Measuring the sustainability of cotton production systems

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ABSTRACT

Cotton farms are intensive agricultural systems that use energy and resources to produce lint and seed. Farms by their nature are open systems that interact extensively with the environment and are highly dependent on natural resources such as fertile soil and good quality water. While every cotton farm is unique due to its location, history, natural resources and human components, cotton farms around the world face many common environmental challenges. These challenges include the management of biodiversity, salinity, water use and quality, soil health, interactions with river and groundwater systems and pest management. An important part of this challenge is measuring the sustainability of cotton production systems so that farmers can demonstrate resource stewardship. Although there is some debate on the technical definition of sustainability, the concept of economically sustainable development is well known and broadly agreed. Many Governments around the world are in the process of establishing key indicators of agricultural sustainability and cotton farmers and their industry associations will be required to report on their impacts and benefits against these indicators. Cotton is grown for economic and social benefits, whilst trying to minimize its impact on the environment. For example, in Australia, the Cotton Research and Development Corporation's strategic outcome is "A more sustainable, competitive and profitable cotton industry providing increased economic, environmental and social benefits to regional communities and the nation". So how does a cotton industry demonstrate to the community and government such a broad outcome? One way of reporting on such an outcome is using the Global Reporting Initiative (2000) sustainability reporting guidelines on economic, environmental and social performance, which is also known as triple bottom line reporting. Sustainability reporting requires consistent, comparable and verifiable information on industry impacts and benefits. Examples could include for the economic category; yield, fiber quality, income, yield per unit of water used, gross value of production, contribution to a nation's gross domestic product and exports. Examples in the environmental category could include; soil health, water use, water quality, chemical use, industry code compliance and biodiversity indicator species. In the social category examples could include; employment, occupational health and safety, industry education and skill levels or perceptions of cotton production by the community would be good performance indicators. Care must be taken not to monitor too many indicators and some balance is needed between the economic, environmental and social categories. If farmers are going to detect long term changes in their farm sustainability they need to start collecting some baseline data. This maybe as simple as taking photographs, using standard soil and water testing procedures or compiling data from existing sources. Monitoring is an integral component of environmental management systems and industry codes such as the Australian Cotton Industry's Best Management Practices Manual. The cotton industry needs to develop indicators to measure and report on its sustainability using a triple bottom line framework of economic, environmental and social parameters.

Introduction

The World Commission on Environment and Development (1987), in what is known as the Brundtland report, defined sustainable development as seeking to meet the needs and aspirations of the present without compromising the ability to meet those of the future. A few years later the United Nations Program for Action for Sustainable Development, known as the Rio Earth Summit, or Agenda 21, advocated the development of indicators to measure our progress towards sustainability and acknowledged that economic, ecological and social process are interrelated (United Nations, 1992).

Performance indicators are needed to monitor cotton production systems and report on their sustainability. Sustainability indicators will also assist with planning, resource allocation, trend analysis and provide documented evidence of responsible natural resource management and stewardship.

Effective corporate governance depends on access to relevant, high quality information that enables performance tracking (Global Reporting Initiative, 2002). The United Nations Environment Program launched the Global Reporting Initiative in 1997. The guidelines are for voluntary use by organizations reporting on economic, environmental and social dimensions of their operations performance (Global Reporting Initiative, 2002). The term "triple bottom line" reporting was coined by Elkington (1997), to describe performance reporting against economic, social and environmental parameters.

Measuring and reporting of any data needs to be transparent, inclusive, auditable, relevant, accurate,

repeatable, measurable, and timely. Care must also be taken not to monitor and measure too many indicators, while some balance is needed between the economic, environmental and social categories. The geographic sphere of impact needs to be considered as should how the indicators may vary over time. Knowledge of baseline conditions of the pre-existing environment would be very valuable for any new areas yet to be developed for cotton production.

Cotton is grown for economic and social benefits, while aiming to minimize the impacts of its production on the environment. Many Governments and communities around the world are in the process of establishing key indicators of agricultural sustainability and cotton farmers and their industry associations will be required to report on their impacts and benefits against these attributes. The Australian Government Standing Committee on Agriculture and Resource Management developed a set of measurable attributes to provide a basis for sustainability assessments. These included; long term net farm income, natural resource condition, off site environmental impacts, managerial skills and socio economic impacts (SCARM, 1998).

This paper outlines principles for sustainability reporting of cotton production systems using a triple bottom line framework of economic, environmental and social indicators. The principles outlined in this paper could be applied at the farm, industry or national level. Researchers and extension officers could also use the framework to report and evaluate the outcomes of their research and extension projects.

Sustainability indicators for cotton production systems

Tables 1, 2 and 3 provide examples of economic, environmental and social performance indicators that could be monitored to measure the sustainability of cotton production systems. They are by no means a comprehensive list but for organizations undertaking a triple bottom line report about a dozen key indicators would be a good starting point for any monitoring. These could include yield, fiber quality, profit, value of production, chemical use, water use, water quality, soil health, industry code compliance, employment, occupational health and safety, and skill levels of human resources. The balance of this paper provides examples of these performance indicators for the economic, environmental and social categories.

