eSagu™: A Data Warehouse Enabled Personalized Agricultural Advisory System

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ABSTRACT
In this paper, we explain a personalized agricultural advisory system called eSagu, which has been developed to improve the performance and utilization of agriculture technology and help Indian farmers. In eSagu, rather than visiting the crop in person, the agricultural expert delivers the expert advice at regular intervals (once in one or two weeks) to each farm by getting the crop status in the form of digital photographs and other information. During 2004-06, through eSagu, agricultural expert advices delivered for about 6000 farms covering six crops. The results show that the expert advices helped the farmers to achieve savings in capital investment and improved the crop yield. Mainly, the data warehouse of farm histories has been developed which is providing the crop related information to the agricultural expert in an integrated manner for generating a quality agricultural expert advice. In this paper, after explaining eSagu and its advantages, we discuss how data warehouse of farm histories is enabling agricultural expert to deliver a quality expert advice. We also discuss some research issues to improve the performance of eSagu.

Categories and Subject Descriptors
H 4.2 [**Decision Support**]; H 2.8 [Database Applications]; J.7 [Computers in Other Systems].

General Terms
Design, Economics, Performance

Keywords
e-Farming, eSagu, IT in Agriculture, Computers in Agriculture, Personalization, Information and Communication Technologies for Development (ICT4D), IT for Development, IT for Rural Development, Agricultural Extension, Information Dissemination, Digital Divide, Last-mile Problem, Personalization, Scalable Systems, Query-less Systems.

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1. INTRODUCTION
Developing personal information systems to deliver personal information service to each individual is one of the problem area [1]. Progress in database/data warehousing, data mining, mobile, and internet technologies are enabling mass customization and personalized information services [2]. We are making an effort to design a personalized agricultural advisory system to improve the utilization and performance of agriculture technology to improve the productivity of Indian farmers[1].

In the field of agriculture, agriculture extension wing deals with the dissemination of both advanced agriculture technology and expert advice to the farming community. It is often claimed that agricultural extension (or knowledge) is the cheapest input in bringing a noticeable increase in agricultural output and has now become vital for judicious use of inputs, cost minimization and sustainability. Efforts are being made to improve agricultural productivity by facilitating the advances in agricultural technology to reach farmers through magazines and news papers, broadcast media, organizing seminars and gatherings and Web sites. Such methods are not meeting the expectations of the farmers due to the lack of coverage, accountability, timeliness and personalization [3]. The traditional system does not consider the cases at the individual farmer's level as each farmer needs a distinct guidance for each crop he/she cultivates. It also lacks instant feedback mechanism to fulfill the needs of the farmer to his satisfaction.

By integrating both agriculture and information technologies, we are making an effort to develop a personalized agricultural advisory system called eSagu[2] [4,5]. (The word "Sagu" means Cultivation in Telugu language.) The eSagu system aims at providing fresh agricultural expert advice to the farmers in a timely and personalized manner. The agricultural experts generate the advice by using the latest information about the crop situation received in the form of both photographs[3] and text. In eSagu, the agricultural expert's advice is delivered to each farm[4] on a regular basis (typically once in a week/two weeks depending on the type of crop)

[1] The proposed system has been developed by considering agriculture situation in the state of Andhra Pradesh, India. Typically the farm size is about 1.5 hectares.

[2] eSagu is a trademark of IIIT-H, Hyderabad and Media Lab Asia

[3] Here, the photograph taken by visiting the farmer's field.

[4] The word "farm" means a piece of land in which a crop is cultivated. In this paper the words "farm" and "crop" are used interchangeably.

from sowing stage to the harvesting stage to the farmer without farmer asking a question. It is a scalable, query-less and personalized agricultural expert advice delivery system.

During 2004-06, through eSagu, agricultural expert advice has been delivered to about 6000 farms covering six crops. It has been found that the expert advices helped the farmers to achieve significant savings in the capital investment and improvement in the yield. Mainly, it has been found the data warehouse of farm histories has been developed which is helping the agriculture expert to generate a quality advice by providing the crop related information in an integrated manner. In this paper, we explain the architecture, operation, advantages and discuss the research issues.

In the next section, we explain the overview of eSagu which includes the basic idea, architecture and operation. In section 3, we explain implementation details, results and advantages of eSagu. In section 4, we explain how database/data warehousing technology is helping the agricultural expert to give quality advice. In section 5, we discuss some of the research issues. The last section contains summary and conclusions.

2. Overview of eSagu

In this section we explain the basic idea, architecture and operation of eSagu.

