Agro-Finance System

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Abstract - **Sri Lanka is mainly considered as anagriculture based country, yet the contribution from agriculture to the Gross Domestic Production (GDP)is very low at present. Nevertheless a larger portion of the Sri Lankan labor force is absorbed into agriculture sector. This clearly highlights that there is an issue in productivity in the agriculture sector and this has to be addressed immediately. One major factor that contributes to low productivity is due to lack of knowledge in identifying the most suitable crops to grow in a particular area. This project adopts a Multi – Agent based approach to get information on cultivation and productivity and Neural Network based approach to improve the financial level of farmers. The system is capable of predicting the cost of production as well as the expected price for a selected crop from the productivity enhancement module. The low values of root means square for the difference between the actual price and the predicted price indicate the high accuracy of the system.**

1. Introduction

In Sri Lanka the economy depends to a large extent on agriculture production. The country is predominantly an agriculture based country and agriculture plays a dominant role in the economy in terms of food security, value addition, employment generation and export earnings. The total useable land area is about 1.887 million hectares and out of that about 1.0 million hectares is under permanent plantation crops mainly tea, rubber and coconut. Seasonal crops such as paddy, maize, sugar cane, green gram, vegetables, finger millets cover about 0.887 million hectares. According to 2011 annual report of Central Bank of Sri Lanka agriculture sector in Sri Lanka employs 32.7% of the total labor force of the country in 2010 and 32.9% of the total labor force of the country in 2011.Yet the contribution to the Gross Domestic Production (GDP) is 11.9% in 2010 and 11.2% in 2011. Above statistics shows that engagement of labor force slightly increased and GDP contribution has slightly decreased in the year 2011 compared to 2010. These statistics shows huge amount of labor force engaged in the agriculture sector, but contribution to the GDP is comparably very low. Another considerable factor is that a large amount of the agriculture labor force belongs to rural areas yet they still suffer with poverty withl ow living conditions. Rural poverty in Sri Lanka accounts for 82% of the poor (Department of Census and Statistics, 2008) in the country, with the majority engaged in some form of agriculture. Small farmers in Sri Lanka are unable to engage effectively in agricultural markets which are prone to inefficiencies. The high seasonal, inter and intra-day price volatilities have meant that farmers are unable to plan the type, volume and timing of crop harvest and cultivations to reflect demand conditions.

Another set of major problems that Sri Lankan agricultural community meet are lack of investors, financial support to start and maintain their productivity, transportation, storage and customer interactivity etc. At present dissemination of information and knowledge pertaining to agriculture sector is at a very low level. Because of this reason currently most of the farmers waste their money and crops annually. Currently there are many issues involved in cost of cultivation / production. These costs can be reduced or minimized by introducing an efficient, easy to use method which will give information about all process of production stages to selling process. This will lead to eliminate unnecessary cost of cultivation and will lead to efficient and effective use of resources. Providing correct and timely information to farmers can make them aware of how to enhance the level of productivity to gain a considerable market value to their product.

The proposed approach in this project is mainly divided into two phases. The first phase gives a solution to enhance the productivity of cultivation. The second phase addresses the financial level of the farmers by giving information on production cost and possible market value for their cultivation. Given all these facts the farmer can make a decision on whether to proceed with the selected crop or not.

The productivity enhancement unit is a Multi – Agent based approach where it identifies the best crop to cultivate in a given area. The financial improvement unit adopts a neural Network based approach to give production cost and future market states for the relevant crop.

The rest of the paper is organized as follows. Section 2 gives an overview of existing approaches for similar problems. Section 3 discusses the overview of the design. Section 4 discusses the multi – agent approach to address lack of productivity. Section 5 discusses neural network based approach to financial improvement. Section 6 describes evaluation of the system. Section 7 describes the conclusion of the solution.

2. Existing Approaches

The literature review looks at existing systems in two angles mainly which are developed to provide information on productivity enhancement and on financial improvement.

The study of Premachandra and Ratnayake (2008) propose a knowledge-based approach to land evaluation for the selection of suitable agricultural crops - Crop Advisor. "Crop Advisor" is a Knowledge-based Decision Support System (KBSS) for crop selection. The expert system is powered primarily by human knowledge collected from crop experts. It also considers economic feasibility of raising a crop by taking market price, cost of production, and access to market and yield levels. After consultation with the farmer the system finally suggests a suitable agricultural crop that can be grown in a land unit.

