Geo information for agriculture sector in Sri Lanka

GL Dilhani[1], DDM Ranasinghe[2]

[1, 2]Department of Electrical and Computer Engineering, Faculty of Engineering, The Open University of Sri Lanka

[1]gdilhani@gmail.com, [2] ddran@ou.ac.lk ([2] correspondence author)

Abstract— *Sri Lanka is predominantly considered as agriculture based country with one third (32.9% in 2011) of the labour force working in the agriculture sector with the usage of little less than half of total available land for cultivation. Yet, the total contribution from the agriculture sector to the total Gross Domestic Product (GDP) is very low at present. According to Central Bank reports contribution from agricultural sector to GDP is 11.9% in 2010 and 11.2% in 2011. On the other hand due to the growth of the population over the years has resulted in encroachment of agricultural land for other purposes. Hence it is quite evident that there is a gap between investment, production and harvest in the agriculture sector.*

One of the major factors that contribute to this gap is unavailability of information regarding the suitable land for cultivation. Most of the farmers tend to follow their ancestors in deciding on the land selection for cultivation as well as for crop selection and have little knowledge about the land usage in surrounding areas due to non-availability of Geo-data. At present finding of Geo-data related to agricultural sector has become a challenge in Sri Lanka because there is no automated mechanism to find such information. Survey Department is the only place that provides Geo-data with few branches spread through the country. The customers have to go to one of these places physically in order to fulfil their requirement. At these places process of providing Geo-data to customers is mostly manual based which is resource consuming, time wasting and a tedious work. Further it lacks the facility for handling customized requests.

The approach presented in this paper is to provide an automated solution for generating Geo-data related to agriculture sector. GTIS System is capable of checking availability of agriculture based geographical information, clipping, converting, creating child Geo-Databases and validating the result using various Geo-tagging and image scaling techniques with a high accuracy and efficiency.

The evaluation was jointly done with the Survey Department with the intention of testing the accuracy of the generated files compared to the files that will be provided by the Survey Department on customer request. The system showed 100% accuracy of the generated geo data and about 72% of the general users said that the development of this kind of a system makes to manage their requirements catered easily. Therefore we can conclude that having knowledge about the arable lands in the area and what sort of environment exists in the surrounding will be an added measure for decision making for farmers.

Keywords— **Image scaling, Geo tagging, Clipping**

I. INTRODUCTION

Sri Lanka is well known as an agriculture based country where the main crops are tea, rubber and coconut. Apart from these export based crops paddy is the other main crop grown in Sri Lanka mainly as a domestic crop. Agriculture plays a dominant role in the economy in terms of employment generation, export earnings, food security and value addition. During the period 1977 contribution from agricultural products to total export products were around 79% (Central Bank of Sri Lanka, Annual Reports). With the introduction of the open economic policies this contribution has fallen down drastically. According to central Bank reports the contribution from agriculture sector to the GDP is at a low level. Yet the agriculture sector employs 32.9% of the total labor force. In addition according to World Bank reports 41.62% of land area is used for agriculture in 2009. With the low contribution to the GDP with a higher labor force and a land area usage clearly indicates that there is a gap between the production and the harvest. One of the major factors that contribute this gap is lack of dissemination of knowledge and information related to agriculture sector.

The required information can be categorized into different segments such as selecting the best arable land area for agriculture, identifying the most suitable crop to grow in a particular area, planting methods, pest and insect controlling methods and usage of different pesticides, harvesting methods and distribution of the harvest etc.

The history of human civilization gives evidence that in pre historical age humans tend to move from one area to another area is finding food for survival. The hunters tend to live in groups where they can find food with a good climatic condition and later on moved to another area when the food in the particular area is exhausted. Later on in the farming age they settled in areas where the basic needs such as good climate, water, and land for cultivation are fulfilled. This clearly gives evidence that selecting of arable land is primary information required for human growth and existence.

At present finding geographic information regarding arable land area in the country is not easily accessible. In Sri Lanka geo information is provided by the Survey Department of Sri Lanka. Geographic information has become a basic need of people in fields of such as natural, social, medical, engineering, sciences and business planning for various purposes namely physical, economic, cultural or biological purposes (Wikimedia Foundation, 2012).

