Decision Support System for Enhancing Upcountry Vegetable Cultivation in Sri Lanka

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Abstract - Sri Lanka is one of the developing countries in South-Asian region where Agriculture remains the mainstay of economy and approximately 33% of the total labor force is engaged in Agriculture. Therefore it is very important to analyze the agricultural information for the purpose of formulating policies and also enhancing the knowledge of farmers to encourage them to be in the Agriculture. In this context, production, price fluctuations, forecasting, seasonal indices and the factors which could affect for these variables are highly important. In this research project, an attempt was made to develop a web-based decision support system, which can be used for effective decision making on expected harvest of selected crops with the utilization of lands, according to Agro-ecological measures and demographic characteristics and also on seasonal indices and time series forecasting to educate farmers, consumers and other interested parties as well. The seasonal indices and most appropriate price forecasting trend lines were generated by considering monthly prices for a period of 2001 to 2010.

Keywords:- Decision, Management Information system & Support system.

I. INTRODUCTION

As other South-Asian countries, Sri Lanka is also essentially an agrarian society and basically depends on agricultural outputs and also had long history, which says that Sri Lanka had sponsored a lot for local Agricultural system. Since the, Agriculture is the most important sector of the economy. It is therefore essentially that the technology thrust should lay greater emphasis on the transfer of scientific and technological information from the sources of information to its actual users. Even though agricultural contribution to the gross domestic product declined substantially during the past two decades particularly from 23 percent in 1990 to 11 percent by 2011, it's the most important source of employment for the majority of the Sri Lankan workforce [1]. Sri Lanka's main goal is to achieve an equitable sustainable agricultural development through expansion and dissemination of improved agricultural technology.

In this context, information related to Agriculture is so important for development of this sector. This data is vital for any policy matter being implemented in the country. The surveys related to agriculture information are conducted at different locations and levels by many researchers, government and non-government institutions. Department of census and statistics and central bank of Sri Lanka run the major role by collecting huge volume of information annually. Institutions under ministry of Agriculture and ministry of plantation also collect data from research, extension, seed and planting material, soil conservation, registration of agro chemicals etc. Extent, production, cost of production, consumption and prices of food crops are major attributes that are concerned by the government for their policies.

Imports and exports information are also another important sector for Policy making. The objectives of all above surveys are to implement policy matters for the increase of life styles of people in the country. The government vision for the Agriculture sector is "*An agriculture sector contributing to regularly equitable economic growth, rural livelihood development, and food security through efficient production of commodities for consumption for agro-based industries and for exporting competitively to the world market*" [2].

Therefore it is very important that those, interest for agricultural information should have a quick access to and free exchange of information at local and national levels. Among the interests for this information, policy makers, researchers, planners, undergraduates, farmers and individuals are the major stake holders. Many government bodies coming under different ministries primarily collect, store and disseminate such information by their publications as well as through their web sites.

In this context extent cultivated, production, per capita consumption, annual requirement and prices of vegetable crops run major role in the economy. This project mainly concerned production and prices of upcountry vegetables, particularly Beans, Carrot, Cabbage and Potatoes were selected. The areas where upcountry vegetables have been cultivated, fall into different agro-ecological zones varying from rain falls, elevation, land type, height of the top soil,

slope of the land, soil erosion etc. The districts such as Matale, Kandy, Nuwara-eliya and Badulla were considered as major growing areas and therefore all the measures were taken from these areas. By observing last decade, it can be reviewed that extent cultivated, however has been increased slightly.

II. RELATED WORK

Vegetables are the best resource for overcoming micronutrient deficiencies and provide small holder farmers with much higher income and more jobs per hectare than staple crops. The global production of vegetables has doubled over the past quarter century and the value of global trade in vegetables now exceeds that of cereals. Amongst vegetable crops, tomatoes are the most important horticultural crop worldwide and grown on over 4 million hectares of land area [4]. Vegetables are generally sensitive to environmental limits, and therefore high temperatures and limited soil moisture are the major causes of low yields and will be further magnified by climate change, since a significant change in climate on a global scale will impact agriculture and consequently affect the world's food supply. Climate changes will influence the severity of environmental stress imposed on vegetable crops. Moreover, rising temperatures, reduced irrigation water availability, salinity and flooding will be major limiting factors in sustaining and increasing vegetable productivity. Extreme climate conditions will also negatively impact soil fertility and increase soil erosion. The text taken from two related studies [5] and [6] was summarized and given below.