The study by Sami, Habib, Ali (2005), describes grand schemes of a model to be used in an agriculture decision support system. The need of using a combined approach of Multi – Agent System and Constraint programming paradigms is highlighted in this paper. Hence the approach taken is Constraint Programming and Multi-Agent System mixing based on controller agent concept. This system models and simulate the interaction between different actors in the whole process such as negotiations between consumers and water suppliers, and to model decision making process, like the criteria and strategy of water allocation that are used by water suppliers.

Web Based Agricultural Wikipedia and e-Learning System is a project maintained by Audio Visual Centre, Department of Agriculture, Gannoruwa which is a web based Wikipedia and a web based e-learning system (http://www.goviya.lk) developed to facilitate farmer training. The Agricultural Wikipedia contains specific information related to all major local crops and is enriched with audio, video and flash animation. This content will be further developed and expanded with knowledge and information added, edited, changed or deleted on a continuous basis. It is expected that with time it will be developed into a comprehensive compilation of agricultural and agriculture related information.

Nava Goviya is a project carried out by CIC Agrochemicals Ltd[16]. This project focuses on 5 districts – Anuradhapura, Matale, Badulla, Moneragala and Kandy. It seeks to improve agricultural productivity and product quality through a modern online agriculture knowledge learning portal and is developed both in Sinhala and Tamil Languages. This portal carries a comprehensive knowledgebase on different aspects of farming such as pests and fertilizer control, farming management, harvesting, post-harvest technologies, food processing and even on development of farming business skills like market reach, banking and commodity exporting.

MAS are asset of agents which perform communication, coordination and negotiation between each other in order to achieve a common goal. In MAS systems the interactions among agents are autonomous and therefore user intervention is not required for agents to communicate or to carry tasks. MAS provide a coordination mechanism for agents to work towards a common goal.

There are several systems designed to improve financial level of farmers. One of the similar systems in Sri Lanka is Dialoag TradeNet(Dialog TradeNet, 2011). Dialog Tradenet is an innovative solution to overcome information asymmetry in the market, especially for communities at the bottom of the economic pyramid. It provides a multi-model information platform in all three languages Sinhala, Tamil and English and a virtual marketplace - that enables dynamic matching of buyers and sellers. In addition it provides reference prices on demand. Once potential buyers and sellers are matched, the communication is allowed to carry through in different media such as SMS, Voice, USSD and Web.

Another web based system in india is www.agriculturalpriceprediction.com. This website publishes the predicted price data (agricultural price forecasting) of Agricultural commodities for the state of Karnataka in India. Itis using the data provided by AGMARKNET.NIC.IN http://agmarknet.nic.in as a reference source to predict the future prices of Agricultural commodities. Currently, it publishes predictions for two (2) months for thirteen commodities. Agriculture sector involves an immense knowledge contributing from different areas such as environmental conditions, knowledge about pesticides, soil conditions etc. Dissanayake and Karunananda in year 2010have deveopled a multi agent system where the agents contain the domain knowledge of various aspects related to agriculture [28]. When pose a problem these agents are capable to communicate and negotiate with each other and come up with a reasonable answer as humans do. The prototype system was build to answer questions for growing green chillie.

The above reviewed systems mainly provide information stored in databases as per user requirements. Therefore those systems lack the ability of considering current changes and lack the ability of future predictions.

3. Design of the System

As stated earlier the productivity enhancement module and the financial improvement module are implemented as two separate modules of the system.

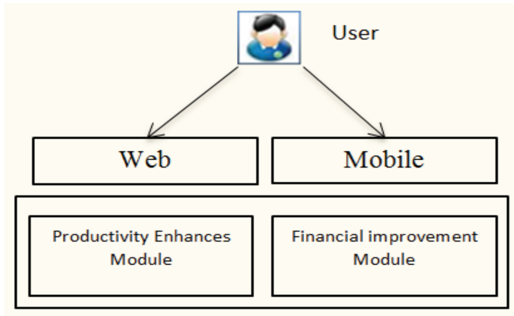

Figure1: Overview of the system

Figure 1 shows overview of the design. The productivity enhancement module and the financial improvement module connect the user through a web application and a mobile application. The productivity enhancement module is designedusing agent technology and providesinformation to select the best crop for cultivation. The financial module developed using a neural network gives the cost associated with the selected crop. Since the farmer is equipped with the knowledge of the suitable crop for cultivation, steps that should follow to get the maximum harvest, cost and profit to relevant crop, the farmer can make a better decision on the path he has to follow.

