Using the farm-scale system model APSFarm to improve profitability of irrigation cropping enterprises.

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Abstract

APSFarm is a whole farm systems simulation model derived from multiple instances of the paddock scale Agricultural Production System Simulator, APSIM. Here it is used to model a case study of an irrigated farm business near Dalby (151.27E - 27.17S), Queensland to try to identify optimum business strategies under conditions of limited available dam water. In this work we compared the long term impacts of reducing or maintaining planting areas of cotton, maize and wheat on the profitability of the farm business.

Interviews with the farmer provided farm specific data, such as water sources and their annual allocations, water storage capacities, cropping areas, agronomy, irrigation management and paddock layout relative to storages. Farm business constraints included: limited availability of land, irrigation water, finance, labour, machinery and time. In this paper we demonstrate the value of developing and applying whole farm systems models to support participatory research with the aim of designing more profitable and sustainable farm businesses.

Key Words

APSIM

Introduction

Irrigators are under increasing pressure to maintain profitability with reduced water allocations, rising input costs, and high market volatility. Desktop studies using crop simulation models are possible tools to assist in identifying more profitable management strategies. However the analysis and optimisation of irrigation enterprises with a point scale production model such as APSIM (Keating et al 2003) is problematic. For example, constraints such as dam capacities and water availability are not appropriate at the point scale. For this reason we used APSFarm, a whole farm systems simulation model derived from multiple instances of the paddock scale APSIM to model homogenous areas of the farm and hence it allows for the dynamics of area in the model

In APSFarm paddock level management rules (e.g. crop agronomy, irrigation scheduling), and farm level strategies (e.g. crop choice, water movement between storages, enterprise mix, risk attitude) are simulated across the whole farm. Model outputs include a wide range of bio-economical and environmental indicators of the farm business useful in trade-off analysis when comparing alternative farm business management strategies. The result is a whole farm model which can capture the dependencies and interactions of household budgets, soil types, climate variability, crop physiology, machinery, and labour It is also able to simultaneously take into account the effects of changes in climate, crop prices, variable costs, water allocations, and soils (e.g. salinity, N fertility). APSFarm has previously been used to identify possible farm business strategies to increase business viability (Cox et al., 2008; Rodriguez et al., 2007; Mayer et al., 2006). In this paper we used the model to explore a question from the farm manager i.e. *"…with lower dam levels,… am I better to reduce my planting area and apply more irrigation per hectare,… or should I maintain a maximum cropping area and rely more heavily on in-crop rain…"*.

Method

Case Study

Interviews with the farm managers of the property were used to describe the farm infrastructure, its management and long term business strategy. The farm business is located near Dalby Qld It has two 500 ML water storages supplying 252 and 314 hectare cropping areas, and a 300 ML storage supplying an area of 215 hectares. The storages are filled via overland flow and there is capacity to transfer water between them. It is possible to purchase an additional 100ML from a neighbour at a cost of $70/ML plus pumping. The farm has 5 bores with an annual allocation of 860ML/year, and can supply water to all paddocks, though at a considerably reduced flow rate compared to that of the storages. All paddocks are irrigated via furrows, and the run-off from paddocks and irrigation tail-water is captured.

Within the model a range of farm operating constraints were included e.g. sowing can only occur when relevant machinery is available. Prices and costs were relevant to the 2004/2005 cropping season. An example of the outputs from the farm cashbook appears in table 1.