High temperature

Temperature limits the production of many crops. High temperature stress disrupts the biochemical reactions fundamental for normal cell function in plants. It affects the photosynthetic functions of higher plants.

Drought

Unpredictable drought is the single most important factor affecting world food productivity. Water availability is also expected to be highly sensitive to climate change and severe water stress conditions will affect crop productivity. Inefficient water distribution systems further decreases water availability. Thus water greatly influences the yield and quality of vegetables; drought conditions drastically decrease vegetable productivity. Drought stress causes an raise of solute concentration in the environment, important to an osmotic flow of water out of plant cells.

Salinity

Vegetable production is threatened by increasing soil salinity particularly in irrigated croplands which provide 40% of the world's food [4]. Excessive soil salinity reduces productivity of many vegetable crops. Salinity also affects agriculture in coastal regions which are impacted by low-quality and high-saline irrigation water due to contamination of the ground water and intrusion of saline water due to natural or man-made events.

Flooding

Most vegetables are highly sensitive to flooding and genetic variation with respect to this character is limited. In general, damage to vegetable by flooding is due to the reduction of oxygen in the root zone which inhibits aerobic processes.

Adaptation to climate change

Potential impacts of climate change on agricultural production will depend not only on climate, but also on the internal dynamics of agricultural schemes, including their capacity to adapt to the changes [4]. Farmers in developing countries need tools to adapt and mitigate the adverse effects of climate change on agricultural productivity, and mainly on vegetable production, quality. Current and new technologies being developed through plant stress physiology research can potentially contribute to mitigate threats from climate change on vegetable production.

Enhancing vegetable production system

Currently technologies being developed to alleviate production challenges such as limited irrigation water and flooding to mitigate the effects of salinity, and also to make sure appropriate availability of nutrients to the plants. Strategies include modifying fertilizer application to enhance nutrient availability to plants, direct delivery of water to roots and use of soil amendments to improve soil fertility and enhance nutrient uptake by plants.

Water saving irrigation management

The quality and efficiency of water management determine the yield and quality of vegetable products. The best possible frequency and amount of applied water is a function of climate and weather conditions, crops species,

variety, stage of growth and rooting characteristics, soil water retention capacity. Too much or too little water causes abnormal plant growth.

Cultural practices

Various crop management practices such as mulching and the use of shelters and raised beds help to conserve moisture, prevent soil degradation, and protect vegetables from high temperatures, heavy rains, and flooding. The use of organic and inorganic mulches is common in high-value vegetable production systems. These protective coverings help reduce evaporation, moderate soil temperature, reduce soil runoff and erosion.

Prioritizing Vegetable investigation to address impact of climate change

It is unlikely that a single method to overcome the effects of environmental stress on vegetables will be found. A systems approach, where all available options are considered in an integrated manner, will be the most effective and ultimately the most sustainable, particularly for developing countries. The World Vegetable Center, as the world's leading international center focused on vegetable research and growth, has expanded its research to further address the potential challenges posed by climate change.

Exploitation of Genetic Diversity

One way to increase vegetable production is considerable diversity of vegetable crops. However, the existence of a lot of diversity in vegetables would require extensive utilization in the varietals development programs.

Increasing Area in improved varieties/Hybrids

Shifting from locally available varieties to improved high yielding and disease resistant hybrids varieties is another way to increase vegetable production. Hybrids are well known for increasing vegetable production due to its high yield potential, quality, earliness and resistance attributes. During the resent past, tremendous progress has been made to develop hybrid varieties in a number of vegetable crops. However hybrids are susceptible to numerous diseases and pests. Hybrids resistant with multiple diseases and pests are being developed in vegetables like tomatoes, brinjal, chilies and carrot. Currently some progress has been made in developing varieties resistant to diseases. The progress in the field of insect resistance is very limited and so far there are no commercially developed insect resistant varieties.

Vegetable nursery management

In nurseries, there is a great problem of damping off disease caused by several fungi. Thus the bacterial blight incidence in nursery has been found to reduce plant population from 12 to 56 percent. Soil and seed treatments with bio-agents are the best feasible methods for the management of soil borne diseases.

