. In developing a sampling strategy for conducting growth analysis studies in sugarcane, the conflicting demands of manpower requirements and analytical costs with data precision must be balanced. The sampling strategy is enables precise and accurate estimation of a number of quantities such as : biomass per unit area, sucrose accumulation per unit area and leaf area index.(Thomas et al, 1993)

2.1.4 Yield Forecasting

Crop yield forecast models are prepared for estimating yield much before actual harvest of the crops. Statistical models was the first model used for large scale yield simulations. Mechanistic models attempt to use necessary mechanism of plant and soil processes to simulate specific outcomes. Functional models use a simplified approach to simulate complex processes. This model usually runs on daily time increments such as rainfall, temperature, radiation, and irrigation.

2.1.5 Crop Modeling

Crop modeling is the use of modeling techniques to be applied in agriculture to estimate the importance and the effect of certain parameters . Using models mean to simulate a situation or an experiment that are impractical, too expensive, or too lengthy. It can help in providing the best management strategies and study the long-term effect of options based on predictions or projections.

Models in agriculture are mathematical equations that represent the reaction that occur within a plant and the interactions between the plant and the environment. Owing to the incomplete status of present knowledge, it is impossible to completely represent the system in mathematical terms, hence, models are images of the reality. Unlike in the fields of physics or engineering, universal models do not exist within the agricultural sector. Models are built for specific purposes and the level of complexity is adopted accordingly.

Models contain factors that are used in agronomic practices in a specific crop. For sugarcane, there are several agronomic practices. Some practices are: improved varieties where the entire production system revolves. It is where we identify the variety which will be used depending on the environment, season, or cultivation. Land preparation is an essential prerequisite in providing optimum soil environment. The use of heavy machinery for planting to harvesting and transporting could also affect the soil's physical condition. Planting time which can affect since sugarcane is grown under diverse agro-climatic conditions in the world therefore there is a considerable variation in planting dates. Germination Irrigation that emphasizes on getting uniform and higher germination (sprouting) percentage of planted sets. Weed management can cause up to 12 to 72 % reduction in cane yield if not done right. The nature of weed problem in sugarcane is quite different since sugarcane is grown under abundant water and nutrient supply conditions and it has a relatively wider row spacing. Irrigation water management that affects since sugarcane produces huge amount of biomass and is classified among plants having high water requirement. Fertigation ensures that essential nutrients are supplied precisely at the area of most intensive root activity according to the specific requirements of a sugarcane crop. Detrashing refers to removal of unwanted bottom dry and green leaves at regular intervals. It is because the bottom green leaves are parasitic on the upper productive leaves and draining out food reserves. Water Shoots affects the growth of adjacent stalks. They also harbor insect-pests leading to reduced juice quality and sugar. Harvesting management ensures the canes are harvested at peak maturity and cutting cane to ground level which adds to yield and sugar; pests and diseases that are diverse in terms of region and climate, highly infectious and possibly reduce yield.

2.1.5.1 Types of modeling

The main goal of constructing crop models is to obtain an estimate of the harvestable yield. According to the amount of data and knowledge that is available within a particular field, models with different levels of complexity are developed. The most pertinent aspects of crop models are described below:

2.1.5.1.1 Empirical Model

Empirical model are direct descriptions of observed data and are generally expressed as regression equations (with one or a few factors) and are used to estimate the final yield.

2.1.5.1.2 Mechanistic Model

Mechanistic model describes the behaviour of the system in terms of lower-level attributes. Hence, there is some mechanism, understanding or explanation at the lower-levels. Models that fall under this category usually have the ability to mimic relevant physical, chemical, or biological processes and to describe how and why a particular response results.

2.1.5.1.3 Static and Dynamic Model

Static model is a model that does not contain time as a variable even if the end-products of cropping systems are accumulated over time, e.g., empirical models. In contrast, dynamic models explicitly incorporate time as a variable and most models are first expressed in differential equations.

2.1.5.1.4 Deterministic and Stochastic Model

Deterministic model is the model that makes definite predictions for quantities (e.g.,animal liveweight, crop yield, or rainfall) without any associated probability distribution, variance, or random element. Although variations due to inaccuracies in recorded data are inherent to biological and agricultural systems, deterministic model may be adequate despite these inherent variations. The greater the uncertainty in the system, the more inadequate deterministic model becomes and in contrast to this stochastic models appears.