With the development of modern technology computer based Geographic Information Systems (GIS) are being developed with the capabilities to store, retrieve, manage, investigate and demonstrate geo data. The basic requirement for proper functioning of a GIS is having necessary geo data with appropriate tools. At present the Survey Department which is the only geo data provider in Sri Lanka cater to the requirements of such requests through a manually operated system. Yet the provided map includes all the details of a given area instead of a personalized map for each user's request and lacks flexibility, accuracy and efficiency. Therefore in this project we have developed an automated GTIS system that is capable of checking availability of geo data, clipping, converting, creating child Geo Databases and validating the result using various geo tagging and image scaling techniques as per the user request.

The rest of the paper is organized as follows. Section 2 describes various technologies used in GIS and some background information of the Survey Department of Sri Lanka. Section 3 contains the methodology adopted. Section 4 is on design of the project. Implementation details are given in section 5. Section 6 discusses the evaluation being done. Overall discussion is given on section 7. Conclusion and some further work are given in section8.

II. EXISTING APPROACHES TO ENHANCE AGRICULTURE SECTOR

In agriculture the success of the field mainly lies on the correct selection of the land, the type of the crop to grow and usage of correct and timely actions on growing, maintaining and on harvesting. Initially selecting the land for cultivation is a crucial factor because the whole process depends on this selection. The selected land has to be in an irrigational area, with means of access and with nutrient soil conditions. The total land area of Sri Lanka is 6.55 million hectare out of which only 50% is suitable for cultivation due to unsuitable terrain, inland water bodies and forest and other types of reservations (Jayasinghe-Mudalige, 2008) of this limited arable land area some pastures are permanently used for the main three exports aimed crops, tea, rubber and coconut. Paddy and other vegetable and fruits are mainly cultivated in family owned lands with low level of infrastructure facilities. The problem of availability of land area for cultivation has aggravated in the recent past due to encroachment of arable land area by growing population for other needs. In this sense we argue that identification of suitable land for cultivation is a critical factor not only for the economy of the country but for the existence of human kind.

In recent past many agriculture based information dissemination systems has been developed. Premachandra and Ratnayake (2008) have developed a knowledge based decision support system for crop selection. The system considers economic feasibility of raising a crop by taking market price, cost of production, and access to market and yield levels along with the primary knowledge collected from a human crop expert. With these inputs the system suggests a suitable agricultural crop that can be grown in a land unit. Negotiation between different stakeholders in taking agriculture decision making is modeled with the use of multi agent system combined with the constraint programming in Sami et al (2005). Stakeholder integration system in agriculture based on individual user profiles is developed in Adikari & Karunananda (2009) with the use of multi agent technology. Audio visual center of the Department of Agriculture, Gannoruwa maintains a web based Wikipedia and e-learning system to facilitate farmer training. Nava Goviya is another agriculture learning portal maintained by CIC Agrochemicals (Department of Agriculture, Sri Lanka).

In addition to above stated knowledge and information dissemination approaches there are some approaches that mainly focus on improving the financial status of the farmers by matching buyers and sellers (Dialog TradeNet). A localized agricultural price prediction system is available for the state of Karnataka in India, which is able to forecast prices of thirteen commodities for a period of two months (Price Prediction).

All above discussed approaches mainly consider either dissemination of information pertaining to the field of agriculture or ways of improving financial statues of farmers by predicting prices of commodities. We argue that the baseline of successful farming is the selection of the most suitable land for cultivation. This decision is affected by many factors such as soil type, vegetation, irrigation and surrounding of the selected land.

Therefore in this project we have developed a system that provides geo data for a chosen location for cultivation. The system is capable of providing geo data for main crop types grown in the vicinity of the selected land, irrigation data, building data. We argue that obtaining of such information for small scale farmers is not feasible at present due to the unavailability of an automated system as well as due to the lack of knowledge in geographical data.

III. METHODOLOGY & APPROACH

The GTIS system is developed with the aim of building a fully-automated and user-friendly system which is capable of Geo tagging and image scaling. For example a farmer can request to obtain the data regarding the crops grown in a particular area.