A. *Productivity EnhancementModule*

The productivity enhancement is mainlydivided into five stages as shown in figure 2.

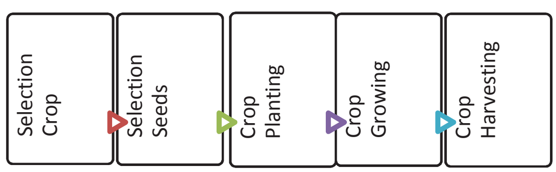

Figure2: Process of Productivity Enhancement Module

The first stage is the Selection of themost suitable Crop for cultivation according to given environment conditions by the farmer. The second stage is Selection of Seeds which identifies the most suitable type of seed for the selected crop type in stage1.Third stage is Crop planting. This stage gives information about methods of planting techniques and method of using Land for crops. Fourth stage is about Crop Growing which provides details about what type of fertilizer to use, fertilizer plan, controlling techniques and management of pest and diseases. Fifth stage is Crop Harvesting, which provides information about techniques and details of harvesting and storage techniques.

Productivity enhancement module goes through the overall process of agriculture providing accurate, timely and actionable decision making information right from selecting a crop to growing and to harvesting. To achieve this goal this module is being created using multi agent technology. Multi – agent system (MAS) is used in this project to handle the complexity of handling information in a parallel manner.

B. *Financial Improvement Module*

This Financial Improvement Module is designed to predict production cost, future market vlaues and climate condition such as rainfall for a selected crop from the productivity enhancement module.

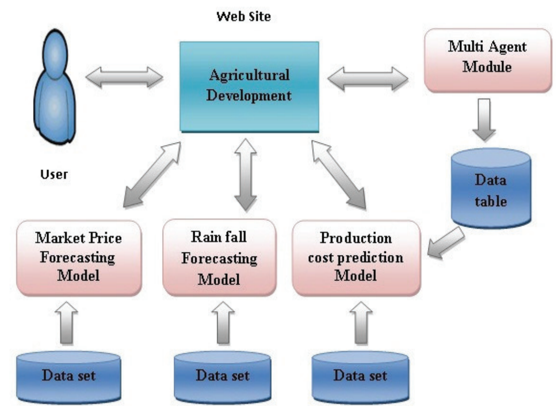

Figure3: Financial Improvement Module

There are three main models in this module.

a. Market Price Prediction Model
b. Rainfall Prediction Model
c. Production Cost Prediction Model

The goal of this module is to provide predicted future market prices and rainfall values from which farmers can know how the prices will change in the future. By giving a predicted production cost farmers can take decisions to choose which crop to cultivate and how much cost will have to bear. This prediction will give an opportunity to the farmer to take an intelligent decision with respect to financial situations in cultivating a particular product.

C. *User Interaction*

User can interact with the system mainly through the web application. User does not need to log-into the system to access the service. Hence the system is open to any farmer who needs information with regard to production enhancement and financial improvement.

4. Multi–Agent Based Productivity Enhancement Module

Productivity enhancement module mainly consists of three layers as shown in Figure 4.
The layers are User Application Layer, Communication Layer and Multi agent Layer. Multi – agent layer consist of agent swarms and ontologies. These agent swarms work along with ontologies to provide decisions to farmers and the generated decisions are send back to the user through the communication layer.

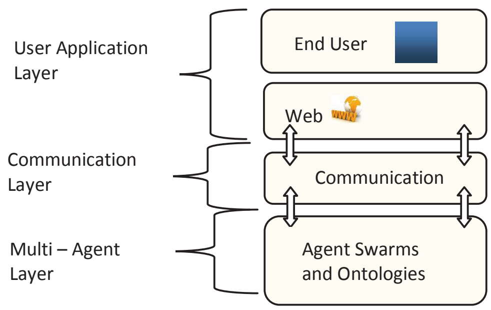

Figure4: Layers of productivity enhancement module

One role performed by the communication layer is transferring information to the user application layer coming from multi–agent layer. The other role is, passing the user request to the multi–agent layer coming from user application layer. User application layer consist of web applications and allow users to interact with the system more easily.

