EXECUTIVE SUMMARY

Introduction

Water-use efficiency in irrigated sugarcane agriculture is notoriously low and could increase dramatically if farmers implement established scheduling methods. A recent survey showed that 70% of sugarcane farmers use dragline irrigation and that 50% of these use fixed irrigation schedules. This leads to severe over-irrigation in times of low water demand and impacts negatively on the profitability of irrigated sugarcane production and on environment. Pressure is also building for water users to demonstrate efficient use of this scarce and sought after resource.

Numerous methods and tools are available to assist the farmer in scheduling irrigation, but adoption by the S.A. sugar industry has been disappointing. The rapid progression of communications technology (cellular communication and Internet) enables quick transfer of large amounts of data and information, further bolstering the potential usefulness of computerised irrigation decision support systems (IDSS). A survey amongst S.A. sugarcane farmers and extension officers showed that IDSS were too complex and impractical to be useful to farmers. In practice, farmers tend to use instinct or simple tools that they understand, even though these may be less accurate and inefficient.

The challenge therefore is to provide simple, practical and useful advice to farmers using state of the art technology such as crop models and weather stations, and to convince farmers of the benefits of irrigation scheduling through on-farm demonstration.

The project objectives were to:

- Develop and refine an automatic irrigation advice system consisting of automatic weather stations, a web-based crop model and a cellular communication network.
- Implement the system for small-scale farmers in Pongola and the Makhathini flats.
- Evaluate the suitability of the system for providing useful irrigation advice and to determine likely adoption rates and impacts on water use.

System development

The ***MyCanesim*** system was successfully improved by developing and implementing a user-friendly, web-based graphical user interface that allows users to set up simulation runs, manipulate simulation input data and view various system reports (including irrigation advice). Extension staff and other role-players were involved in the design and testing of the interface.

A control module was created to allow for the smooth operation and monitoring of the ***MyCanesim*** system. It allows the system administrator to activate or deactivate schemes and fields listed for batch running, to edit key field input variables such as cell numbers and harvest dates, to edit historic irrigation schedules and to manage advice dissemination.

A facility was also developed that enabled farmers to send a blank SMS reply to the ***MyCanesim*** system when they chose not to, or could not, follow advice. The reply is automatically interpreted in the context of the specific advice and then used to adjust assumed irrigation records used as simulation input. The facility works correctly but has seldom been used by farmers, in spite of numerous requests to do so.

Although the ***MyCanesim*** system eventually executed successfully more than 95% of the time, there is room for code optimisation to reduce runtime. There is also a need for more powerful processing power to speed up execution speed to accommodate all prospective users.

System implementation: Pongola

The system was implemented fully on the Pongola small-scale irrigation scheme. Subscription to the service grew steadily from 5 in 2005 to 41 in 2008. Several challenges were met during implementation. Amongst these were:

- Difficulty in obtaining good quality irrigation and rainfall data timeously from farmers. This affected the accuracy of simulations and the relevance of advice.
- Conflict sometimes being created by generating independent (and sometimes contrasting) advice to farmers who shared pumps. This problem can be overcome by making code changes that will synchronise advice as far as possible.
- Unreliable fax and inadequate Internet access was a problem for extension staff at both schemes.

It also became clear during implementation that regular and meaningful interaction between project technicians or extension staff and farmers are crucially important to maintain enthusiasm and assist with interpretation and practical implementation of advice.

The project helped extension staff and farmers gain a much better understanding of the important factors that determined the crop water balance and how irrigation can be scheduled to impact positively on productivity and sustainability.

The various reports available from the system provide concrete information (albeit simulated) for extension staff to benchmark irrigation practices, growth and yield of individual fields. The simulated results provided a good basis for discussion with farmers during field visits to identify agronomic practices that limited yields, such as poor crop stand, insufficient weed control, erratic movements of sprinklers and excessive sprinkler stand times leading to alternating periods of water logging and drought.

*A demonstration field day held in Pongola on 5 September 2007 was attended by 130 small-*scale farmers and other interested persons from Mpumalanga, Makhathini flats and Pongola. Project team members explained the objectives of the project and how the ***MyCanesim*** system works. Three fields were visited and farmers explained how they participated in the project and benefited from the advice. This event stimulated the curiosity of farmers from other areas and exposed them to the potential of irrigation scheduling to improve yields, cut costs and improve the profitability of their businesses.

Observations of canopy cover, soil water status and cane yield in four fields in 2005/06, and in nine fields in 2006/07, show that model simulations of these variables were reasonably accurate when the Canesim model was supplied with accurate input data. Simulated canopy cover and yield compared well with observed values. Wetting front detector responses suggest that the Canesim model sometimes underestimated soil water status and it is recommended that this problem be further investigated with a view to improve the model.

The study showed that, for Pongola, the spatial variation in rainfall was low and that rainfall data recorded by a single automatic weather station was sufficient for accurate simulations. The study also showed the importance of accurate irrigation data input. It proved quite difficult to obtain timeous and reliable irrigation data from farmers. Assumptions that farmers followed advice to irrigate or not were not always correct and this led to incorrect simulations and advice about 5% of the time. The main reason for farmers not following advice was lack

of water supply when advised to irrigate. The causes of this were electricity cuts due to non-payment, pump breakdowns and interruptions in water supply at scheme level.

Factors outside the scope of this study unfortunately played a dominant role in the long-term trends in water use and cane yield observed on the Pongola scheme. Declining water availability, changed method of payment for water and lack of infrastructure maintenance contributed to a general decline in irrigation water use and yield. However subscribers to the service experienced slower rates of decline and applied more water and achieved higher yields than non-subscribers. This suggests that the advisory service had a beneficial impact on the productivity and profitability of farmers who subscribed to the service.