Initially, the GTIS system checks the availability of the data for the requested location based on aerial photographs, data created and updated using satellite images, JICA completed data, data from manual script and data from printed maps. A user can click on the desired location on the given map of Sri Lanka. In the event that requested data are not available then the requester can go for another option.

At present Sri Lanka uses 3 topographic maps with the scale of one inch indexed map with 72 sheets, 1:50,000 indexed map with 92 sheets and 1:10,000 indexed map with 488 printed and another 570 sheets of photogrammetric plots (Withana, 2011). Topographic maps includes a third dimension to normal two dimensional maps by introducing features found on surfaces using contour lines to show elevation change on the surface of the earth (Riesterer, 2008). Topographic data is stored in layers namely as administration, buildings, transport, land use, hydrograph, terrain, places, Grid, utilities and reserves (Withana, 2011). In addition, there are some sub layers in addition to above main layers.

Requested geo data for a particular location can be clipped based on several methods namely, sheet number, location name, x - y coordinates and on shape files. Shape files (.shp) only store geography and attributes for one set of features out of point, line, or area features. For example out of the 92 sheets available for the 1:50,000 series a user can select the required layer such as land use or hydro layer etc. The location names are attached to DS (Divisional Secretary Area) and GN (Gramaseva Niladari) area.

Geo data can be converted to AutoCAD or KML (Keyhole Markup Language) formats with the layer name and the sheet number. A child geo database based on x, y coordinates and shape files can be created from master geo database. Finally the output files generated from the system can be validated by viewing through Shape file viewer, KML file viewer or AutoCAD file viewer.

For example a farmer can request to obtain the data regarding rubber grown in a particular area. Initially, the GTIS system checks the availability of the geo data for the requested location. Then user can click on the desired location on the given map of Sri Lanka. In the event that requested geo data of rubber grown is not available then the requester can go for another option such as geodata of coconut grown in the same area. Because of that GTIS system is capable to show the available geodata details on user desired location.

IV. SYSTEM DESIGN

Overall system design of GTIS System is depicted in figure1. After user authentication the user can click the location on the map of Sri Lanka and check the availability of requested agriculture based geo data. Mainly a user can request agriculture based geographical information conversion, clip shape files, different layer data and child geo databases from the system. For all GIS functions Arcpy API is called through ArcGIS server.

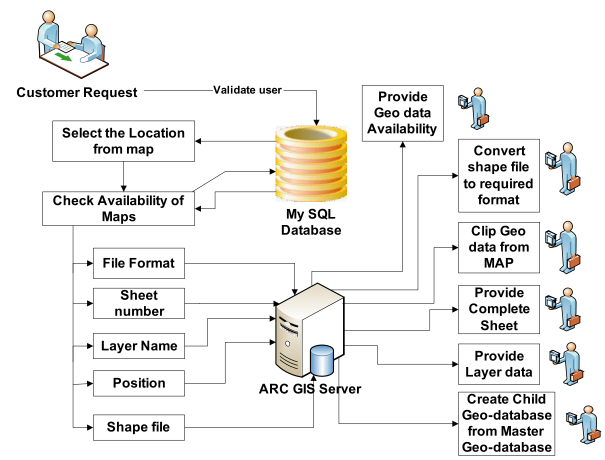

Fig 1. Overall System Design

V. KML CONVERTER

Convert geo data to KML format is data comprised of simple geometries like points, lines, and polygons into KML. A KML file contains translation of geo matrices and symbology. Converted file is compressed using ZIP compression with a .KMZ extension. The zipped, KML file can be read by any KML client including ArcGlobe and Google Earth. The KML converter is shown in figure2.

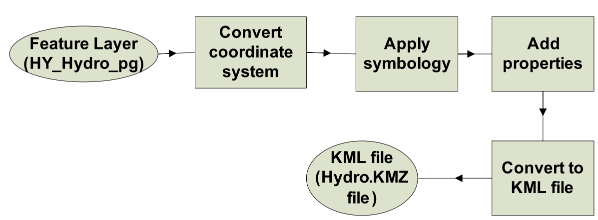

Fig 2. KML converter

When requested to convert into KML format input of feature layer is taken from the personal geo database. Initially, existing coordinate system of the input feature layer is converted to universal coordinate system (UTM - Universal Transverse Mercator). Then necessary symbology is applied to the converted feature layer. Finally, required properties such as scale, boundary extent, resolution, etc are added to the feature layer. The generated KML file can be stored in a given location and the generated temporary files are deleted.

