A REVIEW OF MAPPING AND GEOGRAPHIC INFORMATION SYSTEMS: KEY CONCERNS IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

Historically, mapping of the regulated sugar industry was co-ordinated by the South African Sugar Association Central Board in the form of quota maps. Following deregulation of the industry, co-ordinated mapping initiatives fell away, resulting in the decentralisation of mapping and geographic information system responsibilities to Mill Group Boards. This paper reviews the status of mapping and information systems and documents key industrial concerns obtained from user requirement analysis meetings with industrial stakeholders. Common concerns are monitoring of small scale grower cane areas and crop estimates.

Introduction

Currently there are a number of initiatives in the South African sugar industry, investigating and implementing mapping and information systems. These independent initiatives have raised concern within the industry regarding the lack of industrial standards that are necessary to consolidate mapping and industrial information for the benefit of the entire industry. To address this issue the South African Sugar Association Experiment Station (SASEX) appointed a consulting firm, Geographic Information Management Systems (Pty) Ltd (GIMS), to undertake a study entitled: *Development of a Project Plan for an Integrated Mapping and Information System in the South African Sugar Industry*, which is due for completion in August 2001. This study will propose standards for mapping and develop a framework for consolidating information from the different regions.

Part of this study consisted of a review of industrial mapping initiatives and a user requirements analysis of industrial and map data. This paper summarises the history and current status of mapping and geographic systems within the South African sugar industry and identifies key industrial concerns raised by the various Mill Group Boards (MGBs) during the process. The information presented has been acquired from preliminary investigations of the above study in which SASEX has been actively involved.

History of mapping in the South African sugar industry

During the years when quotas were regulated, growers had to apply for a sugarcane area quota from the South African Sugar Association (SASA) in order to secure supply to their mill. Each farm, with a quota number, was mapped at 1 : 6000 scale. In 1966, the sugar industry contracted a private firm to map the entire sugar industry using 1:30 000 scale aerial photography. Maps were prepared from photographs using a stereo plotter. Surveyed ground control points created a three dimensional (landscape) model from which the cane fields were mapped. The field areas were calculated and printed on each quota map. SASA Central Board updated these maps periodically, using updated photography provided by the same private firm ([1] personal communication).

Until the late 1980s map data was only available in a printed format. The sugarcane areas given on the quota maps were sufficient to make the necessary industrial decisions at the time. From the late 1980s to mid 1990s, the sugar industry explored spatial digital information. Geographic Information System (GIS) was limited to research and development projects at SASEX and began with the capture of old quota maps into digital format. Later, exploratory research used spatial digital information, to which field and topographical information was added for analytical research (Platford, 1990; Wallace 1993,1995; Hellmann *et al.* 1995).

In 1994, the sugar industry was deregulated and the Central Board's mapping services were privatised. Individual farmers were able to update their maps on a private user-pays basis. In this process, the Sugar Association's responsibilities of monitoring cane supply to the various mills were passed down to the local Mill Group Board (MGB) level.

MGBs are made up of grower and miller representatives who negotiate Local Area Agreements (LAAs). All growers supplying sugarcane to a mill are contractually bound by their agreements for a given period of time. A key element of the LAA is the Length of Milling Season (LOMS). Financial penalties are liable from the miller and or growers if either party deviates from the agreed terms.

More recently the expansion of sugarcane areas, particularly in the small scale grower sector, has increased pressure on the mills to crush the crop within the LOMS. This has precipitated the need for accurate mapping of new and existing cane areas. This information plays a pivotal role in determining the throughput of the mill and hence expansion of new cane areas to ensure that the crop can be crushed within the agreed time.

A review of the current status of mapping and GIS at each of the MGBs as well as their key problem areas is given below. Small scale grower (historically referred to as the small growers) and large scale grower mapping issues are considered separately because infrastructural support systems are different.

Current mapping and GIS initiatives

The distinction between mapping and GIS is unclear at times, especially with the advent of new mapping packages that allow

basic GIS functionality. For the purposes of this discussion, mapping will refer only to the delineation of cane areas. Mapped information may be available in digital or hard copy format. Linking attribute data such as variety type or yield results to mapped information will be considered a GIS function.

The status of mapping within the sugar industry varies considerably from mill to mill, as summarised in Table 1. Many mills have inadequate maps. and rely on outdated quota maps that may not include any changes to cane areas since 1994. On the other hand, certain mills have highly accurate digital field maps for all their growers. These maps are continuously revised using Differential Global Positioning Systems (DGPS) and the individual field information is updated when any changes occur. This type of accurate information management lends itself to the implementation of GIS technology for improved business efficiency and decision making.

