Leveraging digital trends for information-intensive farm management – a decade of growth for Mitr Phol Sugar, Thailand

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Abstract Before 2002, the sugarcane-supply contract agreement systems in Mitr Phol Sugar involved a long documentation process with many errors in area calculation that led to difficulties in crop management and in predicting the amount of cane. In 2002-2004, a pilot study was initiated at one of the mill areas to create geo-spatial maps and databases using remote sensing, GIS (Geographic Information System) and GPS (Global Positioning System). Given the positive results, all of Mitr Phol Sugar mill areas were mapped during 2004-2007 at the block level, and farm and farmer data were collected and analysed and input into our GIS system. During 2008-09, a web GIS system was developed using open-source programming, thus enabling users to access information online. In 2011, as tablet computer usage was becoming widespread, an android application was developed for cane management that was linked to the web GIS server. Currently, all extension officers are connected online from the field to a GIS server that has enabled Mitr Phol Group to manage its 350,000 ha of contract farms more efficiently. This has resulted in timely crop-management solutions, benefiting farmers who receive financial loans and farming input supplies on time, as well as analysing yield gaps for productivity improvement. The ICT (Information and Communication Technology) system has contributed to accurate cane area estimation, cane amount prediction, and planning for crop advisory services as well as efficient harvest and transport. The rapid growth in the ICT sector has greatly influenced adoption of precision farming using IoT (Internet of Things), UAVs (unmanned aerial vehicles) and sensors. Mitr Phol Sugar has a long-term vision to implement these advanced technologies by leveraging digital trends. The paper has highlights positive trends in the ICT system in improving the intensive farming system over the years.

Key words Field mapping, remote sensing, web GIS, mobile applications

INTRODUCTION

In today’s dynamic world everything is changing very radically and, as 21st century dawns, revolutionary changes are also beginning to challenge business and markets (Salami and Ahmadi 2010). In agriculture, technologies such as remote sensing (RS), geographical information systems (GIS) and global positioning systems (GPS) have been adopted for improved management of land and crop production (Jhoty and Autrey 2001). The role of management information systems in business and marketing has been also changing continuously, due to rapid advancements in technology (Nasir 2005). In sugarcane, progress has been slow, even in countries known to be at the forefront of these new emerging techniques, such as Australia, South Africa, Brazil and Mauritius. Much of the early work in adoption of these techniques to sugarcane production was undertaken in Australia in the mid-late 1990s (Bramley and Quabba 2002). Other early work was initiated in Mauritius (Jhoty and Autrey 2001). However, the Indian industry has been exploring the use of satellite-based remote sensing and GIS in sugarcane production (Kumar 2001), no doubt drawing on abundant IT expertise in India. Repeat image acquisition matched to key growth stages has enabled discrimination of varieties in addition to assessment of planted areas. Similar work has been done in Thailand to assess spatial relationships between variation in soil properties and variation in sugarcane yield (Kumar 2001).

Thailand’s sugar industry is predominantly a partnership between millers and growers. The key business objective of sugar industry in Thailand is to optimize sugarcane yield and sugar quality in order to maximize sugar production and revenue to farmers and millers. Efficient cane production management, planning of harvests and cane delivery, monitoring cane contractual agreements, effective delivery of inputs and improved yield estimation are all necessary to ensure the success of the business (Weerathaworn et al. 2006). Thus, millers play an important role in improving profitability through
productivity improvement and cost optimization, and they also bring convenience to farming by providing services in time. Sustainability of the sugar industry relies upon the consistent and optimal supply of quality raw material from contract farmers.

Until 2002 in Mitr Phol Sugar, the entire process of cane operation management was handled by manual documentation. It began with cane area estimation using a measuring tape, preparing sketches on paper and attaching relevant documents from farmers to make contractual agreements. This was a time-consuming and labour-intensive process with a high possibility of error that led to difficulties in crop planning, monitoring and financial management.

In 2002, Mitr Phol Sugar initiated the project ‘Sugarcane Information and Management System’ (SIMS) as a pilot study in one of the mills. The system uses GPS, GIS and remote sensing (RS) satellite imagery to build farm-level maps and field-attribute information with the following objectives:

- To map the fields at block level, and collect and update the field database regularly in a GIS system;
- To efficiently manage field operations, planning, monitoring and cane supply;
- To improve productivity through site-specific management;
- To provide near-real-time field information and decision-support systems.