2.1 Basic Idea

An agricultural expert advice is a piece of text which is given for each farm. It contains a list of corrective steps the farmer should carry out in the farm to increase the gain (reduced inputs and improved yield). The main objective of eSagu is to deliver a personalized expert advice in a timely manner to each individual farm at regular intervals (for example, once in a week/two weeks) from the sowing stage to the harvesting stage to each farmer's door-step without farmer asking a question.

Normally, agriculture expert should visit the farm for delivering the expert advice of high quality. To build an effective personalized agriculture advisory system, we should make agricultural expert to visit each individual farm by person. In such a system, the agricultural scientist spends most of the time on traveling rather than being in the farms. As a result, one agricultural scientist can only cover few farms in a day, hence it is difficult to build and operate a scalable and personalized agricultural advisory system.

In eSagu, instead of agricultural expert visiting the farm, the farm situation is brought to him/her in the form of both digital photographs and text. The agricultural expert delivers the expert advice based on digital photographs and other information. Two options exist for sending the photographs. The first method is, the farmers themselves can send the photographs of his/her own farms. The other method is, instead of farmers, educated and experienced farmers of the village can be brought-in as mediators (we call them as coordinators) who will capture and send the photographs of a group of farms. In developing countries like India, the majority of farmers are either illiterate or have a low level of education. It is difficult for them to send the crop situation to agricultural experts. So we preferred to have the second option; i.e., assigning the work of capturing and sending the photographs by the coordinators.

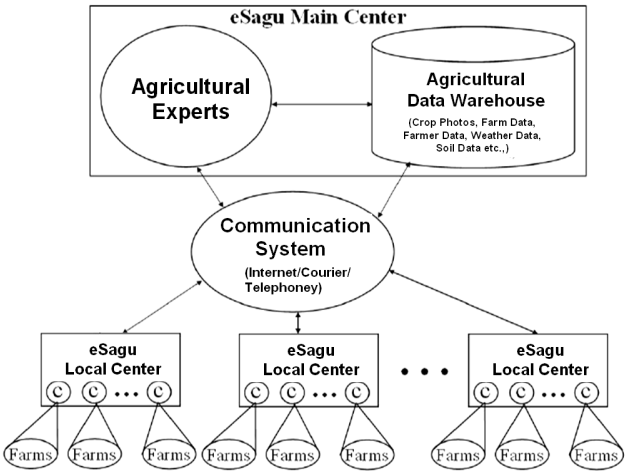

Figure 1. The parts of eSagu system. Here, 'C' indicates coordinator. A double arrow indicates information flow.

2.2 Architecture

The following are the parts of eSagu (Figure 1): (i) Farms (ii) eSagu local center (iii) Coordinators (iv) eSagu main center (v) Agricultural experts (vi) Agricultural data warehouse and (vii) Communication system. We explain these parts briefly.

(i) **Farms (farmers):** Farmers own farms and are the end-users of the system. The farmers could be illiterate. They are not expected to use the system directly. However, if they are educated and have Internet connection, they can use the system themselves.

(ii) **eSagu Local Center:** One eSagu local center is established for about 10 to 20 villages. It contains a few computers, printer and dial-up internet connection and managed by a computer operator.

(iii) **Coordinators:** The coordinator possesses agricultural experience besides the basic literary skills (reading and writing in the local language).

(iv) **eSagu main center**: Normally it is situated in the city. In this center, a team of agricultural experts with diverse background of agricultural related academic disciplines interact with agriculture information system to deliver expert advice.

(v) **Agricultural experts (AEs):** AEs possess a university degree in agriculture and are qualified to provide expert advice.

(vi) **Agricultural data warehouse:** It is a computer information system which contains all the related information. It contains the crop observation photographs and text. Also, from the available agricultural technology, the package of practices' information for each crop (such as the level of pest resistance, requirement of water, and so on) are maintained. It also contains farmer registration data, farm registration data and weather data.

(vii) **Communication System**: It is a mechanism to transmit the crop observation data (photographs and text) to the agricultural experts and corresponding expert advice from the eSagu main center to the eSagu local centers. Transmission of digital photographs from the field to the eSagu main center requires a considerable bandwidth. If enough bandwidth is unavailable, information can be

written onto compact disks and sent through a courier service. However, the expert advice (which is a text) is transmitted from the eSagu main center to the eSagu local center through a dial-up Internet facility.

