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Cultivation Process Facilitator for Selected Five Crops in Dry Zone Sri Lanka

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Abstract : *Sri Lanka is an agricultural country, where most farmers use traditional agricultural practices. Most of Sri Lankan farmers choose a crop or crop combinations to cultivate based on their traditional knowledge. But they do not consider the soil conditions, other alternative crop combinations, market price and demand, profit and cost, water resource access, pesticides and fertilizer costs while selecting crop combinations. They also do not pay much attention about how to manage and schedule water supply, pesticides and fertilizer. Another problem, the most farmers are not aware of the market changes and disaster management. To solve these identified problems of Sri Lankan traditional farming style we have introduced this Cultivation Process Facilitator, a web based solution which helps farmers for their cultivation process throughout the season. In here we have introduced new algorithms for selecting most profitable crop combinations, scheduling water supply and fertilizers, identifying the disasters and market threats.*

Key Words: **Cultivation Process Facilitator, Cultivation, Sri Lanka, Irrigation, Forecast, Dry Zone, Agriculture, Information Technology**

1. INTRODUCTION

The contributions made by the Information Technology to the backbone of the Sri Lankan community life, that is, agriculture, have been very low to date. Under the present system, a farmer or cultivator could gain expert knowledge only by contacting a person or institute dedicated or appointed to divulge such information to the public. The resources .selection of seeds, fertilizers, pesticides and optimum times for cultivation are decided either by experience the cultivators have or by having access to persons appointed by institutions dedicated to such purposes. The reliability of decisions made through experience or prescription can vary with the actual fluctuating circumstances the cultivators are faced with. Moreover, the cultivators concerns linked to aspects like supply demand, real market prices and cost incurred with the cultivation process are of a high variance. There is no system available, at present in Sri Lanka that coordinates and supplies such knowledge to cultivators. This project aims to develop such a useful system to cultivators all over the country.

Cultivation Process Facilitator is a web based solution providing and guiding tool for farmers and cultivators in dry zone of Sri Lanka. As the first version of the project we have chosen only five seasonal crops that can be cultivated in dry zone. This System mainly consists of Expert System and Decision Support System.

The Expert System: The main aim of this level is to supply and support the farmers and cultivators. The expertise and knowledge base related to their choice of the crop and cultivation process. This tier could be further divided in to three clearly discernible sections. Those are crop selection, seeds, fertilizer and pesticides, water resources management.

Decision support system: The main objective of the decision support system is to help the farmers and cultivators take decisions on emergency situations they come across in the lifespan of the crop. For example, when farmers and cultivators grow the same crop, during the time of harvest, the supply would exceed the demand and as a result the price of the unit measurement of the crop might decrease. A data base to avert the occurrence of such situation would be developed through the available market data obtainable through Internet. Besides, the farmers and cultivators would be supported by a disaster management plan to empower them to face natural and unexpected calamities with courage and confidence. And also when there are market threats, like huge increases or decreases in Market Prices, the Decision Support System will give the farmer alternative solutions to overcome and cover major losses.

2. LITERATURE REVIEW

Same problem has identified and has tried to solve using various approaches but through literature exploration it was understood a complete solution was not implemented. There came the need to do a research to identify an optimized solution to the problems at hand. Algorithms are developed through research for each of the problem sections identified.

Numbers of alternative solutions were considered and research was done to figure out the most appropriate

solution to each of the problem area in the cultivation process.

For crop selection we found several previous works. We studied two methods [1] Linear programming method and Decision tree induction technique. But we encountered some problems in that methods relevant to our work. Linear programming model provide optimal cropping pattern at the first time. And also only consider about the profit not about the total cost for the combination.

In Decision tree induction technique profit, cost and revenue are not concerned when getting crop combinations and consider only about environmental factors. Profit, Cost, Revenue and also environmental conditions are taken into consideration in our method for crop selection

The presence of adequate quantities of nutrients in forms accessible to plant roots in soil solution is essential to attain optimum crop growth. Environmental factors and soil plant nutrient content and its availability determine the capacity of a plant to absorb such nutrients. Soil fertility determines the capacity of a soil to supply nutrients. The capacity of a soil to supply nutrients depends on many factors of which moisture content plays a big role.