An intelligent behavior is added to the productivity enhancement module through agent swarms. Ontology provides the foundation intelligence for behavior of agent swarms. This module contains six resource agent swarms and one Admin agent swarm.

Figure 5shows top level architecture of productivity enhancement module. User requests are taken to the system using web application and are send to central agents swarm. Admin agents swarm keep user request in the central message space. Then other six resource agents check whether the request belongs to them or not. If request belongs to one of the resource agent swarm then accept it and process it and after the work is done the result is send back to the central message space. Then that result accepts from admin agents swarm sends it to the web service. After that web service send the result set to the web application and the output is given to the user. The results are saved in the database attached with the web application.

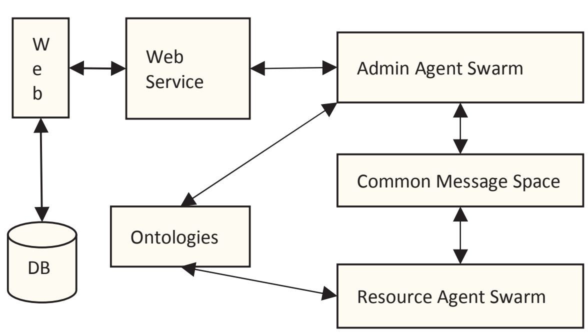

Figure5: Productivity Enhancement Module

Admin Agent Swarm contains four agents. One agent in the swarm administrates the admin agent swarm. This agent creates all other agents when system initializes. Another agent in this swarm handles the communication between admin agent swarm and resource agent swarm. Other two agents handle web service request coming into the productivity enhancement module and responses sends by productivity enhancement module. Common message space is the hub for communication between Admin Agent swarm and Resource Agents swarms. All agent swarms are able to write messages to the central message space hence other agent swarms are able to respond to those messages.

There are six resource agent swarms available in this system namely, Crop Agent Swarm, Seed Agent Swarm, Plant Agent Swarm, Grow Agent Swarm and Harvest Agent Swarm. Figure 6 shows Resource agent swarm architecture. It contains request agent, central admin agent, and set of end point agents, message space and specific ontology for a given knowledge base to the swarm. Response to the request agent's message is written on the central message space. The response from central admin agent is send to the swarm message space. After message is written to swarm message space, end point agents access it and respond to it. Central Admin Agent negotiate with the set result and send correct result out from the swarm using request agent which writes on the central message space. End point agents exit from the system at the end of their job.

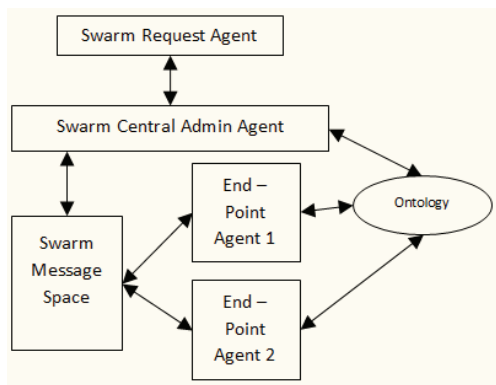

Figure6: Resource Agents Swarm Architecture

All six resource agents swarm contain their own ontology which is used to store the knowledge required for the execution of agents and to enable interaction among each other. The six ontologies identified from the productivity enhancement module contain strong domain knowledge related to agriculture. In addition to the six resource agent swarm ontologies the AgriInfo main ontology module too is included here. This ontology work with Central Admin agent swarm and it contains all the knowledge required to process the system.

If user request to identify the most suitable crop for a given environment that request is placed on the central message space. Then crop agent swarm access that request through request agent in the swarm. After it takes from the central admin agent and send it to the message space. When request comes to the resource swarm End point agents are created and access the message space. Crop ontology used to gain domain

knowledge to process the required action to the end point agents. After each agent finish their work send the result to the swarm message space and central admin negotiate with results. Final outcome sends to the central message space through the request agent.
All the decisions taken by farmer are stored in the Database attached with web application. The financial improvement module can access those data for further processing of the system.

