BUILDING FARM INFORMATION SYSTEMS FOR THE THAI SUGAR INDUSTRY—THE ROLE OF IRS-1D SATELLITE AND GIS

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Abstract

Farm level information systems encompass the technique of mapping cane fields and relating ownership and field data under a single platform to perform spatial analysis for decision support. There is a growing interest in geographic information systems (GIS) in the Thai sugar industry for mapping, monitoring and analysing information. Reasons range from monitoring cane supply agreements to delivering inputs and improving productivity and profitability. In the past, such large scale mapping was only possible with aerial photography or a global positioning system (GPS), but recent developments in satellite technology have shown potential applications to the farming community. Hence, a program was initiated at Mitr Phol Sugar factory to map the sugarcane farms, land use and road network of the mill area using Indian remote sensing satellite 1D (IRS-1D) imagery. The satellite imagery was visually interpreted for cane and other land uses and transferred onto drafting film. This was ground checked and corrected. Ownership and field data were linked with the map using ArcView 3.2. As a result, vector maps of cane farms and other land uses were obtained with relevant data for analysis and applications. This was possible because the farms were large with good road networks. Extensive ground checking using GPS was carried out to collect data and verify boundaries, wherever variation was high. Creating a farm level information system is the first step in precision farming. This system offers potential applications to both millers and farmers for planning, monitoring and improving productivity and profitability coupled with environmental protection. Future plans are scheduled in different phases to identify the limiting factors of production and implement site-specific farm management strategies.

Introduction

The sugar industry is essentially a partnership between millers and farmers. Key business objectives of the partnership are to optimise sugarcane quality and yield in order to maximise sugar production and revenue to farmers and millers. Efficient cane production management, planning of harvest and cane delivery, monitoring cane contract agreement, more effective delivery of inputs and improved yield estimation are all necessary to ensure the success of the partnership.

A primary requirement is access to accurate and current information (spatial and non-spatial) to help with planning and executing daily operations. Information and communication technologies are impacting on our daily life in many disciplines. In agriculture, such technologies as remote sensing (RS), GIS and GPS have been adopted for improved management of land and crop production (Jhoty and Autrey, 2001).

Although much research and development was directed at large-area crop inventory applications of satellite data in the 1970s (MacDonald and Hall, 1980), much less attention has been directed at crop management applications, since satellite data did not have spatial resolution sufficient for the needs of production agriculture.

Why IRS-1D satellite?

Ray et al. (2001) reviewed the reasons for limited utilisation of remote sensing for precision farming, especially in Asian countries. However, high resolution satellite images are now readily available and, considering the operational needs of the industry, the cost-benefits and large areas of mapping, IRS-1D was selected. The spatial resolutions of panchromatic and LISS-III sensors are 5.8 m and 23.7 m respectively, and the repetitive period is 25 days.

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Project implementation

The mapping project was initiated at the United Farmer and Industry Co. Ltd (UFIC) farm with the following objectives: (1) map the cane fields and other land uses using the IRS-1D satellite; (2) build a farm record system with links to the map; and (3) analyse this information using GIS software to ultimately improve cane management operations.

This was scheduled in the following phases: building a farm scale information system; applying the technology for field operations; mapping yield variability; analysing land resource information; identifying the influencing factors; and recommending optimal management solutions. The first step in this sequence was completed by mapping 51 200 ha of sugarcane spread over 686 000 ha.

Methodology

IRS-1D PAN sharpened LISS-III image of January, 2002 was acquired in digital format. The image was enhanced applying a linear stretch to the histogram using ILWIS 2.1 software. Finally, a photographic satellite map with a scale of 1:12,500, covering 7 x 7 km was prepared as a false colour composite (FCC: green- red- infrared) for interpretation.

The satellite image was visually interpreted to separate the sugarcane farm boundaries and other land uses such as: other crops, fallow fields, tree plantations, water bodies, scrub lands, vacant lands, built-up areas and roads on tracing film.

In this process, sugarcane fields were demarcated individually based on the differences in tone, texture and shape. Questionable areas were visited and random sample sites were checked to verify land use identifications. Also, the field survey was carried out using GPS wherever the area difference between farmer record and satellite image differed by more than 15%.

Farm ownership information (e.g. contract number, farmer name and village) and field data (e.g. soil type, variety, planting date, crop type, water source, fertiliser rate, yield and quality) were collected and were updated continuously using a Microsoft Access database. The flow diagram is shown in Figure 1.