The remaining mills' mapping systems fall between these two extremes. Several mills have recently commissioned an external contractor to use digital orthophotography from 1:20 000 scale aerial photography to map their Mill Supply Areas (MSAs). The major driving force behind this decision has been the LAAs. Two different types of maps have been produced using the digital orthophotos:

- Detailed panel mapping – where individual panels are delineated.
- Gross cane area mapping – where the bulk cane areas are mapped with delineations only in cases where rows, breaks or roads are greater than six metres.

The decision to select either of the two different mapping products is essentially based on the perceived cost benefits from an individual MGB perspective. The latter product is cheaper as less work is done during the initial delineating or digitising of individual panels. The product itself still provides suitably accurate gross areas under cane, but is not ideally suited to GIS applications.

The use of GIS within the sugar industry is limited. SASEX has been the industrial forerunner in using GIS technology in a research capacity. Recently, Komati and Malelane MGBs appointed consultants to conduct a full GIS user requirements analysis and develop a database that was spatially enabled. The system developed allows maintenance of all their data. There were several problems initially, most of which have now been resolved.

Sezela MGB has also made use of their small scale growers' digital map information within a GIS environment. Thematic maps of financial status, weed control and loan repayments of small scale growers, obtained from Umthombo Agricultural Finance (formerly Financial Aid Fund) databases, have been successfully used to support and enhance decision making with regard to small scale growers.

Key mill group concerns

Key concerns of MGBs were raised at the mapping user requirement analysis meetings held at each mill. These are summarised below.

- The area under cane of many large and small scale growers is not accurately known.
- The compilation of grower estimates to determine equitable grower allocations and annual crop forecasts are problematic. (Corrective weighting factors are frequently applied by MGBs to the estimates of growers who manipulate their figures to obtain favourable allocations.)
- Small scale grower estimates in particular are very difficult to determine, as the majority of their farms are unmapped and the area estimates have been shown at times to be highly inaccurate ([2] personal communication).
- The pirating of cane and defaulting on loan repayments is problematic in the small scale grower sector.
- Rateable delivery and scheduling of cane is problematic.

The mapping system should be easily updateable and must monitor new expansion.

- The approach to mapping small scale growers should be handled with social and political sensitivity. Concern was expressed over the potential threat to the mapping process, if the small scale growers perceived the mapping as a means of delineating tribal or magisterial boundaries within their communities. This false perception could derail the mapping process.
- Certain growers are dual agreement holders (i.e. they supply cane to two mills). The mapping and information of systems at the mills should therefore be cross-compatible.
- Identification of the most suitable geographic datum for mapping and incorporation of existing spatial information is required.
- Universal standards for mapping using different techniques must be identified to ensure consistency.
- Mills with varied bio-climatic growing regions have identified the need to selectively harvest cane from the different geographic regions during the year to maximise the overall Recoverable Value of (RV) sugar.
- Integration of software used by many of the large scale growers and the SASA Information Systems initiatives is considered important.

Key applications of the information system

- Improve the accuracy of estimates.
- Assist in scheduling to improve rateable delivery.
- Improve Pest and Disease and Extension services through better use of climatic, soils, cane variety, pest and disease and irrigation system information.

Discussion

Quota maps remain the main source of mapping for large scale farmers while the majority of the canelands of the 50 561 small scale growers remain unmapped. The areas stated on the quota maps may be up to 7% too large. This increases the existing difficulties mills have in estimating the annual crop. Some mills

Table 1. Summary of mapping and GIS status for all the mills.

Mill	Using a GIS	Mapping Small scale Growers (SG)	Status of: Large scale Growers (LG)
Amatikulu	No	No mapping.	Quota maps.
Darnall	No	Recent digital orthophoto mapping of SG and LG using 1 : 20 000 scale photography. Aggregate cane area mapping. (Individual fields within panels not mapped.) All new SG mapped by DGPS.	
Entumeni	No	No SG mapping. Wide geographic distribution.	Quota maps. Limited DGPS contract mapping. Limited digital orthophoto mapping.
Eston	No	Partial survey by DGPS contractors.	Quota maps. Individuals have used DGPS and digital orthophoto contractors to map farms.
Felixton	No	Colour photography (1996) used to map SG. Not very accurate.	Quota maps.
Gledhow	No	Recent digital orthophoto mapping of SG and LG using 1 : 20 000 scale photography. Aggregate cane area mapping. (Individual fields within panels not mapped.) All new SGs mapped by mill extension staff using DGPS.	
Komati	Yes	Field level mapping of all SG and CG using DGPS.	
Maidstone	No	Recent digital orthophoto mapping of SG and LG using 1 : 20 000 scale photography. Aggregate cane area mapping. (Individual fields within panels not mapped.)	
Malelane	Yes	Malelane Field level mapping of all SG and CG using DGPS.	
Noodsberg	No	Dept. of Agric. mapped all SG.	Quota maps. Individuals have used DGPS and digital orthophoto contractors to map farms.
Pongola	No	Field level digital orthophoto mapping using 1 : 20 000 scale photography of all LG. SG farms are partially mapped using 1 : 20 000 photography.	
Sezela	Yes†	10% of SG areas mapped by DGPS. No other SG mapping.	Quota maps. Individuals have used DGPS and digital orthophoto contractors to map farms.
Umfolozi	Yes†	Mapped and updated using DGPS.	Field level digital orthophoto mapping using 1 : 20 000 scale photography of all CG.
Umzimkulu	No	No mapping.	Quota maps).
UnionCoop	Yes	Field level mapping from digital orthophotos using 1 : 30 000 scale photography of all CG and SG.	