To maintain sustainable agricultural systems while achieving optimum yields, a supply of adequate and balanced amounts of plant nutrients must be provided at the correct time. The Fertilizer section helps for these facts. It provides balanced amount of fertilizers to be provided at the correct time. By entering the starting date of fertilizing user can get the details about ending date of fertilizing according to the different fertilizer types and dressing types. Actually it gives the best time duration for the fertilizing. And amount for per hectare, amount for per plant and other details about fertilizing also provided by this section according to the selected crop/crop combination by the user.

In Sri Lanka, the pest control is mostly dependent on the use of synthetic pesticides. Sri Lanka strongly advocates adoption of IPM technology to control pests, thereby, reducing the over dependence on pesticides. This in the long run helps to minimize pesticide-related hazards, in addition to ecological benefits. In management of pests, the plantation sector approach in a more organized manner whereas, in the domestic sector it is more complicated due to large number of farmers, crops and the pests involved.

In pesticide section, user should identify the symptoms of diseases and should select the disease name according to the identified symptoms. If some area is affected by the disease then user also can get the pesticide amount for affected area by entering the affected area in hectares. Then it provides details about crop disease, amount for per hectare and amount for affected area. Otherwise, the symptoms are not available in our system then user can enter the symptoms as he identified. After he entered, we stored it into our database to give most suitable solutions

3. DESIGN

In our study about the problem domain we found out some applications which are strived to address the same problem. But their solutions were not exactly same to the application we implement. Our aim was to give solutions to each and every problem we identified while studying our problem domain. But most of the applications we studied were designed to solve a single problem. Some areas implemented were rear to find out and some have never implemented.

CULTIVATION PROCESS FACILITATOR project covers several areas of the cultivation process. So it has divided into manageable small components. Partitioning systems into subsystems and components, each does a separate task, make it easy to design and develop. Therefore entire system has divided into components. Each component operates separately and use interfaces to communicate with each other.

A. Crop Selection

A research based algorithm which is used to select a crop/crop combination in order to make the crop selection process more effective and profitable by considering the total cost, profit and revenue of each crop/crop combination. Farmers can select a basic crop combination or get a further crop combination according to their preferable total cost, profit or revenue which provides profit optimizations on each basic crop combination. This algorithm is unique to the CULTIVATION PROCESS FACILITATOR project and this method is not yet used in any Agricultural Crop Selection System in Sri Lanka.

B. Seeds, Fertilizer and Pesticides

CULTIVATION PROCESS FACILITATOR also provides ending date calculation for fertilizing. When the user enters the starting date of fertilizing the system provides ending date of fertilizing according to the selected crop/crop combination and to the different fertilizer type or dressing type. Although most of the agrarian centers and research centers situated in Sri Lanka provide advices to the farmers about fertilizing but by using our system they can get accurate details for their farming.

C. Water Resource Management

In Sri Lanka most agrarian centers and Research centers

provide advices about water scheduling and water resource management base on the all common requirements of all Sri Lankan farmers rather than considering their individual requirements. Cultivation Process Facilitator provides the most accurate water scheduling system for each farmer separately based on their individual requirements such as starting date of the cultivation, eco-region of the cultivation location, soil conditions of each land and the crops they have cultivated.

D. Crop Disaster Management

Most of the agrarian centers and research centers situated in Sri Lanka provide advices to farmers how to manage the water resource/ tanks during the dry season and what are the methods to follow/ pre solutions before a disaster happened rather than suggest any alternative crop solution. Disasters can be happened in an unexpected moment. So pre solutions may be not enough. CULTIVATION PROCESS FACILITATOR provides alternative crop solution after disaster happened by considering disaster type, remaining time period for harvesting and cultivated season.

E. Market Threats

The Cultivation Process Facilitator provides alternative solutions to cultivators who face the crisis of changing market prices. Due to Sri Lanka being an agricultural country, there is a high percentage of cultivations within the country, which in time to time causes the Market Price to differ. The Cultivation Process Facilitator will ensure that cultivators will have an option to at least cover up the cost related to their cultivation rather than facing a total loss. It will give cultivators suggestions regarding the crop combinations that can be cultivated to gain maximum profit, taking into regard the remaining time period that was allocated to gain the harvest of the currently cultivated crops.