METHODOLOGY

The SIMS in Mitr Phol was developed in three phases. The first phase began with a pilot study in one mill area, Phukieo district, to standardize the technique of mapping and digitizing farms using remote sensing, GIS and GPS. On successful completion, this was expanded to remaining five mills located in North East and Central region of Thailand. In the second phase, a web GIS system was developed using an open-source map server. In the third phase, an android application was developed for mobile mapping and real-time connectivity using the cellular network.

Phase I: Pilot study and expansion to all mill areas (2002-2006)

The pilot study was planned in one of the six factories of United Farmer Industry Company (UFIC) in Chaiyaphum province, utilizing GPS, GIS and high-resolution satellite imagery to map cane areas and build the database of farmers and fields. Despite being initiated at a pilot scale, the area was 51,200 ha of cane contracted from farmers, which was divided into nine zones for efficient operation. More recently, this area has been expanded to 70,000 ha to meet the increased crushing capacity provided by the recently built Plant B.

Unlike developed countries where farm sizes are larger, the average farm holding in Thailand is 3-5 ha. We chose to map the boundaries using GPS rather than using the very-high-resolution satellite images and digitizing them. Garmin GPS Map76 was used by the field officers to capture the field boundaries by walking around the field. Generally, the planting season starts in early November and lasts until April. Hence, all the field officers were then equipped with GPS to map the field at the time of contract agreement. Along with the field boundaries, farmer’s details and basic field data was recorded in forms. Database information includes contract number, farmer’s name, village, soil type, irrigation source, etc. The GPS track file and data sheet were sent to the mill’s GIS centre for input in GIS format. Any abnormalities such as overlap and/or mismatches with satellite boundaries were reported back to field staff for correction. In the pilot study we took all possible steps to standardize the method (Fig.1), hence it took 2.5 years longer to complete the mapping of the entire cane area of UFIC’s mill. Apart from cane field boundaries, other natural resource features such as bore wells and ponds were also mapped.

Following standardization and realization of the benefits, the process in the flow diagram (Fig. 1) was expanded in parallel to the other four sugar mills in 2004, covering 204,000 ha. Mapping was completed in 2006 (Figs 2 and 3). In the subsequent years only new field boundaries have been created and inputted into the GIS database. Those fields continuing to grow cane or changing to other crops have been updated in the database by retaining the original boundary if it is unchanged.
**Fig. 1.** Flow diagram describing the methodology of the sugarcane information system.

**Fig. 2.** Contract cane areas in green.
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Fig. 3. Field boundary map produced using Garmin Map76 GPS.

Role of satellite Imagery

Ray et al. (2001) reported that limited utilization of remote sensing for precision farming, especially in Asian countries, is due to small land holdings, the cost/benefit aspect, and heterogeneity of cropping system. Considering the operational needs of the industry, cost-benefits, and the large mapping area, (Indian Remote Sensing) IRS-1D 5.8 m pan-sharpened images were used for validation of the cane area. These images were further sharpened with LISS-III (Linear Image Self Scanning) 23.5 m resolution using Erdas Imagine software. The image was enhanced by applying linear stretching to the histogram to detect the edges more clearly. Then it was geo-rectified using ground-control points (GCPs) from topographical maps and hand-held GPSs. Finally, the enhanced and rectified image at 5.8 m resolution was imported to ArcGIS as a background layer to validate the accuracy of the boundaries captured using GPSs.

Farm management

The collected data has limited value unless it is efficiently used for farm management and business operations. It paves the way forward towards information intensive farming. Field data is collected in all stages of crop growth, viz., pre-planting, cultivation and harvest. Sugarcane, being a long-duration crop, has the advantage of management of the crop at every stage to mitigate the yield if the information is analyzed and farmers are advised timeously. Field extension officers record the farm data, viz., soil type, water source, and crop data, viz., variety, crop type, planting date, fertilizer rate, irrigation, pests and diseases, crop health, and finally yield estimate and Brix data.