VI. AUTOCAD CONVERTER

AutoCAD Converter creates one or more CAD drawings based on the values contained in input feature layers. Figure3 shows the AutoCAD converter.

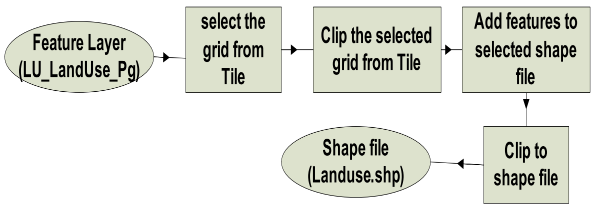

Fig 3. AutoCAD converter

In converting to AutoCAD format input feature layers are again taken from personal geo databases in a similar manner to KML formatting. Initially CAD properties such as entity property, text property, layer property, etc are added to the input feature layer. Finally all entities are combined to a single AutoCAD file and can be stored in a given location. At the end of the processing generated temporary files are deleted.

A. Clip geo data to shape file

Features like points, polygons or lines can be clipped from input feature class. Clip process by grid number is shown in figure4.

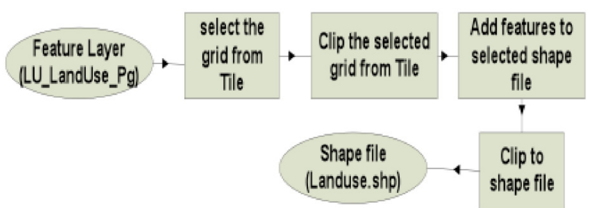

Fig 4. Clip process by grid number

When the user requests to clip shape file the input feature layer is taken from personal geo database. If user request geo data by grid number then grid is selected from the entire tile sheet of Sri Lanka and clip the selected grid from the tile shape file. If the request is for clipping shape files by location name then the system clip the selected area to the shape file. If user request geo data by x, y coordinates along with x length and y length then the system generates a window shape file to the given size. If the request is by a shape file then the system super impose the given shape on the entire shape file and clip only the required area. Finally the features are added to shape file created by any of the above mentioned methods. Once completed the clipping process, generated temporary files are deleted.

VII. IMPLEMENTATION

The system is implemented as a standalone system on the Java platform. Use of Java language was essential to access the functionalities of ArcGIS8 software. Since there is no script for automating a series of tasks in ArcGIS, executable were written to navigate a complex tree of interfaces and objects to find the required tools, and compile DLLs and type libraries to expose custom functionality. ArcGIS9 software supports scripting and geo processing framework for customization. One of the scripting languages supported by ArcGIS9 is Python. Python is being used in this project because Arcpy module is embraced by ESRI developer of ArcGIS9. It comes with large standard library support for data analysis, data conversion, data management and map automation and further support for large projects as well. MySQL is being used here because it supports geographic objects such as coordinate systems, projections and geographic functions.

A. GTIS System

User rolls are being controlled by user authentication. Administrators can update/modify geo data, add/remove users and allow multiple selections of functions. The GTIS system consists of five modules namely, geo data availability (module1), clip geo data to shape files (module 2), convert geo data (module 3), creating child geo databases (module 4) and validation (module 5). Figure5 shows the functions available in the GTIS system for administrators.

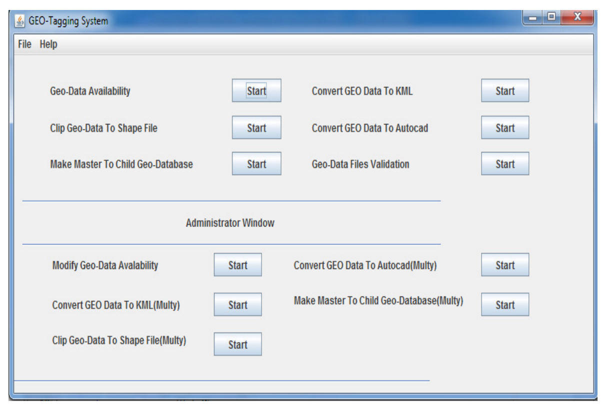

Fig 5. GTIS system – Administrator mode

B. Geo data Availability (module 1)

When requested to check geo data availability a map of Sri Lanka will be shown as in figure6.