2.1.5.1.5 Simulation Model

Simulation models are a group of models that are designed for the purpose of imitating a behaviour of a system. They are mechanistic and in majority of cases, they are deterministic. Since they are designed to mimic the system at short time intervals, the aspect of variability related to daily change in weather and soil conditions is integrated. The short simulation time-step demands a large amount of input data to be available for the model to run. This models offers the possibility of specifying management options and they can be used to investigate a wide range of management strategies at low costs. Most crop models that are used to estimate crop yield fall within this category.

2.1.5.1.6 Optimizing Model

Optimizing models have the specific objective of formulating the best option in terms of management inputs for practical operation of the system. For deriving solutions, they use decision rules that are consistent with some optimising algorithm.This forces some rigidity into their structure resulting in restrictions in representing stochastic and dynamic aspects of agricultural systems. Optimizing models do not allow the incorporation of many biological details and may be poor representations of reality. Using the simulation approach to identify a restricted set of management options that are then evaluated with the optimizing models has been reported as a useful option.

2.1.5.2 Model Development

2.1.5.2.1 Model Calibration

Model calibration is an important part of developing models because it is the stage that involves with the adjustment of the parameters being used to reach a predetermined level in the simulation results. The reason calibration is important is because even if the model is solely based on observed data that does not mean that the simulated values exactly comply with the observed data and therefore minor adjustments have to be made for some parameters.

2.1.5.2.2 Model Validation

Model validation is yet another important phase because it involves with the checking and confirming if the calibrated models closely represents the actual and real situation. One procedure of doing that is by comparing the simulated output to that of observed data that had not been used before. Mechanistic models should be validated on both the output and internal components and processes that reach to that output. Sampling errors may also contribute to inaccuracies in the observed data. Validation procedures involves both quantitative and qualitative comparisons. It is advisable to qualitatively assess trends of simulated and observed data for both internal variables and its outputs before starting quantitative tests.

2.1.5.3 Limitations of study and models

Validation of all components is not possible due to the lack of detailed datasets. Furthermore, agricultural models are reflection of systems for which the behaviour of some components is not fully understood and differences between model output and real system may not be fully accounted for. Prediction of models may require adjusting of the regression curves or fine tuning of the variables. It is best to seek reliable data through further experimentation than going for extensive modifications of the model parameters to achieve an acceptable fit to doubtful data. The decision also relies on the modellers expertise, human resource and time available to have a fine tuned model prediction. Crop models are also not universal and so the user has to choose the most suitable model according to his objective.

Agricultural systems are characterized by high levels of interactions between components that are not completely understood. Models are therefore are just crude representations of reality. Wherever knowledge is incomplete, the modeller usually adopts a simplified equation to describe an extensive subsystem. Simplifications are adopted depending on the model's purpose or the developers view and this therefore constitutes some degree of subjectivity. Model quality is dependent on the quality of scientific data used in model development,calibration and validation. Most simulations models require meteorological data to be reliable and complete although the sites may not fully represent the weather at a chosen location. There are times that data may only be available for only one or a few parameters which is usually rainfall or others like temperature. If data is not available or records are incomplete then the user has to rely on generated data. Using approximations would have an impact on the model’s performance.

2.1.5.4 Model uses and tools

Despite its limitations, simulation modelling is increasingly being applied in research,teaching and resource management,policy analysis and production forecasts. The models can be applied in 3 areas which are 1)research tools,2)crop system management tools and policy analysis tools.

2.1.5.4.1 Research tools

2.1.5.4.1.1 Research Understanding

Adopting a modelling approach could help towards a more targeted and efficient research planning. Model development ensures the integration of research understanding and which can therefore identify the major factors that run the system and highlight areas that have not been really researched on.

2.1.5.4.1.2 Improvement in experiment documentation and data organization

Simulation model development,testing and application require the use of large amount of technical and observational data. This data handling forces researchers and modellers to resort to formal data organization and database systems. This organization of data enhances the efficiency of data manipulation in other research areas like productivity analysis and change in soil fertility status over time.

2.1.5.4.1.3 Yield analysis

The use of several models to assess climatically-determined yield like the CANEGRO model which has been used in the South African sugar industry. Using the modelling approach,quantification of yield reductions caused by non-climatic causes like soil fertility,pests and diseases becomes possible. Almost all simulation models have been used for such purposes.