Table 1. Example of the outputs from the cashbook calculations. Income, expenditure and cumulative balance ($).

date	income ($)	expenditure ($)	cumulative balance ($)	comment
15-Feb-07	316,756		25,296,781	cropprice (maize)what's cropprice
30-Jun-07		136,000	$25,160,781	Farm Overheads
30-Jun-07		$94,958	$25,065,823	Loan repayments for initial capital outlay
28-Sep-07		$4,309	$25,061,514	Dam_irrigation
9-Oct-07		$33,280	$25,028,234	Maize seed
9-Oct-07		$5,383	$25,022,851	Maize fertiliser Starter Z
9-Oct-07		$52,237	$24,970,614	Maize fertiliser Big N
9-Oct-07		$17,032	$24,953,581	Maize herbicide Primextra
9-Oct-07		$8,320	$24,945,261	Fertiliser
9-Oct-07		$509	$24,944,752	fuel & oil costs of tractor_1 + planter
9-Oct-07		$138	$24,944,613	Repairs & maintenance of tractor_1

9-Oct-07	$55	$24,944,558	Repairs & maintenance of planter
16-Oct-07	$9,828	$24,934,730	Cotton seed
16-Oct-07	$8,505	$24,926,225	Temik
16-Oct-07	$30,263	$24,895,961	Cotton Insurance
16-Oct-07	$1,351	$24,894,609	Cotton fertiliser application gas knife
16-Oct-07	$23,461	$24,871,148	Cotton fertiliser Anhydrous ammonia
16-Oct-07	$2,016	$24,869,132	Cotton fertiliser Liquifert Emerald
16-Oct-07	$4,536	$24,864,596	Cotton fertiliser Urea
16-Oct-07	$1,890	$24,862,706	Cotton fertiliser Foliar triple 7
16-Oct-07	$18,326	$24,844,379	Cotton herbicide and application
16-Oct-07	$14,279	$24,830,100	Cotton insecticides and application
16-Oct-07	$1,627	$24,828,472	Cotton conditioning
16-Oct-07	$8,946	$24,819,526	Cotton consulting fees
16-Oct-07	$31,500	$24,788,026	Cotton licence fees
16-Oct-07	$10,686.	$24,777,340	Cotton seed

Figure 1, shows the implementation of the rotation for the farm business in APSFarm. The circles, or nodes, indicate the states in which any management unit can be found, and the arcs between nodes holds the description of the rules allowing the transition between the connected states, i.e. rules for planting , and harvesting the different crops. The arc in blue shows an alternative path when the rules to plant wheat are not satisfied e.g. if there is insufficient soil moisture then wheat will not be planted and the system will go into fallow. Wheat is not irrigated and its inclusion in the rotation is to primarily provide ground cover.

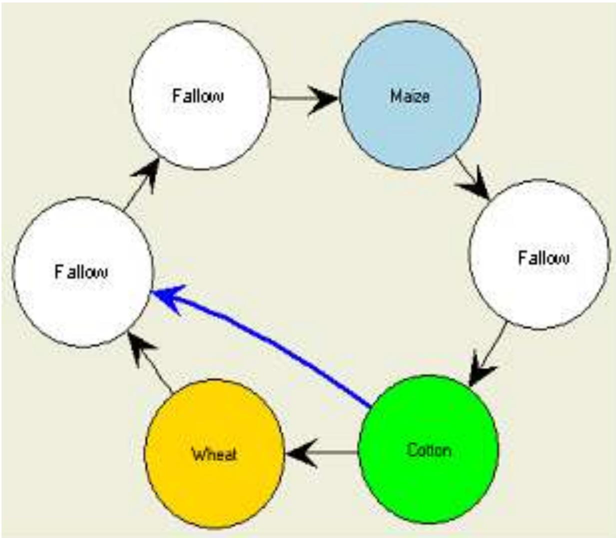

Figure 1. Crop rotation of the analysed farm business at Dalby, Qld.

Planting area

Planting Area

Each section of the farm serviced by one of the three dams is represented in the model by an APSIM paddock, which has planting area as an attribute that can vary from season to season. The initial state of each of the paddocks, at the start of the simulation, is set to a different stage of the rotation to avoid the three parts of the farm being synchronous and causing a disproportionate demand on farm resources such as irrigation water.