† = Advanced digital mapping with limited GIS capabilities. P&D= Pest and Disease RV= Recoverable Value
SASA IS= South African Sugar Association Information Systems

have developed a work-around solution to this problem by using cumulative yield information for the different small scale grower loading zones. By assessing the season's rainfall and assuming an average yield for the growers, mills have determined approximate cane areas with reasonable success.

A problem in mapping small scale grower sugarcane areas is that frequent changes are made from sugarcane to other crops. These dynamic changes make estimation of small scale grower cane areas and the updating of maps difficult.

Most mill group areas identified grower production estimates as a key problem. Collation and authentication of the accuracy of the figures has been an onerous task for most MGB's. Currently there are no standards provided to growers that facilitate delivery of estimates in a digital format. This could greatly improve the efficiency and accuracy in collating estimates. Many large scale growers have purchased software that is customised for sugarcane farming. These packages produce estimates on a field basis, which are then printed out, faxed or mailed to the MGBs to be re-captured into a digital format. MGBs require estimates to calculate the weekly allocations for growers and provide the mill with cane estimates.

The recent LIMS/DAK software that is being installed at selected mills by the SASA IS (South African Sugar Association Information Systems Department) will assist in automating grower estimates based on historical field information. However, in many cases, the field areas associated with these fields are based on old quota map areas that already have inherent inaccuracies.

The authentication and capture of accurate field information at the mill weighbridge is another aspect of concern at most mills. Sezela has automated this process to minimise errors relating to the manual capture of field information. However, not all

growers submit complete and accurate field information on their consignment notes, resulting in inaccurate information being automatically incorporated into the information system.

One of the main concerns with respect to the various MGBs actively involved in mapping and/or GIS is the lack of procedures, standards, software and resources to maintain, update and verify topological, spatial, structural and logical correctness of the data. For example, many mills have used DGPS to map the small scale growers. This information is not stored in a spatial database and closer inspection of the data has revealed certain fields:

- with overlapping field boundaries (spatial error)
- without the grower code information (logical error)
- with perimeters that are not continuous to form polygons (topological errors)
- that have been mapped twice or updated with new boundaries, without the old boundaries being removed (topological errors).

The maintenance of an accurate spatial database has, in many cases, become the responsibility of a mapping contractor whose knowledge and skills are often lacking in spatial information management.

Conclusions

The need for accurate mapping within the South African sugar industry has re-emerged following industrial decentralisation of mapping responsibilities in 1994. It is important to ensure that mapping is conducted in a manner that will not prohibit the use of the mapped information within a geographic information system in future years. Careful thought must be given to the future utilisation of mapped data so as to avoid costly duplication of mapping and data collection.

Furthermore, the mapping process should not be seen as a single event but rather as a continuous process that maintains the information system that management uses to make important business decisions. Careful consideration should be given to the social and political dimensions in developing a holistic mapping approach.

The use of GIS within the sugar industry is currently limited to a few mills. This is expected to increase rapidly in the near future as management realise the importance of using existing technology to assist and enhance their business decision making. In this regard a single set of procedures and standards to which the MGBs could subscribe, would be beneficial to all industrial stakeholders.

The results presented in this study are preliminary findings of a larger project commissioned by SASEX. The main objective of this project is to establish the necessary digital data standards and associated procedures that could enable compatibility of mapping, data and information to satisfy common industrial needs.

REFERENCES

Hellmann, DB, Wallace, MG and Platford, G (1995). Interpreting farm sugarcane yields using a Geographic Information System (GIS). *Proc S Afr Sug Technol Ass* 69: 87-92.

Platford, G (1990). A Geographic Information System for use in the sugar industry. *Proc S Afr Sug Technol Ass* 64: 83-87.

Wallace, M (1993). Surface modelling : Applications in the sugar industry. *Proc S Afr Sug Technol Ass* 67: 107-110.

Wallace, M (1995). Geographic Information Systems: Potential applications in the South African sugar industry. *Proc S Afr Sug Technol Ass* 70: 73-77.

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