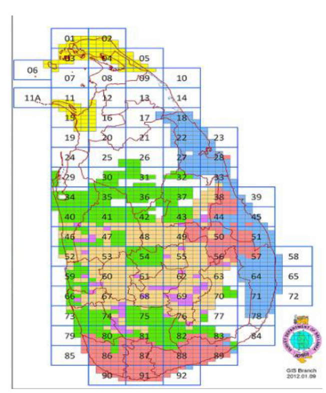

Fig 6. Geo data availability

Once the user selects the location from the map it will display the availability of geo data.

C. Clip geo data to shape file (module 2)

As mentioned before clipping geo data to shape files can be done based on sheet number, location name, x-y coordinates and shape files as shown in figure7.

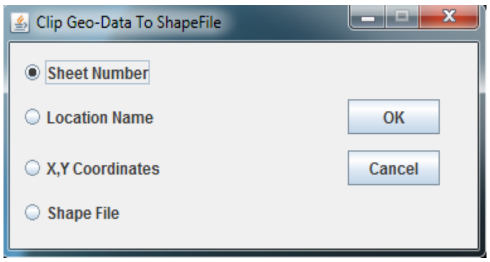

Fig 7. Clip geo data to shape file

The user has to select the required layer from building, hydro, grid, toponomy, land use, GN, reserve, terrain, utility, transport or boundary. Next, sheet number, grid number, DS area and the GN area have to be selected. Finally the GTIS system will generate the shape file based on the selections.

D. Convert geo data (module 3)

Module 3 in the GTIS system handles the conversion of geo data into KML format or to AutoCAD format as per the user requirement. The KML converter is shown in figure8.

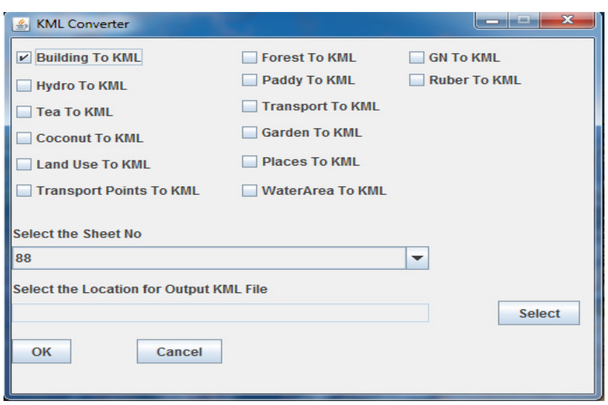

Fig 8. KML converter

KML converted files are mainly used to validate the accuracy of geo data.

E. Creation of child database (module 4)

Child geo databases can be created from master geo database based on X-Y coordinates and based on shape files as shown in figure9.

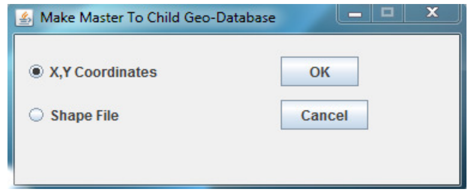

Fig 9. Create master to child database

F. *Validation of geo data files (module 5)*

The output files of the GTIS system can be validated for accuracy in all three formats using KML file viewer, AutoCAD file viewer and shape file viewer. KML files can be validated by Google earth as shown in figure10.

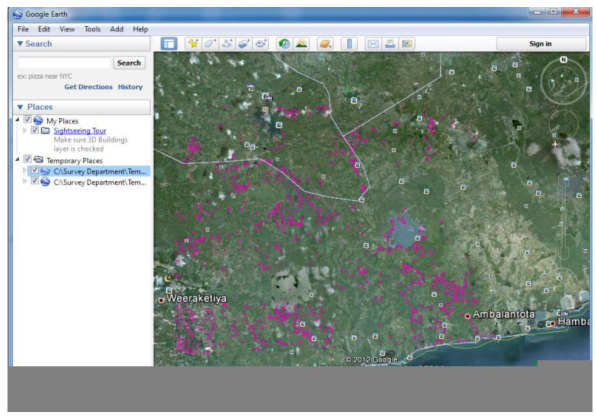

Fig 10. Coconut KML files validation

Shape file validation is shown in figure11.