2.3 Operation of eSagu

The operation of eSagu is as follows. A team of agriculture experts work at the eSagu Main Center supported by agricultural data warehouse. One small computer center (few computers and one computer operator) is established for a group of about 10 villages. Appropriate number of coordinators are selected from the villages. Depending on the type of crop, each coordinator is assigned with appropriate number of farms. At the beginning of a crop, the coordinator collects the registration details of the farms under him/her including soil data, water resources and so on, and sends the information to the eSagu main center. Every day, the coordinator visits a fixed number of farms and takes four to five problematic photographs for each farm. The coordinator also fills-in a feedback farm with the levels of pest incidence and indicating the impact of previous advice to that farm. (Note that the coordinator visits and takes the crop photographs at regular intervals irrespective of the problem; i.e., once in a week or two weeks depending on the type of crop.) The data (the photographs and other information) is burnt onto compact disk and transported to the main system by a regular parcel service. The agricultural experts at the eSagu main center prepare the farm specific advice in the local language by analyzing the crop situation by observing the crop photographs and the photograph of crop observation form. While preparing the expert advice, the agricultural experts also consider the soil, weather, and agronomic practices information. The advice is downloaded at the eSagu local center electronically through a dial-up Internet connection. The coordinator collects the advice and delivers it to the concerned farmer. In this way, each farm gets the expert advice at the regular intervals starting during the crop season.

3. Implementation, results and advantages

In this section we discuss implementation details, results of implementation and advantages of eSagu.

3.1 Implementation Details

The development of eSagu was started in March 2004. The eSagu main center was built at IIIT-H, Hyderabad, Andhra Pradesh, India. During 2004-05, we have developed the system for 1051 cotton farms. During 2005-06, a scaled-up version of eSagu for 5000 farms had been implemented for Cotton, Chilies, Rice, Groundnut, Castor, Groundnut and Redgram crops. The courier/postal system was used to transmit crop photographs from the eSagu local center to the eSagu main center. The expert advice was transmitted from eSagu main center to the eSagu local center through a dial-up Internet connection.

3.2 Results

The main results of eSagu implementation are summarized as follows.

- It is demonstrated that the agricultural expert can provide the expert advice based on the crop photographs and other information available in agricultural data warehouse.
- It has been found that the expert advice helping the farmers to improve input efficiency by encouraging integrated pest management (IPM) methods, judicious use of pesticides and fertilizers by avoiding their indiscriminate usage.
- The impact study shows that the farmers have realized considerable monitory benefits by reducing the fertilizers and pesticide sprays, and getting the additional yield.
- The turnaround time for advice delivery is 24-36 hours.

3.3 Advantages

The advantages of eSagu system are summarized as follows.

The eSagu sytem provides a quality personalized agro-advice to the farmers. It is a query-less system and provides agro-advice even without the farmer asking a question by following a proactive approach and averts problematic situations. Through eSagu, accountable advice can be provided with two-way communication. The advice is comprehensive, complete and regular in terms of diagnosis, analysis, advice delivery, follow-up and feedback. The eSagu system enables farmers (marginal and poor) to cultivate with the knowledge on par with that of an agricultural expert.

The eSagu is a scalable system. It is a cost-effective system and can be made self-sustainable. The system provides strong database to support decision making and documents success stories and new problems. It aids in successful implementation of crop insurance scheme by making farm as a unit of insurance. It also enables quick deployment of services during the times of crisis.

The eSagu system capacitates rural livelihoods and generates rural employment. The system can be used to validate agriculture technology. It significantly reduces the lag period between research efforts and field application. Finally, eSagu improves the capacity and knowledge of the farmer in the era of globalization to compete in the international market. It also provides the expert advice that is crucial to the farmer to harvest different kinds of crops based on the demand in the world market with quality and assurance.

4. Agricultural Data Warehouse

The agricultural data warehouse (ADW) is playing a crucial role in eSagu. It is a repository of crop observation photographs and the other related information. The agricultural expert interacts with ADW to provide the expert advice. The agricultural expert considers the following information to prepare the expert advice.

(a) **Crop observation photographs**: Farm photographs taken by the coordinator.

(b**) Farm history**: The chronological list of preceding weeks' crop observations and the corresponding advices delivered.

(c**) Case based histories**: The list of expert advices delivered for each problem situation.

(d) **Crop specific agricultural package of practices**: All the information regarding agricultural practices of several crops, details of available pesticides and corresponding dosages.

(e) **Other information**: The information about farmer registration, farm registration, soil properties, daily weather and so on.

Due to ADW, the efficiency of the system is increased in the following aspects.

(i) Creation of virtual visit to the farm by a team of agricultural experts: All the related information of the farm is provided to the agricultural expert in an integrated manner. Also, a team of agricultural experts specialized in diverse disciplines will be operating in an interactive mode at the main system which is as

good as all these experts visiting the crop at a time. The system is enabling a virtual visit to each farm once in a week by a group of scientists. Otherwise, it is very difficult and expensive also to take all these experts to the farms at remote villages each time.