2.1.5.4.2 Crop system management tools

2.1.5.4.2.1 Cultural and input management

Management decisions regarding cultural practices and inputs have a major impact on yield. Simulation models that allow management options offer a relatively inexpensive way of evaluating a number of strategies that would relatively be expensive if one were to use and adopt the traditional experimentation. There are many publications available that describe the use of simulation models in relation to cultural management like planting, harvest date,irrigation,spacing and variety type and also input applications like water and fertilizer.

2.1.5.4.2.2 Risks assessment and investment support

The combination of simulated yields and gross margins,economic risks and weather related variability can be assessed. This data can then be used as an investment decision support tool.

2.1.5.4.2.3 Site-specific farming

Profit maximization can be achieved by managing farms as set of sub-units and providing the required inputs at the optimum level to match variations in soil properties across farms.

2.1.5.4.3 Policy analysis tools

2.1.5.4.3.1 Yield forecasting

The technique uses weather records and forecast data to estimate yield across the industry.

2.1.5.4.3.2 Global climate change and crop production

Assessing changes in crop yield is important at the producer and government level for planning purposes.

2.1.6 Agricultural Practices

Agricultural practice are practices used in agriculture to facilitate farming. They are used to help the farmers as well as their farms in order to produce more and prevent harm to the environment. Good agricultural practice should economically and efficiently produce sufficient crops, sustain and enhance natural resources, maintain and contribute to sustainable livelihoods, and meet the demands of society. Most importantly it can help increase farmer's yield. In sugarcane agricultural practice include:

2.1.6.1 Land Preparation

Land preparation is an essential pre-requisite in order to provide high sugarcane yields. It involves providing optimum soil environment, tilling, plowing, harrowing, and furrowing. Furthermore, we also have to monitor the traffic of heavy machinery from planting to harvesting since mechanization can cause deterioration of soil physical conditions. This could cause soil compaction which reduce storage and movement of air and water making it difficult for root growth and absorption of nutrients itself. The objective of Land preparation is to prepare a seed bed which permits optimal soil water air relations, provide good physical conditions for early root penetration and proliferation, incorporate preceding crop residues or manures, destroy weeds and hibernating pests, and to facilitate microbial activity.

2.1.6.2 Variety

Variety is the center around which the entire production system revolves. Therefore it is important to choose for the appropriate variety to use depending on the agro-climatic zone, soil type, and season concerned. The classification of sugarcane is based on their maturity. Though it is not a natural classification, the goal of maturity-based classification is to facilitate harvesting of variety at the proper time in order to enhance all recovery and be consistent in sugar production. Important considerations in choosing an appropriate variety include cane yield, juice quality, age group, suitability to the growing conditions, soil type, irrigation regime, season, ratooning potential, resistance to pests and diseases, and adverse growing conditions.

2.1.6.3 Irrigation Management

Since sugarcane is known for being a long duration crop producing huge amounts of biomass, it is already classified among those plants having a high water requirement and yet it is drought tolerant. The main purpose of irrigation management is to use water in the most profitable way at sustainable production levels.

The water requirement of sugarcane depends on the different phases of the crop. For the germination phase, which is from 0 to 35 days, Sprinkler irrigation is recommended for this early stage. During the tillering phase, which is from 36-100 days, irrigation can be given at 0.75 IW/CPE and the interval of irrigation days can be 8 for sandy soil and 10 for clay soil. 101 to 270 days after planting is the grand growth phase for sugarcane. During that phase, irrigation can be provided at 0.75 IW/CPE with irrigation days interval of 8 on sandy soil and 10 on clay soil.The next phase is maturity phase (271 days - harvest), which requires 0.50 IW/CPE and 10 days of irrigation interval on sandy soil and
14 days on clay soil. (“Irrigation Management - Sugarcane”, n.d.)
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There are four (4) irrigation methods for sugarcane, namely, flood irrigation, large furrow system, contour furrows system, and alternate skip furrow method.