Protected cultivation

Since the protected cultivation technology is still in its preliminarily stage, concerned efforts are required from all concerned agencies to bring it at par with the global standards. The work should be canalized in finding suitable and locally available construction material for low and medium cost greenhouses. Further, economically viable and technologically feasible greenhouse technology is suggested.

Vegetable seed production

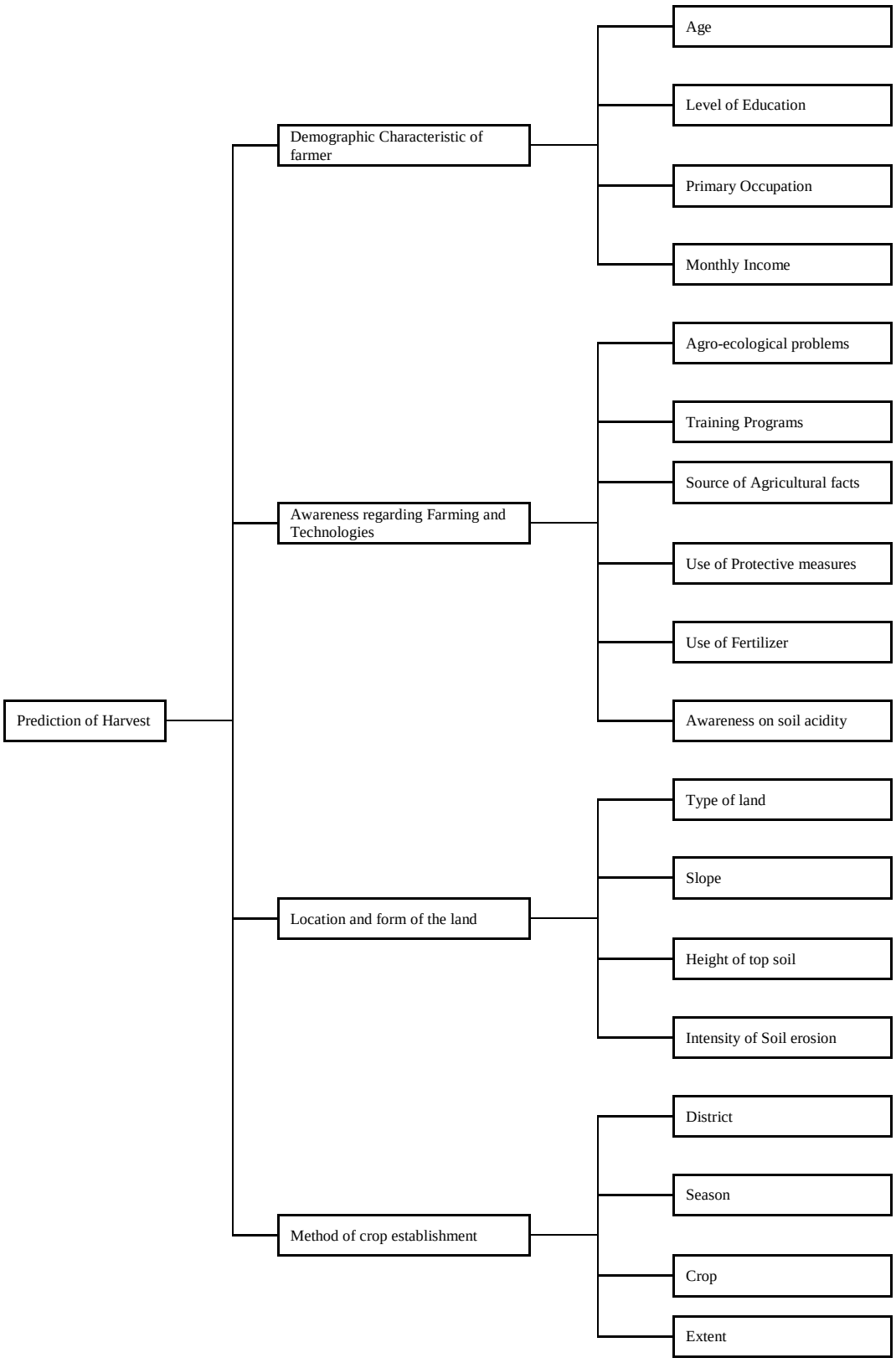
Seed production in vegetables is the limiting factor for cultivation of vegetables. The vegetables need specific temperature and other climate conditions for flowering and fruit setting. Seed production in open conditions in a rainfall environment is very difficult.