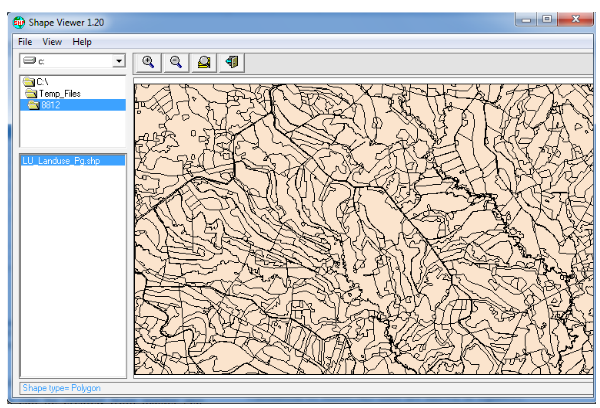

Fig 11. Validate Landuse shape file

Once the requested files are generated user can re validate them using shape file viewer.

Validation of AutoCAD files are shown in figure12.

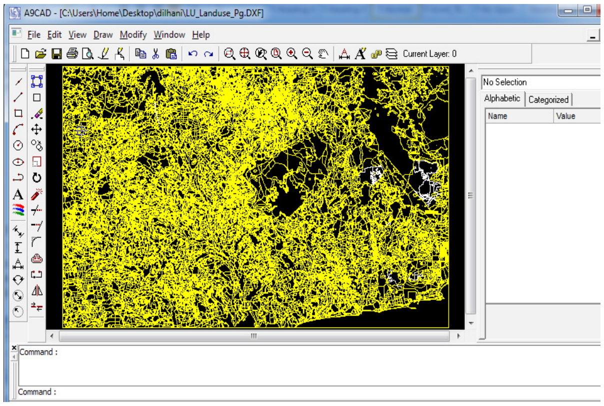

Fig 12. Validate Landuse AutoCAD File

This is again a revalidation system for the output AutoCAD files. Since AutoCAD viewer has different labeling system for different layers the validation process is made simple.

VIII. EVALUATION

The system was evaluated with the intention of validating the functionalities of the GTIS system and their accuracy. At initial stages of the development of the GTIS system unit testing was carried out to validate the accuracy of the software developed. Secondly the evaluation was done jointly with the survey department using test data to test the accuracy of the generated files by comparing them with the manually developed files. Finally, through a questionnaire the overall system performance was validated. The questionnaire was answered by a sample of users from the survey department as well as from the general public.

All users agreed on 100% accuracy of the system and 90% of the users are strongly satisfied with the speed of the GTIS system compared to manual system at the Survey Department as shown in figure 13. The 10% of users who said that the speed is satisfying are mainly from the general users who have previously purchased maps from the Survey Department. Their perception about the efficiency depends on the service they have obtained and there can be a lot of other contributing factors. The 80% of the users said that the system is user friendly. When we checked with the actual reasons from those who said less user friendly it was revealed that they are mostly the general users who do not know the technical terms used in the system. Therefore they were unable to decide the required map on their own. About 10% users from the survey department mainly requested to incorporate more functionality to the system. About 72% of the general users said that the development of this kind of a system makes it easier to manage their requirements. The idea of the rest of the users was that due to lack of knowledge related to the subject area the general users are not that convenient in using such a system but will be of immense use to the Survey Department.