In the flood irrigation method, irrigation water is flowed in all directions of the field. It is best practiced in flat planted cane, but with this method, the water loss is high. The large furrow method system is used on slopes of up to 0.1%. In this method, water is sprinkled in between the rows of the crop. In the contour furrow systems, the furrows are created along the adjusted contour lines. It is used in regions where land is wavy. Another method is the serpentine method, where big ridges and furrows are formed after 3 months of planting and before the grand growth phase. The alternate skip furrow method is used for saving water. In this method, sugarcane is planted in flat beds and after germination. The furrows are 45 centimeter wide and 15 centimeter deep which are created in alternate inter row spaces. ("Irrigation methods in sugarcane", 2009)

2.1.6.4 Weed Managment

In sugarcane weeds have been estimated to cause 12 to 72% reduction in cane yield depending on the severity of infestation. The nature of weed problem in sugarcane is quite different from other crops because of the following reasons: Sugarcane is planted with a relatively wider row spacing providing opportunity for weed to grow in a large scale; sugarcane is grown under abundant water and nutrient supply conditions; and in ratoon crop, very little preparatory tillage is taken up, hence weeds that have established in the plant crop tend to flourish as well. Weeds are present in furrows cause more harm than those present in the inter-row spaces during early crop growth sub-periods. Therefore the initial 90-120 days period of crop growth is considered as most critical period of weed competition. Thus, it is always a practice that the weed management should ensure a weed-free field condition for the first 3-4 months period.

2.1.6.5 Harvesting Management

Harvesting management ensures harvesting of sugarcane is done at a proper time by adopting techniques that is necessary to realize the maximum weight of the millable canes produced with the least possible field losses under the given growing environment. Several standard analytical methods are available to determine the peak maturity or quality to know that the cane is harvestable. Without this analysis, farmers take-up cane harvesting based on crop age and appearance. To avoid such extremes, harvesting should be done at the right time in the right method. The following criteria enable harvesting of cane at the right time adopting proper procedures: Crop age; Visual symptoms, Quality parameters (e.g., Juice Brix, Purity Coefficient, Commercial Cane Sugar), Manual or Mechanical Harvesting.

2.1.6.6 Pests and Diseases

Matching with the long diversity of conditions under which sugarcane is grown in the world, there is a vast spectrum of pests and diseases which have come to acquire a place of priority for control on regional or international basis due to the agro-climatic conditions associated within the area. Besides the susceptibility of the variety to the diseases and pests making the situation worse. Below herein is given a brief account of symptoms of important pests and diseases that happen in several parts of the world.

2.1.6.6.1 Early Shoot Borer

Early Shoot Borer(Chilo infescatellus) attacks the sugarcane during the early part of cane growth, before internode formation. Larvae enters the cane through one or more holes in the sugarcane stalks (shoot) and drills downwards as well as upwards killing the growing point. Thus, it cuts of the central leaf spindle, which eventually dries forming a ‘deadheart’. The ‘deadheart’ can be easily pulled out although it emits an offensive odor. Borer infestation during the germination phase kills the mother shoots resulting in the drying up of the entire clump leading to gaps in fields.

2.1.6.6.2 Internode Borer

Internode Borer(Chilo Saccharifagus Indicus) damages crops soon after the internode formation occurs and it will do so until harvest. Lodging, high dosage of nitrogen, waterlogged condition and presence of water shoots are reasons that favour buildup of pest. Caterpillars bore at the nodal region and enter the stem. The entrance hole is usually plugged with excreta. Larvae feeds and multiply in water shoots. The length and girth of the infected internodes get reduced.

2.1.6.6.3 Yellow Top Borer

Symptoms are similar to those produced by other borers. Young larvae eat small in leaves, especially in leaf-sheaths, and at a later stage the growing points are killed. The terminal leaves then die and form characteristics dead hearts. Older larvae in stems eats out extensive galleries and excreting frass, which resembles sawdust.Thus, tunnelled stems may break, especially in high winds.

2.1.6.6.4 Smut

Smut is a disease that spreads through infected setts and the secondary spread is through wind borne teliospore. Stunting of infected stools, profuse sprouting of lateral shoots, reduction in internodal length, formation of thin stalks, and narrow erect leaves are certain symptoms of smut. Losses due to smut in sugarcane depend on various factors such as: primary or secondary infection, plant or ratoon crop that is affected, and early or late infection.

2.1.6.6.5 Pineapple disease

Pineapple disease essentially, is a disease of seed material like setts. This type of disease can only be detected in setts after 2-3 weeks of planting. Pathogen enters the sett mainly through the cuts ends and destroy the central soft portion and then damages the buds. Affected tissues develop reddish colour at first, which turns to brownish black in the later stage, Cavities are formed inside the severely affected internodes. The presence of the fungus inside the sett prevents their rooting. Thus causing germination failure.