Promotion of organic cultivation

Considering the growing concern and potential global market, a need is felt in recent years to standardize and develop protocols for organic agriculture. The commonly used bulky organic manure can be used at least once in a year before monsoon crops to improve the soil physiochemical and biological properties. Farmer's community has also identified organic farming as an important tool for second green revolution in the rain fed areas in the country.

Use of insect pollinators

Low productivity in most of the vegetable crops is directly connected to use of genetically inferior varieties coupled with low input farming and incidence of insect pests and diseases. Gradual elimination of natural pollinating insects by modern agricultural practices has also increased growing dependence.



Minimizing Post harvest losses

The post harvest losses in vegetable crops vary from 21-30 percent depending upon crop and variety due to lack of required mechanization which includes suitable containers, poor packaging, commercial storage houses and transportation, organized marketing systems and procuring units. Reduction of post harvest losses can be achieved by

adoption of good pre-harvest production practices, harvesting at proper harvesting, optimum maturity, and adoption of pack house practices similar to washing, grading, sorting, packaging, transportation and storage under controlled condition of temperature under humidity.

III. SYSTEM DESIGN

Description of sample survey data

For this purpose, data from already conducted sample survey among over 200 farmers who were engaged in cultivating of upcountry vegetables; covering several Agro-ecological zones particularly in Matale, Kandy, Nuwara-Eliya and Badulla districts was gathered and stored for the purpose of prediction of expected harvest. A well-structured sample questionnaire had been used to collected primary information from farming community in the selected areas. The raw data set consists of demographic information, pattern of vegetable cultivation, land utilization, conservation of lands, farmer's knowledge regarding Agro-ecological problems, use of protection measures relating to vegetable farming, use of fertilizer, awareness on soil acidity and other cultivation methods aimed at protected farming systems and knowledge regarding environmental conservation. It was basically considered that the vegetable production could be a function of the measures coming under following broadly classified groups.

Demographic characteristics of farmers

- Awareness/Knowledge regarding farming and technologies
- Location and form the land
- Crop establishment

Throughout the entire process, with the availability, reliability and accuracy of data, a proper coding was applied to observe the variations of information. To calculate the expected harvest with the variation of different measures identified throughout the project it had been taken in the following way. It was basically considered according to the sample there were three broad categories of variables which fall into demographic characteristics of farmers, Awareness regarding farming and technologies and location and nature of the land. The figure 3.1 describes how these variables are supposed to correlate with the production. The method of crop establishment district, season and crop were taken as identification variables. The figure 3.1 shows the classification of main areas.

Description of Retail prices

Monthly retail prices of selected crops were gathered for a period of 11 years. The primary source of the data is Department of census and Statistics and secondary source is Agrarian Data bank of HARTI. The data is available for a period of eleven years commencing 2000 from which 2000 to 2009 data was considered for generating seasonal indices. A total of 132 continuous values are available for the purpose of analysis. The data has been stored in MySQL data base in the following format. The way that manipulating these data is, initially district-wise retail prices are collected and then average prices for Sri Lanka is calculated for each month. The annexure 06 contains the complete data set.

IV. DATA ANALYSIS

The existing conditions of the sample population with special focus on demographic pattern, Ageing, Level of education, Primary occupation and income of the sample household. It is further examined farmers knowledge about all farming activities, nature of the land in which selected crops were cultivated. After examined basic characteristics, then the analysis was focused to address expected harvest according to the variables identified. For this purpose, regression analysis was carried out. Retail prices were analyzed to build seasonal indices and trend lines for price forecasting purposes.

The statistical method of regression analysis includes many techniques for modeling and analyzing two or more variables in which, relationship is supposed to formulate between one dependent variable and two or more independent variables as per the assumption. More specifically, regression analysis helps to observe how the value of dependent variable changes when any one of independent variable changes. When the independent variables are changed, regression model estimates the average value of the dependent variable. In all cases, the estimation target is a function of the independent variables. Regression analysis is used to understand which among the independent variables are related to the dependent variable, and to enhance the forms of these relationships. A general linear model when there exits many independent variables and one dependent variable, can be written as ;

$$Y=b_1x_1+ b_2x_2+ b_3x_3+ b_4x_4+ b_5x_5+ b_6x_6+ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots b_nx_n\ldots..+E \ldots(1)$$

In the equation (1), Y is the dependent variable which has to be estimated and x_1 to x_n are independent variables and b_1 to b_n are coefficients. The E is the constant. In this Analysis back word method was used to calculate b_1 to b_n and the constant E where at the beginning all the independent variables have been considered and after removing one by one more appropriate models are produced. The best model is selected with the significance of F and t values which have been calculated throughout the process.