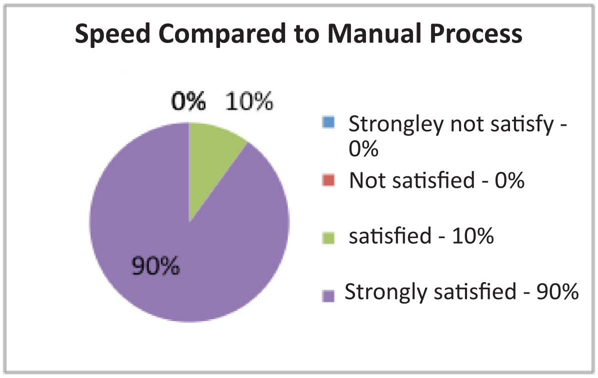

Fig 13. Speed of the system compared manual process

IX. DISCUSSION

The developed GTIS system is capable of checking geo data availability from a given geo database, clipping and converting geo data, creation of child databases and validation of the generated files.

Since finding the sheet number is difficult for a general user a database is developed with the names of DS and GN areas. Once the user selects the DS area the corresponding GN areas will be shown and the user can select the specific GN area. The system will identify the sheet number to the given GN area.

At present Survey department is providing geographical information to the customers as one geo data file. But with the implementation of the GTIS system we have been able to overcome this limitation successfully. For example, if a farmer wants to start a large farm to grow vegetables then he can get the required information regarding the land availability, what has grown in nearby lands, hrdro, transport etc. Therefore this system is capable of giving required information for the agriculture sector with minimum effort.

X. CONCLUSSION & FURTHER WORK

The Project aimed to develop a completely automated user friendly system which is able to cater geographical information requests by customers such as providing agriculture geo data. With the implementation of the GTIS system we have successfully addressed the above issue by automating the whole process of handling geographical information of the Survey Department, as it is the only place that provides geo data in Sri Lanka. Thus the efficiency and flexibility is incomparable to the existing manual system.

Currently this system is developed as a standalone application and can be implemented as a web based system in future. If this enhancement is added to the system it will ease the burden of customers who have to walk to a branch of Survey Department to get their requirements fulfilled. Specifically in agriculture sector the customers are dispersed all over the country and a web enabled system will be of immense use to them.

This will generate extra income to the Survey Department and it will also help them to delegate their work load. In addition, with the development of the GTIS system we have provided a cost effective highly efficient solution to generate customer specific geo data such as for agriculture sector in Sri Lanka.

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REFERENCES

Adikari AAPS and Karunananda AS (2009). Multi Agent Systems for Agricultural Stakeholders, Proceedings of ITRU Research Symposium, PP.45-49.

Central Bank of Sri Lanka, Annual Reports (various issues from 1950 –2009)

Department of Agriculture, Sri Lanka. Web Based Agricultural Wikipedia and e-Learning System, Audio Visual Centre, [Online]. Available: http://goviya.lk/

Dialog TradeNet [Online] Available: http://tradenet.dialog.lk

Jayasinghe-Mudalige UK (2008). Role of Food and Agriculture Sector in Economic Development of Sri Lanka: Do We Stand Right in the Process of Structural Transformation? Journal of Food and Agriculture Vol.1(1) 2008 pp.1-12.

Nava Goviya, CIC Agrochemicals Ltd. [Online]. Available: http://navagoviya.org

Premachandra MMA and Ratnayake U (2008). Advising Farmers on Crop Selecting Using Expert Systems: Proceeding of the fifth Annual Sessions. Colombo: Sri Lanka Association for Artificial Intelligence (SLAAI).

Price Prediction [Online] Available:wwwagriculturalpriceprediction.com.

Riesterer J (2008). What is a Topographic Map? [Online] Available at: http://geology.isu.edu/geostac/Field_Exercise/topomaps/topo_map.htm [Accessed 12 October 2012].

Sami A, Habib A, and Ali N (2005). Constraint Programming and Multi-Agent System Mixing Approach for Agricultural Decision Support System, Emergent Properties in Natural and Artificial Dynamical System in ECCS'O5 International Conference, PP. 113-119.

Wikimedia Foundation I, (2012). GIS applications. [Online] Available at: http://en.wikipedia.org/wiki/GIS_applications [Accessed 05 August 2012].

Withana PK (2011). Survey Department of Sri Lanka. [Online] Available at: https://sentinel.tksc.jaxa.jp/announce/2010/08/03/SECRisis0001201008030001/SA2JPTM3/Survey%20 Department.pdf [Accessed 07 August 2012].