2.1.6.6.6 Yellow Leaf Spot

Prolonged rain with irregular sunshine, waterlogged conditions and higher nitrogen doses are pleasant for disease development. Warm humid weather favours rapid and abundant production of conidia by the pathogen and spread of the disease.

2.1.7 Estimates

Estimation in general, is to approximate the value of significance of something. Estimates can be classified in two to categories: Point estimate which consist of a single value; and Interval Estimate which consists of two or more defined values or points. A good estimate must satisfy three conditions. Estimate should be unbiased, consistent, and relatively efficient.

Estimate can be applied in a lot of aspects. It can be used for estimating population given a sample statistics, or projecting costs of a project, or even predict the weather given the parameters. Estimates can even be used in agriculture. Estimate can be used to get the area harvested, area planted, planning of planting and harvesting requirements, and most importantly yield. Estimating the yield is very important to agriculture because it will be used to decide what would be the price for that crop in that market. It can also be used in providing support to farmers as an assistance.

2.2 Review of Related Cases

2.2.1 Climate Based Crop Advisor for Sugarcane and Pomegranate

In India, change in climate is in terms of exponential increase in average temperature, and rainfall, which can be costly for agriculture because of degradation of the crop.

2.2.1.1 Problems

The area faces a lot of problem in climate change because of the lack of technology and proper knowledge. Diseases and their solutions are introduced from new weather conditions like smog, humidity, heavy rain, etc. Farmers realize the disease as soon as symptoms are seen on the infected crop. Only then will he call an adviser for help. Adviser comes to the farm and then gives advice after a proper analysis. The farmer will then bring the prescribed pesticides, and other requirements to treat the disease. At this point, the disease might have damaged the crop. This process is time consuming, and the farmer needs the advice within time to take action and save his crop.

2.2.1.2 Solution

The solution would consist of a web-based simulation model that estimates the recent, current, and future crop status, yield from field information, and real time weather data. The system automatically generates and distributes simple advices by SMS to farmer's cellular phones. The system is evaluated on a small-scale sugarcane and pomegranate scheme at Pandharour, Maharashtra.

2.2.2 Decision support system for enhancing crop productivity of smallholder Farmers in Semi-Arid Agriculture

The case is aimed at the creation of a system that would use a simple yet affordable way of accessing information for farmers to use. The aim is to be able to create a decision support system to assist farmers in making strategic and tactical decisions. The value of DSS in agriculture can be enhanced by exploiting new opportunities of web and mobile technologies linking to existing telecentres implemented in rural areas.

2.2.2.1 Problems

The problem the case is trying to address is the inaccessibility of information to farmers and the farmers lack of proper tools and techniques to make proper decisions. Difficulty in selecting crops in response to different weather conditions for improved productivity.

2.2.2.2 Solution

Decision making in agriculture involves selecting alternative choice that has improved effect on productivity. The problem is addressed by the creation of a decision support system and the system would provide weather forecast information to the farmer so the farmers can make sound plans for agricultural production. They could also determine when to plant their crops by determining possible drought times. With this design, when a farmer request an advisory about a crop, then the DSS scans the current issues seasonal climate forecast and recommend suitable crops. This knowledge can also be linked with topographical zones and other socio-economic status of farmers and so therefore a farmer can be provided with specific forecast.

2.3 Review of Related Systems

2.3.1 Decision Support System:

2.3.1.1 GoldSim

A software that supports decisions and risk analysis by simulating performance. The platform is flexible enough that it can be used in population modeling. Its visual elements make it easy to learn and explain. The system provides release new versions which are constantly improving the model's utility and capability.

Features:

- **Application Development**
- **Budgeting & Forecasting**
- **Data Analysis**

2.3.1.2 Analytica

A decision-making software that is transparent and easy to use with its influence diagrams and built-in probabilistic analysis. Using influence diagrams, we can both understand the model and also distinguish key decision-making variables and their relationships. There are also built-in tools for managing risk and uncertainties.

Features:

- **Application Development'**
- **Budget & Forecasting**
- **Data Analysis**

- **Monte Carlo Simulation**
- **Sensitivity Analysis**
- **Version Control**

2.3.1.3 Paramount Decisions

A software that helps in collaborating for the decision -making process. Decisions that will include multiple stakeholders with complex and competing trade-offs. By using the Paramount Decisions platform, the user is now provided with a structured approach to making and deciding complex decisions.