(ii) Coverage of more number of farms by agriculture expert: In the proposed system, the agricultural experts are placed at one place and crop environment comes to them in the form of digital photographs and text images. Neither the experts nor the farmers should waste their valuable time and energy in traveling to each other either to push or pull the advice. Each expert will spend very less time on good crop and relatively more time on problematic crops which facilitates him/her to cover more number of farms each day.

(iii) More equipped for the correct diagnosis of the problem and decision making: The comprehensive information provided by ADW helps agricultural scientists for the right diagnosis of the problem and decision making. The information includes farm history, soil parameters and weather, and so on.

(iv) Zooming facility is creating a microscopic effect: The agricultural experts can zoom the farm photograph to several folds on the computer screen to have a close look at the things. So the camera is acting as a microscope. Even minute things such as insect eggs can be seen very clearly to identify the problem in a proactive manner.

5. Discussion on Research Issues

In this section we explain the type of data available in ADW. Next, we discuss some of the research issues to improve the performance of eSagu.

5.1 Type of data in ADW

The ADW contains the following types of data.

(i**) Crop photograph**: It is a problem specific photograph taken by the coordinator by visiting the farm.

(ii) **Crop observation**: It is a collection of problem specific photographs of a particular farm on particular date and time and the corresponding advice which has been delivered. It also includes a photograph of feedback farm. (The coordinator fills-in the feedback form and takes its photograph.)

(iii**) Farm history**: Note that crop observation comes to eSagu main center at regular intervals; i.e., once in a week/two weeks. A farm history is a sequence (chronological order) of crop observations from the sowing stage to harvesting stage.

(iv**) Other data**: The information about soil, weather, pesticide, agronomic package of practices, farmer registration, farm registration and so on.

During 2004-06, a large number of crop photographs, crop observations, and farm histories were collected as a part of eSagu project (Table 1) and about 54,889 advices have been delivered to 5,947 farms for six major crops. The data set contains about 5,947 farm histories and 3,73,591 crop observation photographs. For each crop observation, about six photographs are being taken.

Table 1. Details of data set

Variable	Value
# farms (or farm histories)	5947
# observations/ advices	54,889
# photographs	3,73,591
# photographs per observation	6
Photograph size (approximate)	200KB

5.2 Research Issues

As eSagu expands, in due course of time, ADW will be populated with a huge repository of photographs and other information regarding various crops under diverse agro-climatic conditions and zones. It is possible to add video and voice data also. The data set becomes a rich resource to improve the performance of eSagu and carrying out teaching, learning and research. The list of some research issues are as follows.

(i) One of the research issue is to enable agricultural experts to improve both quality and efficiency of advice delivery by extracting different kinds of information. Regarding quality aspect, the system should provide all the required information to help agriculture scientist to prepare the high quality expert advice. The quality of advice should be equivalent to that of the advice he/she delivers by physically observing the farm. Regarding efficiency aspect is concerned, the system should help the agricultural expert in delivering the advice to more number of farms (more is better).

(ii) Scalable methodologies and systems are required for efficient storage and online retrieval of a text, image, video, and voice data.

(iii) The data set is a rich resource for data mining and extracting patterns. One of the issue is to identify and extract several patterns to improve the quality and efficiency of agriculture scientist and other stake holders like bankers, insurance companies, researchers and so on.

(iv) Efficient search facility for photographs, video and voice is required.

(v) Development of system is required for multi-lingual access and automatic translation. Note that the expert advice is provided in local language. It is necessary to find cross-lingual information to improve the performance of agriculture expert and other stake holders.

(vi) It is possible to improve the performance of agricultural scientists by facilitating him to extract different kinds of information from farm histories and other data. Here are sample information requirements.

(a) The set of farms which received the same advice in a given week where the pest name is Helicoverpa (for that matter any pest) with the condition that the same farms should receive different advice (you can also say same) in the preceding week.

(b) Variation of different crop varieties in disease and pest incidence.

(c) Variation of certain types of pest or disease intensity with weather.

(d) Relationship between fertilizer, nutrient, pesticide application with the crop disorder.

6. Summary and Conclusions

In this paper, we explained eSagu project, which is an effort to build an IT-based personalized agro-advisory system to help farming community. The feasibility of such a system has been tested. It was found that the farm productivity could be improved by providing agriculture knowledge to the farmers. In eSagu system, agricultural data warehouse is playing a major role in helping agricultural experts to improve their efficiency. As a part of future work, we investigate the methods to improve the performance of eSagu.

7. ACKNOWLEDGMENTS

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