Two scenarios were simulated, (i) *adaptive strategy:* the area to be planted was set at sowing as the product between the maximum allowable area for that paddock, and the fraction of available water for irrigation stored in its respective dam, to a minimum of 50%, i.e. having less crop that are more fully irrigated; and (ii) a *non-adaptive strategy:* in which the area to be planted was set as the maximum allowable area for that paddock i.e. relying more on in-crop rainfall. Each strategy was run with APSfarm for 117 years of available patchpoint climate data i.e. 1890 to 2007.

Results.

From the cumulative cash flow output from the 117 year simulation for the two scenarios i (Figure 2) it appears that for this particular farm business and crop rotation the *non-adaptive strategy* (black line) outperformed the *adaptive strategy* scenario. This demonstrates the significant contribution to yields that in-crop rainfall has in this environment. The median annual return for *the non-adaptive strategy* was significantly greater than for the *adaptive strategy* (*p* value = 0.04) (Figure 3), However, the *adaptive strategy* was less variable and hence slightly less risky as it relies less on highly variable in-crop rainfall.

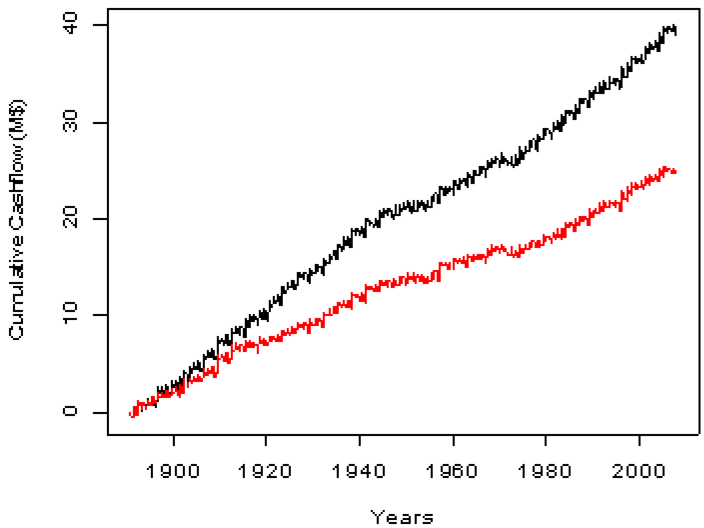

Figure 2. Cumulative cash-flow for the traditional (black line) and adaptive (red line) irrigation strategies for a farm at Dalby Qld.

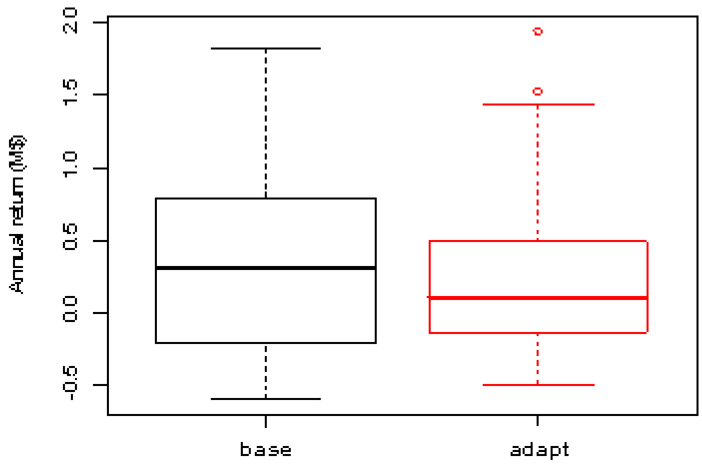

Figure 3. Annual returns for the traditional (black) and adaptive (red) irrigation strategies for afarm at Dalby Qld.

Conclusion

In this paper we provide an example of how a whole farm simulation model can be used to test farm business designs and strategies before they are implemented. The use of the model with the farmer permits more informed discussions and thus helps farmers increase their adaptive capacity to cope with changes in the availability of resources such as irrigation water.

Future work in this project will include the use of evolutionary optimisation techniques to identify farm business tactics and strategies that maximise trade-offs between alternative business outcomes e.g. profit, economic risk, and environmental impacts.

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