System implementation: Makhathini

Implementation at Makhathini was problematic. Five fields were monitored in 2005/06 and advice was provided to an equal number of farmers. However, only two farmers out of twenty-three that were evaluated fulfilled the criteria for monitor participants, and in 2006/07 only two fields were monitored. The main problem was inadequate irrigation systems that result in excessively long irrigation cycles that exceed the design specifications by two or threefold. In practice, this amounts to supplementary irrigation. Irrigation was often also stopped entirely midway through the growing season because sprinkler stands were too short to distribute water above the cane canopy.

Another frustration was the unavailability of quality data at field and scheme level. It was very difficult to obtain reliable irrigation and rainfall data during the first season because it was difficult to make farmers understand the trial objectives and methods. The integrity of yield data at a scheme level is questionable, while no water-use data was available. It was further impossible to obtain harvest schedules in advance. This makes effective research and service provision impossible. It was therefore decided to terminate field monitoring in May 2007, while advice is still provided to all farmers that subscribed.

Most Makhathini farmers were unable to benefit from the advice because the irrigation systems are inadequate to supply the required amount of water. It is estimated that, on average, farmers could and should have applied approximately 85% more water, even with the long irrigation cycles of existing systems. This caused an estimated yield shortfall of 60%. The estimated irrigation and yield shortfalls are much larger when benchmarked against ideal irrigation schedules with the specification cycle of 7 days. Despite numerous attempts to convince participants to upgrade and repair irrigation systems and to improve

crop husbandry, nothing has changed. Lack of land ownership, lack of cash-flow and a 12-hour per day water supply are severe limitations to correcting these problems.

Farmer survey

Interviews with 20 Pongola farmers showed that most farmers found the irrigation advice useful and easy to understand, and trusted the advice most of time. The project made farmers more aware of the importance of irrigation scheduling in increasing revenue and reducing costs, and most farmers have changed irrigation practices because of the advice. The majority of farmers indicated that they wanted the service to continue and were prepared to pay a small service fee.

Economic feasibility study

The study suggests that farmers can obtain a positive net benefit from the "Advice only" service. The benefit of the more costly "Advice plus monitoring" is more doubtful. These results are based on the assumption that the service will result in a saving of 584 mm of irrigation water per season. Model recalculations with more realistic impacts show that a full cost recovery for the "Advice only" service (R649 to R384/ha depending on subscription levels) would only be feasible in scenarios where cane yield can be increased (by as little as 4 t/ha) by better scheduling. It is unlikely that service implementation costs can be fully recovered from irrigation water savings only.

General

The approach used here for developing and implementing an irrigation decision support system proved highly appropriate. The fact that users were involved in the design and implementation and the fact that system complexity was hidden from users contributed to quick and wide adoption of the technology. It was also shown that there is no need to scale down on technology when providing decision support for small-scale farmers. In fact, modern technologies such as the Internet, cellular communication, electronic weather stations and crop models made it possible to (1) develop a system that addressed the unique needs of small-scale farmers and their agents and (2) overcome many constraints.

It is believed that this type of irrigation scheduling advisory service (as provided to Pongola small-scale farmers) has many indirect benefits (e.g. reduced soil degradation, reduced leaching of nutrients) that were not monitored in this project. The study showed that significant direct (monetary) benefits are possible, provided the following prerequisites are in place:

- Reliable and adequate supply of water,

- Adequate irrigation systems,
- Adequate control over water supply and irrigation at the field level,
- A sense of ownership of land and infrastructure,
- Monetary incentives for farmers to benefit from water savings,
- Willingness of farmers or water-use agencies to contribute to the cost of service delivery,
- Competent and committed support from field support agents that are needed to assist farmers with implementing advice and to obtain accurate field data,
- Adequate Internet access and fax facilities for field support agents, and
- Adequate computer processing power and optimal system code to reduce system run time and enable system expansion.

The project provided ample opportunity for capacity building. The 47 farmers from Pongola and Makhathini that were directly involved in the project enhanced their knowledge and skills needed for irrigated sugarcane farming. KZN DAEA and Illovo mill extension staff learnt how to use crop and weather data to assist them in their job. Project researchers learnt more about participative research, while the two project technicians learnt how to interact with farmers and capture and process field data. Both technicians have also furthered their studies, one towards a diploma and the other towards a degree in agriculture.

Recommendations

An advisory service that provides real-time irrigation scheduling advice based on weather data could be implemented on other sugarcane irrigation schemes, provided that the stated concerns are addressed. It is recommended that:

- The issues of landownership, inadequate irrigation infrastructure and inadequate or inflexible water supply are resolved first before considering the implementation of an irrigation scheduling advice service.
- Modern broadband technology is implemented to address the inadequate Internet bandwidth at support agencies in rural areas.
- Fax machines of the Kwazulu-Natal Dept. of Agriculture Office in Pongola are fixed and properly maintained.
- Staff from government agencies (such as Water Users' Associations, Dept. of Water Affairs and Dept. of Agriculture) and sugar industry organisations (such as SASRI and Milling companies) are trained to understand and use the ***MyCanesim*** system. Apart from providing real time scheduling advice, it could also provide information to predict water use and yields and compare these to actual yields and water use.

- The use of electronic equipment to monitor irrigation and rainfall at a field level and integration of this data into the ***MyCanesim*** system are explored to improve the quality of simulation output and advice.
- Aspects of the system are customised to address the unique needs of each irrigation scheme or scenario. This requires involvement by potential users (farmers and their support agents) and a phased implementation.
- Full cost recovery of such a service is unlikely under the current scenario. Subsidisation by role-players who have an interest in more efficient use of irrigation water must be considered, or alternatively a scheme should be devised to provide a better incentive for farmers to subscribe to such a service.