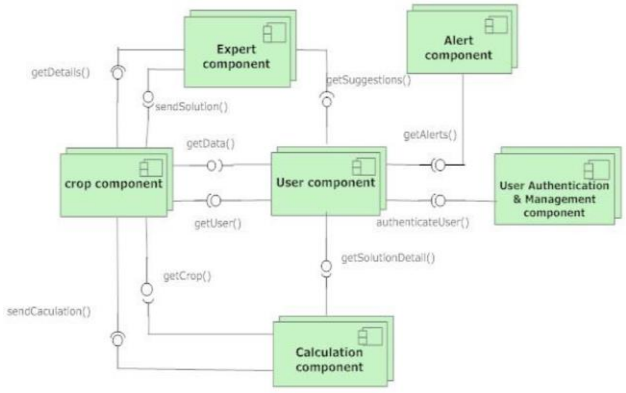

Fig.1. High Level Components and Their Interaction

4. MEATHODOLOGY

4.1. Layered Architecture Using MVC

Since layered architectural style is one of the best suitable architectural styles for a web application. We tend to use it in the project. As it is needed to separate presentation logic form, business logic and data access logic, MVC will come across that situation in a very systematical way.

- Model

The Model layer represents the part of our application that implements the business logic. It is responsible for retrieving data and converting it into meaningful concepts for our application. This includes processing, validating, associating or other tasks related to handling data.

- View

The View renders a presentation of modeled data. Being separated from the Model objects, it is responsible for using the information it has available to produce application might need. For example, as the Model layer returns a set of data, the view would use it to render a HTML page containing it. Or a XML formatted result for others to consume.

- Controller

The Controller layer handles requests from users. It's responsible for rendering back a response with the aid of both the Model and the View Layer. Controllers can be seen as managers taking care that all needed resources for completing a task are delegated to the correct workers clients, checks their validity according to authentication or authorization rules, delegates data fetching or processing to the model, and selects the correct type of Presentational data that the client is accepting, to finally delegate this rendering process to the View layer.

5. IMPLEMENTATION

The key issue addressed by the project CULTIVATION PROCESS FACILITATOR is support farmers in the agricultural field in their cultivation process. This is done by supporting farmers to select a best crop combination, control fertilizer and pesticide requirement, manage water requirement, provide alternative solutions for natural disasters and provide alternative solution for market threats.

5.1. Crop Selection Algorithm

CULTIVATION PROCESS FACILITATOR is first starting with providing a profitable crop combination. The main aim of crop selection algorithm is to provide user best crop combinations with profit, revenue and total cost for each crop combination.

We selected five crops for this purpose and all the algorithms of this research based on the five crops.
Providing details about previous crop combination which is cultivated before and soil condition user can get feedbacks about which crops are suitable to cultivate in this time.

- Basic crop combinations

In crop selection, first we consider about giving basic combinations that the user can cultivate in their location by dividing the land into the same pieces according to the number of crops in the combination.

Number of basic crop combinations = 2^n - 1;

n <-- no of crops we considered

- Further crop combinations

Then also user can get further crop combinations of basic combinations to maximize their profit. Further combinations are obtained by dividing the land into various deviations

5.2. Fertilizer and Pesticides

- Calculate the remaining days for fertilizing.

If user enter the starting date as MM/DD/YYYY
M-Month
D-Date
Y-Year

This algorithm calculate the time duration for each and every crop/crop combination according to the fertilizer type and then display the ending date for fertilizing.

First, system gets the starting date; that is entered by the user.

Modify date=7*Time duration + Start date

Then categorize the months which have 31 days, 30 days or less than 30 days.

If (Start month==1 || Start month==3 || Start month==5 || Start month==7 || Start month==8 || Start month==10 || Start month==12)

```
If (Modify date>=31)
    {
        Remain date=Modify date-31;
        New date=Remain date;
        New month=Start month+1;
        New year=Start year;
    }
        else
    {
        New date=Modify date;
        New month=Start month;
        New year=Start year;
    }
```

According to above algorithm, then display the ending date for fertilizing.

5.3. Seasonal IWR Mapping

The main aim of development of this algorithm is to inform the exact amount of water required by the cultivation location throughout the season to farmers. For these calculations the cultivation Process Facilitator has used the internationally accepted irrigation engineering practices and equations. Based on the each farmers individual requirements these calculations are carry on and therefore the final result of this calculation is unique for each cultivation area based on the soil conditions, eco region data , crop static data, expected weather changes and etc.

- Considered factors

a) Crop evapotranspiration:

For a given Crop,
ETC = KC x ETO

ETO - rate of evapotranspiration from an extensive surface of 8 to 15cm tall green grass cover of uniform height, actively grown completely shading the ground and not short of water. (Only depends on climatic parameters)

KC – Type of crops growth stage

ETC= $\Sigma 4i=1,j=1$ kci (ET0)j

b) Natural Conditions Considered

a) Effective Rainfall: Effective rainfall is the portion of the rainfall that contributes directly or indirectly for crop production at the site where it falls.