Phase II: Standalone GIS to Web Mapping 2007

Standalone GIS has limitations of accessibility to its users (clients) working in remote locations. Mitr Phol leveraged the open-source web GIS mapping to migrate from a standalone system to a web application. The architecture of the system is shown in Figure 4. The GIS database shape file was converted to an SQL database with spatial extension that stored both geo database and attribute data in a single file. Currently, every mill's information is maintained separately in web databases, but will likely be integrated into a single system soon. Clients can access information from a web interface through an intranet application. It provides a map view and reports on area, crop type, field activity, crop condition, crop estimation, etc. that help the manager to follow-up closely with field officers for productivity improvement.

Phase III: Mobile Mapping 2011

Leveraging the advantages from the growth of IT trends and the cheaper cost of devices, we have migrated from hand-held GPS and data sheets to online tablet PCs, where both field boundary and field data are captured online or offline and synchronized with our web GIS server (Fig 4). An Android application was developed in-house and SQLite database used
to transact between tablet and server. Other layers available to view along with cane boundary are the administrative boundary, road, water streams, village locations, etc. Compared to GPS, there are other advantages in tablet usage. A few of the examples are geo-tag photo capturing, geo-fencing that forces the officer to enter data from the field, real time information access, planning the day, week, and month, and giving infield advice to the farmers.

**Fig. 4.** Web GIS and Mobile architecture.

### RESULTS AND APPLICATION

Mitr Phol realized successful results from the Phase I of digital transformation in the field mapping and GIS system for crop management. At the end of Phase I in 2006, all the cane areas of the six sugar mills were mapped in digital GIS format with farmer and field data. Results from Phase I were applied for precise cane area estimation to the level of 98% accuracy and also cane production estimation that had been inaccurate without field area mapping. As the sugar business has strong linkage between the millers and farmers, the information systems and technologies intend to add value to both parties. Farmers are the key customer in the cane-production chain, and the system benefits include reductions in the turnaround time for services from 2 weeks to 6 days for contract agreements and finance loan approvals. At the completion of web GIS system in Phase II, each map and report can be viewed from remote locations using the internet, providing timely information to crop managers. These reports include region-wise cane area, crop type, variety, production estimation, yield, quality, harvest and supply status. In 2011, after the implementation of mobile mapping in an android platform in Phase III, field maps and data are input from field in real-time to web GIS server. This saves time and reduces errors in field data collection by officers. In addition this provides an efficient decision-support system to the cane managers and directors of an information-intensive farming system.

We found from the initial analysis that handheld GPSs produce an error up to ±5% in terms of accuracy during field boundary mapping. However, considering the cumulative area at regional and mill levels, this variation is insignificant as there is offset between positive and negative. We experienced more errors while migrating from GPS to tablet, as there are varied accuracies attained from different brands of tablets. Apart from accuracy, some models of tablets required longer start-up times. Since the base map has been already mapped using the handheld GPSs, tablet GPSs are used only for new area mapping, hence the cumulative error was kept less than 3%. When comparing to handheld GPSs, we realized the many benefits associated with tablet GPSs, such as (a) time efficiency in uploading and digitizing field boundaries, (b) navigation to fields, (c) planning activities, (d) real-time transactions, etc. Possible positional errors might occur from the overlapping of two field boundaries, or when a field boundary lies on the road or waterway. This error was eliminated using high-resolution multispectral satellite imagery at IRS 5 m resolution. Thus, overall accuracy has been improved to 98%. After introduction of the geo-spatial based information management system, the work process and decision making in the crop production chain has become faster and more data driven.

Farmers can now access farm and field information in kiosks and cane supply quantity and quality are communicated via SMS. At the next level, the collected field-level information are analysed into actionable information to manage the field.
activities in real time, thus improving the farm’s productivity, which is a win-win situation for both farmers and millers. These geo-spatial technologies have been used for precision agriculture in number of countries such as Australia (Lee-Lovick et al. 1992) and South Africa (Plattford 1990). A few examples are: advice on suitable crop fertilizer application, irrigation management, operations to improve crop conditions from poor to average and good (Grade C to B and A). This information is linked to the field boundary map and analyzed to segregate the zoning, which helps the field officers to scout and advise farmers on the focused hotspot areas where immediate attention is needed to improve the crop. An integrated web-based farm information system is highly valuable to business operations in terms of planning, monitoring and managing the process, finance and cane supply.