A. Implementation

Productivity enhancement module is implemented using Multi Agent based technology. Agents swarms are created using JADE framework which compiles with FIPA standards. The overall multi agent layer developed using J2SE platform. Protégé framework was used to model the ontology with the necessary knowledge regarding different domains of agriculture. Communication layer created following SOAP web service. User application layer is designed using .NET framework 4 and ASP.NET. To create user application layer database used SQL Server 2008 R2.

5. Neural Network Based Financial Improvement Module

Second module of this system is financial improvement module which is a Neural Network based approach and it predicts production cost,future market values and future rainfall values for relevant crops.

A. Market Price Prediction Model (MPP model)

The Market Price prediction model includes a feed forward multilayer neural network which predicts the market prices for selected crops. A data set is inserted to train the neural network which consists of all island retail prices of the selected cropson daily/weekly/monthly basis for the last five years. These data are then normalized and preprocessed to prepare them for the model building process to achieve an efficient and effective forecasting process.
For each crop, a separate data set is prepared and used to predict the market price of that crop. For all the selected crops each input data set includes;

- Week/Day/Month of the Year
- Price

The first column (day/week/month of the year) is selected as the input and second column (market price) is selected as the output and as the value to be predicted.

B. Rainfall Prediction Model (RP model)

The rainfall data are collected on daily/weekly/monthly basis for the past five years and they are used to predict future values. This also includes a feed forward multilayer neural network.
Separate datasets consisting of daily/weekly/monthly rainfall data are used as inputs and each input dataset includes,

- Week/Day/Month of the Year
- Rainfall

Same method which is used to forecast market price is applied here to forecast the upcoming rainfall values.

C. Production Cost Prediction Model(PCP model)

This model also includes a feed forward multilayer neural network which predicts the production costs for the entries output by the Multi agent module. These entries include data on crop type, seed type, land size, planting technique, type of fertilizer and harvesting technique. These data are stored in a data table which is accessed by the Production cost prediction Model.

Table1. Data set to train PCP model

Input						Output
1	**2**	**3**	**4**	**..**	**10**	11
65.48	**68.72**	**70.26**	**71.25**	**..**	**100.26**	?
68.72	**70.26**	**71.25**	**75.83**	**..**	**98.36**	?

A separate data set is inserted to train the neural network which consists of data such as crop type, seed type, land size, planting technique, type of fertilizer and harvesting technique and production cost. The last column is used as the output and all the other columns are used as the inputs to the neural network. These data are collected from the Department of Agriculture. The data stored in the table which are taken out from the multi-agent module, are used to do the predictions.

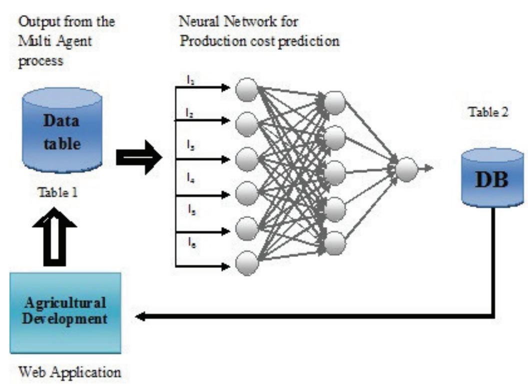

Figure7: Overview of Production cost prediction Model

The method used for market price and rainfall prediction is called windowing. The basic idea is that data set is divided into two windows (groups) of fixed sizes which contain input data and target data. The data in the input window is inserted to the neural network as inputs and the data in the target window is used as the output value. The value in the output window is used to compare with the predicted value of the neural network and then the neural network is further trained to reduce the minimum difference between the predicted value and the actual output value. This process of training is carried out step by step shifting both input and target windows down along the data set while reducing the difference.

Table2. Data input method for Price Prediction

Crop Type	Seed Type	Planting	Land size	Fertilizer type	Harvesting	Production cost
Tomato	11S	1PT	4.5	11F	11H	70,000
Potato	21S	1PT	6	21F	12H	86,000
Onion	32S	3PT	4	31F	11H	64,000

A window of 10inputs (10 consecutive prices) is fed to the neural network and the network will try to predict the 11^{th} value, corresponding to the next week in the row, of each of the crop.