Effective rainfall (Pe)=f% of total rainfall

As the Cultivation process facilitator is for the dry zone, this project considered the expected monthly rainfall of

each moth and calculated the expected rainfall per day. For each stage of the plant, the expected rain fall is used to calculate the IWR, based on the life periods.

b) Ground water: (Ge) in calculations it considered as zero.

c) Stored Water (Wb): The amount of water already stored in the root zone from a preview rainfall amount or irrigation application

Net IWR= CWR- (Pe – Ge +Wb)

IWR- Irrigation Water Requirement

CWR- Crop Water Requirement

Pe- Effective Rainfall

Ge- Ground water

Wb- Stored water
Gross IWR= Net IWR/Ea%

Ea% -Application efficiency of the soil

In here the project identifies the ecoregion of the location using the location ID of the cultivation area and then according to the ecoregion, the system identifies the soil category of location and based on the soil category it filters the soil static data from the data base.

Seasonal Gross IWR= Σ4 Gross IWR

To calculate the Seasonal Gross IWR of a crop the project gets the sum of gross IWR of the four growth stages of the crop. Then calculate the sum of all Gross IWR s of each crop in the combination of the specific location to get the Seasonal Gross IWR for the location.

5.4. Crop Disaster Management

The main purpose of development of this algorithm is to define disaster types (Flood and drought) and identify the extreme events based on the rainfall data and suggest the alternative crop solution.

a) Define the Disaster Type

- General Methodology for data analysis

The “CULTIVATION PROCESS FACILITATOR” project was basically done for the dry zone. Therefore we have selected Anuradhapura district as our target area and according to that area we have gathered monthly rainfall data. Due to data availability to represent the Anuradhapura district only four stations are considered among the 14 stations. Those are Anuradhapura, Ehetugaswewa, Kalawewa tank and Mahailluppallama. To define the disaster type, at least we need 30 years of past rainfall data and those data have collected from the Meteorological Department of Sri Lanka.

STATION NAME : ANURADHAPURA (METEO)
LAT: 8.35N LON: 80.38E ELEV: 92.5M
ELEMENT : Precip,Total Mly in Millimeters
Missing data values are coded as -9.9M

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
1980	.1	.0	112.1	184.1	103.8	22.1	2.6	.0	103.3	21
1981	46.7	19.3	53.8	151.7	74.1	13.8	61.2	85.8	146.0	16
1982	.0	.0	122.3	137.8	77.9	33.4	4.9	.0	76.8	25
1983	4.6	.0	.0	74.6	190.3	18.2	19.3	24.3	72.8	12
1984	289.7	527.5	156.1	169.9	26.3	.3	75.9	.0	161.2	11
1985	132.3	68.9	81.6	56.8	159.3	9.7	16.9	64.3	119.0	4
1986	199.9	17.2	148.7	122.7	110.0	.0	9.0	10.1	22.3	24
1987	49.7	.0	22.9	159.2	112.1	.0	.0	4.3	143.3	42
1988	14.8	41.7	16.0	302.5	24.2	7.1	86.7	67.1	88.8	8
1989	35.5	.0	22.2	54.9	65.8	59.1	146.5	7.8	102.3	24
1990	208.9	6.3	185.1	58.2	180.1	.0	.2	78.1	49.0	27
1991	59.5	15.0	74.3	153.8	145.3	49.7	17.9	3.3	32.2	21
1992	10.1	.0	.0	168.3	81.0	20.0	33.1	12.3	60.0	14
1993	13.1	1.4	52.8	150.1	74.7	1.3	20.7	.0	2.1	40
1994	224.8	226.2	23.5	156.6	27.1	.1	5.9	.1	62.8	39
1995	114.1	10.7	5.9	194.0	77.9	1.7	.3	.9	-9.9M	20

Fig.2. Past 30 years of rainfall data in Anuradhapura Station

Using Microsoft Excel 2010, first we have taken total amount of rainfall data for past 30 years separately for each station. In order to do that we have considered October to march as ‘MAHA Season’ and May to September as ‘YALA Season’. From above total rainfall data for above 4 stations we have taken average rainfall data to represent the Anuradhapura district separately for each season.