Sample size

In the clean data set there were 151 numbers of farmers in the sample which was distributed approximately equal basis. The table 4.1 shows distribution of farmers by districts.

Table 4.1 - Distribution of sample by districts

District	Frequency	Percent	Valid Percent	Cumulative Percent
Matale	33	21.9	21.9	21.9
Nuwara-eliya	39	25.8	25.8	47.7
Badulla	39	25.8	25.8	73.5
Kandy	40	26.5	26.5	100.0
Total	151	100.0	100.0	

Primary source : Survey data[7]

It can be further observed that some of farmers were engaged in more than one crop cultivating. In the sample 30% have reported that they had been cultivating potatoes while Beans, Carrot and Cabbage farmers are in equal basis. The table 4.2 described how these are distributed.

Table 4.2 - Distribution of sample by Crops cultivated

Crop	Frequency	Percent	Valid Percent	Cumulative Percent
Potatoes	82	30.0	30.0	30.0
Beans	64	23.4	23.4	53.5
Carrot	64	23.4	23.4	76.9
Cabbage	63	23.1	23.1	100.0
Total	273	100.0	100.0	

Primary source : Survey data[7]

Price forecasting models

The purpose of price forecasting models are to examine behavior of changing whole sale prices in the future based on past information. Same set of data used in generating seasonal indexes were used to build up forecasting models. From year 2000 to 2010 prices were used to formulate forecasting models *(Appendix E)*. Initially without considering any of independent variables which affect to change of prices, prices were graphically represented by five different models such as exponential, linear, logarithmic, and polynomial and power. The correlation coefficient R^2 was obtained for each case and then most appropriate model *(Appendix F)* was selected for each crop.

Accordingly for each crop the model with highest R^2 reported was selected for forecasting prices. Then estimated values have been calculated based on the equation derived from most appropriate model. For the examination of performance; prices in 2011 year have been compared with the estimated prices according to the equation.

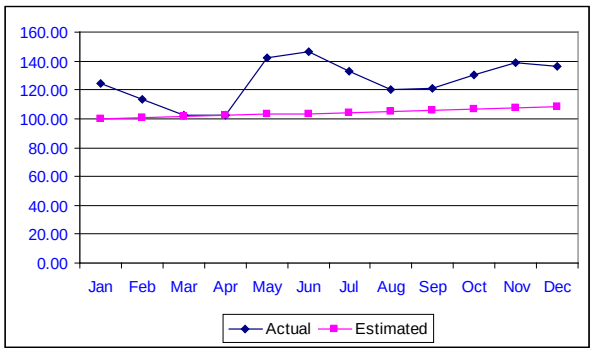


Figure 4.23 – Actual and Estimated prices of Beans in 2010.

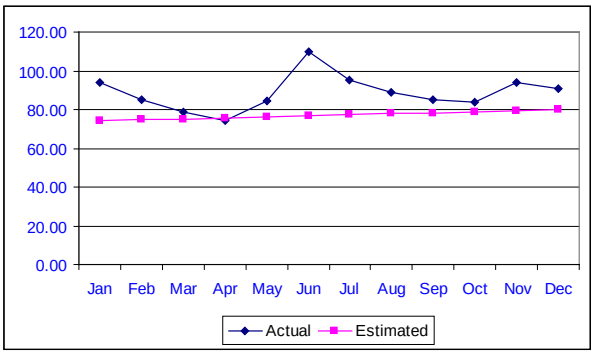


Figure 4.24 – Actual and Estimated prices of Cabbage in 2010.