CONCLUSIONS

Mitr Phol has leveraged the opportunities of information technology from the introduction of GPS and GIS in 2002, which has morphed into web mapping and mobile mapping since 2011. With the growth of technologies aligning with global trends, the utilization of the information has broadened from area estimation to crop monitoring, and yield improvement toward digital agriculture. This system has brought positive digital transformation in the crop-production value chain from planning of areas, contract agreement, and financial assistance to farmers, crop scouting, yield improvement, harvest and logistics. These benefit both farmers and millers in terms of efficient time and resource management, productivity improvement and data-driven decision support. Sustainability of the raw material supply lies in the hands of the farmer who wishes to achieve the greatest possible return from every unit of land. A younger generation of people are entering farming, and they will use smarter devices and applications to manage their farms efficiently, rather than using traditional ways. Despite developing an integrated farm management system, field officers still have to spend excessive time collecting the data manually, which necessitates the future introduction of other technologies such as satellite, and UAV-mounted (unmanned aerial vehicles) sensors for crop monitoring. As we are generating voluminous data from internal and external sources, there are future opportunities for the Internet of Things (IoT), big data analytics and precision farming to reap the real benefits of information to our business and stakeholders.

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REFERENCES


Mots-clés: La cartographie de terrain, télédétection, SIG web, applications mobiles

**Apalancamiento de tendencias digitales para una administracion agricola con informacion intensiva – una década de crecimiento en Mitr Phol Sugar, Tailandia**

**Resumen.** Antes de 2002 los sistemas del acuerdo de contrato para el suministro de caña de azúcar en Mitr Phol Sugar involucraban un proceso largo de documentacion con muchos errores en los calculos de area que llevaban a las dificultades en la administracion de cosecha y en la prediccion de la cantidad de caña. En 2002-2004, un estudio piloto fue iniciado en una de las areas del ingenio para crear mapas geo-espaciales y una base de datos usando sensores remotos, GIS (sistema de informacion geografica) y GPS (sistema de posicionamiento global). Dado los resultados positivos, todas las areas del ingenio Mitr Phol Sugar fueron mapeados durante 2004-2007 a nivel de bloques, y la informacion de granjas y cañeros fue recolectada y analizada y cargada en el sistema de GIS. Durante 2008-09, un sistema de web GIS fue desarrollado usando una programacion de fuente-abierta, facilitando asi a los usuarios el acceso a la informacion en linea. En 2011, a medida que el uso de la computadora tablet se iba expandiendo. Una aplicacion android fue desarrollada para la administracion de la caña que fue conectada con el servidor de la web GIS. Actualmente, todos los empleados extensionistas estan conectados en linea desde el campo al servidir GIS que ha permitido al grupo Mitr Phol administrar eficientemente sus 350.000 ha de tierras bajo contrato. Esto ha dado como resultado soluciones oportunas en la administracion de cosecha, beneficiando a los cañeros que reciben financiamiento y los insumos para la cosecha a tiempo, asi como analisis de rendimiento en campo para mejoras en productividad. El sistema de ICT (tecnologia para la informacion y la comunicacion) ha contribuido a precisar el estimado de area cañera, prediccion de la cantidad de caña, y la planeacion de los servicios de asesoria de cosecha asi como eficiente cosecha y transporte. El rapido crecimiento en el sector de ICT ha influenciado enormemente la adopcion de agricultura de precision utilizando el IOT (internet de cosas), los UAV (vehículos aereos no tripulados) y los sensores. Mitr Phol Sugar tiene una vision a largo plazo para implementar estos avances tecnologicos a traves del apalancamiento de las tendencia digitales. Esta presentacion ha subrayado las tendencias positivas del sistema ICT en el mejoramiento del sistema de agricultura intensiva a traves de los años.

**Palabras clave:** Mapeo de campo, sensores remotos, web GIS, aplicaciones moviles