ARD = (TORF_S1+ TORF S_n..etc) / No of Stations (1)

Where;
ARD is Average rainfall data for each season
TORF is Total rainfall
S_n is Each Station

- Extreme Rainfall Events

An extreme event is commonly called as existence of assumed ‘normal’ state. This assumption of normal state is defined from a temporal series of observed conditions. Also extreme event can be defined in terms of deviation from mean with low frequency of event happening. The definition given by IPCC for extreme events of meteorological conditions is as follows:

“Extreme weather event is an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile.” (IPCC,2001).

A deviation from the general pattern becomes an anomaly when the event is largely outside the general pattern of variation. In case the anomaly is rare, i.e. when the frequency of the event occurring is in the 10th or 90th percentile (IPCC, 2001) the event is classified as extreme.

- Thresholds(Minimum/Maximum)

The threshold criterion records the incidence of a defined event occurring over a set period. It does not as such record the number of occurrences of a threshold value being exceeded. While limited in the interpretation thresholds are easily understood and undemanding for processing requirements.

Microsoft Excel 2010 was used to calculate percentile values and 10^{th} percentile value set as minimum and 90^{th} percentile values set as maximum. Based on the calculated percentile values extreme events were identified. All the events above the 90th percentile value considered as 'FLOOD' and all the events below the 10th percentile value considered as 'DROUGHT' and all other events are considers as 'NORMAL'.

b) Suggest alternative crop solution

The purpose of developing of this algorithm was to recover famer's loss up to some limit after disaster happened. Several factors were considered in order to provide alternative crop solution. Remaining time period for harvest, cultivated season and disaster type are the main factors that we considered. In our project we did not suggest any alternative crop solution if there is only one month remaining for harvesting. If the remaining time period>1 month and according to other factors (Season/ disaster type) that user entered our system will provide suitable alternative crop solutions.

5.5. Market Threats

The purpose of this section is to provide the User with alternative solution crop combinations if there is a market threat, so that at least the cultivator can cover up the loss. If there is a huge deviation in the current and estimated profits, the alternative solution algorithm will provide the cultivator with other crop combinations and suggestions which the cultivator can take into note.

- Alternative Solution Algorithm

Alternative solutions will be provided if there is a huge difference in the market prices from the time the cultivator started cultivating to the current time.

The algorithm will take into account mainly, the remaining time for the current cultivated crops harvest and will provide crops or crop combinations that will provide the farmer with the highest profit within the remaining time period which was calculated with reference to the current cultivated crops.

- Calculations

Other algorithms provide the cultivator to calculate details regarding crop cultivations according to the input he can provide. For example, by entering a desired cost, the cultivator can get details regarding the profit and amount of land area he should cultivate in as well as other details. The cultivator also has the option of entering a desired profit and getting the cost and amount of land area he needs to cultivate in in-order to get the desired profit that was input.

6. RESULTS AND ANALYSIS

To have the optimum results the Cultivation Process Facilitator should apply for the actual cultivation field in a suitable season. These field application results may take from 4 months to 6 months. Still we did not apply this project to the actual cultivation field and we hope apply this in next season.

There for we selected the some other way of evaluating results rather than applying to the actual fields. So we selected some parts of our project such as SIWR mapping, and fertilizer phase and collaborate with some experts in the field we compared the obtained results from the cultivation process facilitator against the manually mapped results.

Table 1: Results Table

Tested Unit	No of tested cases	No of Successful cases	No of failure cases	Percentage of success
SIWR	10	10	0	100%
SIWR scheduling	10	10	0	90%
Fertilizer Scheduling	10	10	0	100%
Market threats	10	10	0	100%

7. CONCLUSION

To obtain the final conclusion of the entire project we need to wait until the actual field results are obtained. Until there we can conclude the each phase like this,

- To have the maximum profit from the crop selection phase we need to have much more no of suitable crops rather than having only five crops.
- Fertilizer and pesticides phase, Market threat phase as well as water scheduling phase can be apply for any seasonal crop or crop combination independent of no of crops used in.

- As the crop disaster phase is little bit complex need to do a further research to how to manage the disasters in well-defined manner.

When we talking about the crops that we have selected for our research were not the best crops for the dry zone. Rather than paying attention to the best crops for dry zone we had pay our attention to the crops needed same conditions.

However we did able to success each part of the project, which did provide most accurate results for any seasonal crop or crop combination independent of selected available crops.

Some phases of project such as water resource management phase and Fertilizer and pesticides phase can be applied for any seasonal crop or crop combination independent from the conditions of the cultivation field.

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