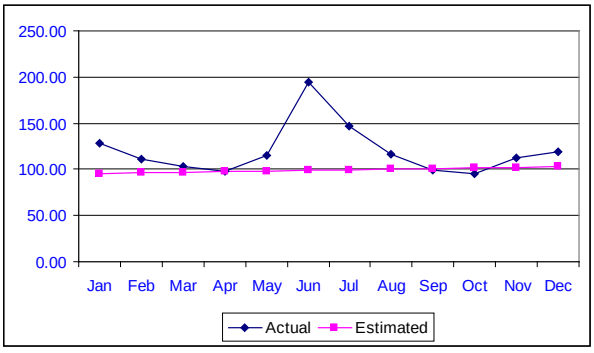


Figure 4.25 – Actual and Estimated prices of Carrot in 2010.

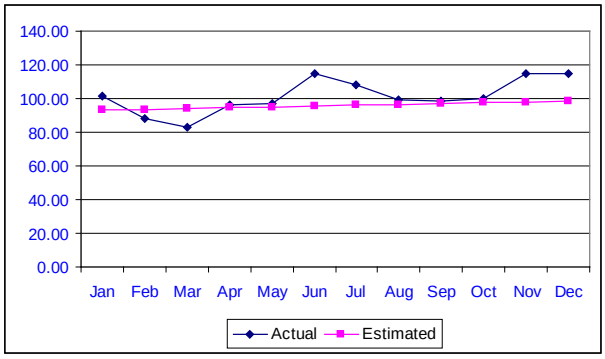


Figure 4.26 – Actual and Estimated prices of Potatoes in 2010.

V. EVALUATION

Generating of price forecasting models is another aspect of the project, since with the availability of current and past data, forecasting for the future is highly important. The web users could study the pattern of monthly price fluctuation in the past and accordingly observe the price variation that could happen in the recent future. The data, without taking into consideration of possible independent variables, was analyzed to observe the trend for the given period and by selecting most appropriate model from combination of graphs drawn through statistical software and then estimated prices for past and future were calculated accordingly. This was incorporated as awareness for users; it was not attempt to consider independent variables for the changing of prices, due to complexity of situation. However when there are sudden ups or downs in a year, estimated value is highly deviated from actual. The given below is a line chart drawn through the web site to show actual and estimated prices for potatoes, which has high deviation and it can be expected that this is because of government intervention for import of potatoes.

Figure :8.2 – price forecasting

VI. FUTURE WORK

This web-based software has been developed basically as a decision support system which could be used to enhance the up country vegetable cultivation for the satisfaction of country requirements. Similar decision support systems could be developed for the applying of other highly consumable vegetables too. Further, such systems could also be expanded by conducting sample surveys for demanded crops in relevant areas. Based on findings of this system, effectiveness of similar variables could also be carefully measured through well-organized farming practices. It can be assumed that rain falls and climate changes also important factors to be considered when cultivating of vegetables. Therefore, the systems could also implemented covering agro-ecological zones where factors like condition of soil, soil erosion and rain falls and slope of lands are highly differs.

This software basically has been developed for up country vegetable cultivation, especially for selected crops in four different districts. Since this price fluctuation and production are common to other agricultural products crops, it is so important to have such system for that cultivation too. i.e. systems should be implemented extended for other agricultural crops as future development and it will be important factor for agricultural improvement enhancement for both consumers as well as producers in the country. Further data on rainfall is also vital component for such system and those data too can be related with expected price and harvest. Forecasting data on whether is also important for farmers; such data too can be published in this web site in collaboration with Metrology Department. Then farmers can get more accurate decision

on cultivation in accordance with such data minimizing the bad impact from weather conditions.

Other area to be considered for future development is that, demand and supply with increase of population and this will obviously help to make certain decisions on certain time for balancing of economy. Another aspect of that user of fertilizer and agro-chemicals with the considering soil conditions and possibility of occurring deceases. Now more than 80 percent of small land holders apply fertilizer without considering the soil condition. But to get maximum productivity from fertilizers applied, composition of the soil should be studied and accordingly fertilizer mix should be adjusted. Facility should be added to the system to assist the farmers to determine the appropriate fertilizer quantity for highest yield.

Even though government and private organizations and many researchers have been conducting numerous studies on price variations, marketing, cost of productions and in various discipline, many problems have been created during the harvesting seasons. Furthermore in Sri Lanka there is no derivative market for any product and financial market should be upgraded and strengthen for such market. This is mainly affected to agricultural products as in other countries derivatives market is more powerful for agricultural market and benefitted to the farmers. Now discussions are going on the development of derivative market in Sri Lanka.

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