D. Training

Training is the process of adjusting weights and threshold values of a neural network to get the desirable outputs. The training method used here is the Resilient Propagation training. The resilient propagation training (RPROP) algorithm is usually one of the most efficient training algorithms provided for supervised feed forward neural networks. One particular advantage to the RPROP algorithm is that it requires no setting of parameters before using it.There are no learning rates, momentum values or update constants that need to be determined. This is one of the best methods because it can be difficult to determine the exact learning rate that might be optimal.

E. Data Normalization

To get the best performance from the Neural Network each input variable should be preprocessed and normalized so that themean value, averaged over the entire training set, is close to zero, or else it is small compared to its standard deviation. The ranges of the indexes vary slightly, as their domain is totally different. The purpose of normalization is to modify the output levels to a reasonable value. Without such transformation, the value of the output may be too large for the network to handle, especially when several layers of nodes in the NN are involved.

A transformation can occur at the output of each node, or it can be performed at the final output of the network. In normalization original values are mapped to a smaller range of value set (-1, 1 or 0, 1).In order to normalize each index range to [0, 1], the following simple formula is used:

$$\text{Price}(x) = (P_x - P_{Min}) / (P_{Max} - P_{Min}) \quad (1)$$

Price(x) = New value after scale
Px = Actual value before scale
P_{Max} = Maximum value
P_{Min} = Minimum value

Thus each of the input variables will lie in the same range (0, 1).

F. Selection of Optimum Neural Network

Several techniques were used to implement the program and to improve the forecasting performance of the neural network. Initially, Group of neural networks is created having different combination of hidden layer processing units and learning rates. Finally the neural network which has a higher performance of forecasting according to the performance function is selected.

Neural network training algorithm was designed to train the neural network and the same time simulate the neural network with testing data set and calculate the root mean square(RMSE) error using two value sets simulate output vector and target actual data vector. The training error is used to select the best suitable network by getting the error value for given number of iterations.

Error = ideal value – actual value(2)

RMSE = (ideal value – actual value) / Set size(3)

This evaluation was done for all neural networks. Then the neural network structure having optimum forecasting performance was selected based on the RMSE value.

6. Evaluation

Several testing methods were used to evaluate the productivity enhancement module. At the development level each module was subjected to unit testing and integration to ensure proper functionality of the module. After integrating the individual modules the entire system was subjected to system testing. Evaluation has been done in terms of accuracy of processing and final decision respect to different information types using questionnaires where agriculture field experts participated in the evaluation process.

Agent Module	Output Decisions	Accuracy
Selection Crop	100%	88%
Selection Seed	98%	85%
Crop Planting	95%	83%
Crop Growing	96%	80%
Crop Harvesting	94%	76%

Table3: accuracy level of productivity enhancement module

According to above evaluation results it is evident that the productivity enhancement module has a high accuracy.

System has been tested on real data: daily vegetable market prices are collected for the period 01/01/2007 to 15/03/2012. There are 250 data points without any null values.

Data from 01-01-2007 to 22-12-2011 were used as the training set and from 01-01-2012 to 08-03-2012 period was used for testing purposes. Following table displays the predicted prices for the potato crop.

Table 4: Predicted results for potato

Date	Actual Price	Predicted Price	RMS Error
2012-01-01	127.33	127.62	0.0038
2012-01-08	128.5	128.42	0.0011
2012-01-15	124.17	124.29	0.0016
2012-01-22	136.5	136.23	0.0036
2012-02-01	130.43	130.37	0.0007
2012-02-08	122.61	122.67	0.0008
2012-02-15	116.84	116.85	0.0002
2012-02-22	114.5	117.16	0.0347

As seen in the above table, for a given date/week the predicted price is calculated and the rms error between the actual price and the predicted price is also calculated.

7. Conclusion

The proposed system includes two main modules,productivity enhancement module and the financial improvement module.The productivity enhancement module is capable of identifying the most suitable crop to grow in a given land area. The evaluation shows that the system is capable of predicting the crop type with a high accuracy. Due to very low RMS error it is evident that the prices predicted are comparable with the actual values. Therefore we can conclude that with the implementation of this AgroFinance system we have been able to address the problem in the gap of making an intelligent decision on the type of the crop to grow based on financial situation.

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