Results

The IRS-1D PAN sharpened colour image demonstrated potential utility for farm level mapping. Even though farm size is relatively small (1 to 3 ha), it was possible to delineate the individual farm boundaries as shown in Figure 2.

The error was within 10% when the digitised area from the satellite map was compared to the GPS survey in sampled fields. Considering the industry requirement to estimate cane area at a mill scale, the variation is acceptable. In some areas where the area planted to sugarcane was very compact, the boundary was not visible on the satellite image. In these cases, the field boundaries were corrected with GPS.

Creating a successful information system is not possible without extensive field visits to check boundaries and collect agronomic data. When the map was compiled with data in the GIS, it could deliver powerful management solutions. Initial results were encouraging to apply the system for various operations for both millers and farmers.
Potential applications

This information system, comprising spatial location of cane fields and land use coupled with relevant information such as ownership, field data and soil characteristics, could play a vital role in farm management operations. The primary requirement is to mark the location, estimate the area, and link ownership details to make a contract agreement for the efficient delivery of inputs and for planning harvesting and cane delivery. Mobile GIS can accomplish these tasks using PDA and Arc Pad to monitor daily operations. Bramley and Quabba (2002) detailed opportunities for significant change in the sugar industry by adopting such technologies.

Query and analysis is the key function of GIS for decision support. Spatial analysis of soils, land use, weather and slope would derive areas suitable for new cane planting. Over time the data system could be strengthened. This would offer potential for farm and site-specific management involving the mapping of yield variability and identifying the limiting factors by combined analysis of soil, nutrients, slope and weather information along with field data. In the longer term, crop yield modelling could also be integrated.

Fig. 2—Satellite picture and cane field map of a sample area used in this study.

Conclusion

High resolution satellite imagery and GIS are powerful tools for combining data and information with mapping that allows interpretation, analysis and decision making for sustainable and profitable farming. Careful planning, collection of timely accurate data and continuous updating is required for developing a fully functional GIS system. The maps and field data are being used currently for monitoring cane area, delivering inputs and planning for locating new potential areas for planting. There is scope for site specific management which requires soil property, nutrient status, fertiliser application, and pest and disease information for each farm.

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CONSTRUCCIÓN DE SISTEMAS DE INFORMACIÓN DE HACIENDAS PARA LA INDUSTRIA DE AZÚCAR TAILANDESA - EL PAPEL DEL SATÉLITE IRS-ID Y SIG

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PALABRAS CLAVES: Interpretación de Imagen, Datos de Campo, Sistema de Información de Producción.

Resumen

Sistemas de información a nivel de la hacienda, que abarquen la técnica de mapeo de campos de caña y relacionen propiedad y datos del campo, bajo una sola plataforma realizando el análisis espacial, para el apoyo de decisiones. Hay un interés creciente en los sistemas de información geográficos (SIG) en la industria de azúcar tailandesa, por trazar, supervisar y analizar información. Las razones van de supervisar los acuerdos de suministro de caña a proveer datos y mejorar la productividad y rentabilidad. En el pasado, tal cartografía de larga escala sólo era posible con fotografías aéreas o un sistema de posicionamiento global (SPG), pero los recientes desarrollos en la tecnología de satélite, han mostrado las aplicaciones potenciales para la comunidad cultivadora. De ahí, que un programa tuvo inicio en la fábrica de Azúcar Mitr la Phol para trazar el mapa de las haciendas de caña de azúcar, del uso de la tierra y de la red de carreteras del área de la fábrica usando las imágenes del satélite de detección remota de India - 1D (IRS-1D). Las imágenes del satélite se interpretaron visualmente para caña y para otros usos de la tierra y se la transfirió para película de diseño. Esto se verificó y corrigió en el campo. Los datos de propiedad y de campo fueron vinculados con el mapa usando el ArcView 3.2. Como resultado, se obtuvo mapas vectoriales de haciendas de caña y otros usos de tierra, con los datos pertinentes para análisis y aplicaciones. Esto fue posible porque las haciendas eran grandes, con buenas redes de carreteras. Se realizó extensiva comprobación en el campo usándose SPG, para colectar datos y verificar los límites, dondequiera que la variación fuese alta. La creación de un sistema de información a nivel de hacienda es el primer paso en el cultivo de precisión. Este sistema ofrece aplicaciones potenciales a fábricas y hacendados, para planear, supervisar y mejorar la productividad y rentabilidad además de proteger el ambiente. Se proponen planes futuros en fases diferentes, para identificar los factores limitantes de la producción e implementar estrategias de gestión de haciendas específicas para los sitios.