Features:

- **Data Analysis**
- **Performance Metrics**
- **Rule-Based Workflow**
- **Sensitivity Analysis**
- **Version Control**

Comparative Table

	GoldSim	Analytica	Paramount Decisions
Application Development	✔	✔	
Budgeting & Forecasting	✔	✔	
Data Analysis	✔	✔	✔
Decision Tree Analysis		✔	
Monte Carlo Simulation	✔	✔	
Performance		✔	✔

Metrics			
Rule-based Workflow			✔
Sensitivity Analysis	✔	✔	✔
Thematic Mapping			
Version Control		✔	✔

2.3.2 Farming Management Information Systems

2.3.2.1 Cropio

A field management system that facilitates remote monitoring of agricultural land and enables users to plan and carry out agricultural operations efficiently. Cropio provides real-time updates on current field, determines vegetation levels, and deliver precise weather forecast.

Features:

- **Digital Maps**
- **Field Zoning**
- **Harvest Estimate**
- **Automated Reports**
- **Integrated Private Weather Stations**

2.3.2.2 Agrivi

A cloud farm management software that helps farmers improve their productivity and profitability. It enables farmers to manage inventory, people, financials, and mechanization of farms and fields. This software lets farmers know about best practice farming processes and smart disease alarm alert farmers when there is a risk of disease occurrence.

Features:

- **Automated Inventory Tracking**

- **Detailed Activity Tracking**
- **Weather Forecasts**
- **Project-oriented farm management**

2.3.2.3 LandMagic

Is a web based agricultural software designed for small and commercial farming operation. It is a group of products that can be acquired individually or join together depending on the needs of the user's farming operation. Other software that can be used to collaborate with one another includes the following: LandMaster, CropCare, GeoMaps, FieldTime, and MobileMagic.

Features:

- **Independent Modules**
- **Electronic Timekeeping**
- **Land tracking**
- **Geospatial Tools**

2.3.2.4 Agri360

A cloud-based system that provides good record keeping, compliance, and job management. Agri360 provides a comprehensive record that is customisable for the user's farming operation. It easily recall records using simple search filters. Furthermore, Agri360 provides a record of the actual hours being worked on the farm which managers can then use to audit and approve time sheets in real time.

Features:

- **Record Keeping**
- **Task Management**
- **Comprehensive Timesheets**
- **Interactive Farm Mapping.**

Comparison Table

	Cropio	Agrivi	LandMagic	Agri360

Contract Management	✔		✔	
Crop Management	✔	✔	✔	✔
Customer Management	✔	✔		
Financial Management		✔		
Inventory Management		✔	✔	✔
Labor Management	✔			
Order Processing		✔	✔	✔
Pricing Management				
Supplier Management		✔	✔	✔
Traceability	✔		✔	✔

2.4 Review of Technology Concepts

For the web application, the group has decided to use Java, JavaServer Pages (JSP), and HTML5 for design. The database to be used is MySQL for storing all data used in the system. A server is also needed for receiving data that was sent. A computer is to be used by employees of RD&E. And lastly, farmers will be sending text messages (Short Messaging Service) or use mobile applications for data and feedback.

2.4.1 Mobile

A mobile device is a portable handheld tablet or other device and is made compact and lightweight. Mill district officers need mobile devices to be able to send their data to RD&E. Farmers also send SMS messages for data and feedback.

2.4.2 MySQL (DB)

MySQL is a popular open source database and is the leading choice of a database for creating web-based application. This database will store records from farmers about their farm and their productivity.

2.4.3 HTML5

HTML is a requirement for creating a website. It's a language that uses tags, attributes, events, color names, entities, and more. HTML5 is going to be used for creating the interface of the web application.

2.5.4 Server

A server is computer or device that manages the network resources. There are three types of servers, namely, file server, print server, and a database server. For the proposed system, a dedicated database server is needed for recording and retrieving all data and information.

2.5.5 Java

Java is a programming language that is commonly used for developing and making content on the Web. There are more than 9 million Java developers in the world and more than 3 billion mobile phones run on Java. The latest version of Java to date is Java SE 8.

2.5.6 JavaServer Pages

JavaServer Pages is a programming technology for creating dynamic Web-based applications that is independent of platform. JSP has access to the entire Java API's.

2.5.7 Computer

A computer is an electronic device that manipulates information to a result based on a program. Computers will be used in the system for generating reports, data inputs, and data processing.

2.5.8 SMS

SMS or Short Message Service, is a service that is capable of sending messages for up to 160 characters. These messages are being sent to mobile phones.