Economic returns are closely related to yield and Figure 1 shows how the Australian cotton yield has increased at the rate of 30 kg/lint/ha/year between 1960 and 2002. While there have been some decreases during certain years due to floods and drought, the overall trend in yield and productivity is upwards due to research, technology adoption and improved management.

Between 1992 and 2001, Table 4 shows the operating profit of cotton production was around AUS $1500/ha in Australia, which is higher than most crops, but is trending downwards. Important factors determining profitability are costs and part of the economic triple bottom line report could include an analysis of operating costs. Table 4 shows that insecticide and fuel/oils costs have risen significantly, while herbicide and fertilizer costs have risen by a smaller amount between 1992 and 2001.

In the environmental category there are many potential sustainability indicators, which are listed in Table 2. Water quality is an important integrated indicator that can reflect changes in many different practices. Figure 2 shows an example of how the endosulfan insecticide levels have declined in the Namoi River at Narrabri. This decline is due to a number of reasons including research and monitoring, the implementation of the Industry's Best Management Practices Manual and better spray application techniques.

Water use efficiency (WUE) is a critical performance indicator, but long-term historical data sets are very difficult to obtain due to the complexities of measuring all the aspects of water inputs and losses. There are numerous water use efficiency definitions and it is essential that measurable and repeatable data is collected in the same format over time. For example, in the Gwydir Valley, Australia, data shows that WUE has increased from 1 bale/mega liter in 1987, up to about 1.5 bales/mega liter in 2002.

Measuring and monitoring social aspects of the sustainability equation has proven more elusive. Data sets are not available or collected infrequently by government agencies. However, there is now more emphasis being placed on social indicators given cutbacks being made by Government to water allocations, which has many flow on effects into local communities. Social performance indicators could be of greater importance in under developed countries of the world and the Global Reporting Initiative (2002) includes a long list of social indicators that do not apply to developed nations like Australia.

The Cotton Research and Development Corporation has data that shows the average age of cotton farmers is less than other agricultural industries in Australia such grain, beef and wool, while at the same time their education levels are higher with more of owner operators having post Year 12 school training from an agricultural college or university. Another example of education, training and skill levels is described by Stanley *et al.* (2003) in these conference proceedings. Technology access can indicate social development. For example, in the 1980s weather forecasts were received by farmers via the radio, in the 1990s by fax, and now they receive them via the Internet.

Health and safety of farm workers is another im-

portant social indicator. Table 5 shows that most accidents on farms are associated with machinery operation. The industry responded by developing a Managing Farm Safety Program, and accident levels on farms and in cotton gins are now declining.

This paper has provided a list and some examples of sustainability indicators in each of the economic, environmental and social categories of the triple bottom line framework.

Conclusion

Performance indicators are needed to monitor cotton production systems and report on their sustainability. This should be done using a triple bottom line framework of economic, environmental and social indicators. Measuring and reporting of any data needs to be transparent, inclusive, auditable, relevant, accurate, repeatable, measurable, and timely. Care must be taken not to monitor and measure too many indicators and some balance is needed between the economic, environmental and social categories.

About a dozen key indicators would be a good starting point for a triple bottom line report. These could include yield, fiber quality, profit, value of production, chemical use, water use, water quality, soil health, industry code compliance, employment, occupational health and safety and skill levels of human resources.

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Table 1. *Examples of economic indicators of sustainability.*

Yield (per/ha, per unit of water used ML)
Profit ($/ha, $/ML)
Operating costs ($/ha, $/bale, eg fertilizer, chemical, water, labour, etc)
Capital costs and value (eg machinery, land, etc)
Income ($/bale)
Financial ratios (eg return on assets, debt, etc)
Industry gross value of production
Industry contribution to exports and gross domestic product
Employment
Cotton fiber quality parameters (length, strength, micronaire, color, etc)

Table 2. *Examples of environmental indicators of sustainability.*

Chemical use
Water quality (eg P, N, EC, pH, turbidity, pesticides, nutrients, biological)
Water use (surface/groundwater, efficiency ratios, drainage, water table)
Salinity and sodicity
Energy and greenhouse
River health (flows, water quality, riparian vegetation, indexes)
Soil health (eg OM, C, pH, N, P, K, EC, ESP%, biology, soil structure etc)
Biodiversity (Pick a focal species such as birds, native vegetation, or fish)
Landscape and catchment biophysical indicators
Weeds, insect pests, and diseases
Compliance with Industry codes, and Best Management Practices

Table 3. *Examples of social indicators of sustainability.*

Employment/unemployment (including age, gender, salary, sector trends)
Occupational Health and safety (accidents)
Education, training and skills of people
Population levels and trends
Attitudes and perceptions by the community towards cotton
Technology access and adoption
Farmer groups and industry networks/ associations
Stewardship of transgenic technology and community/market acceptance
Community and infrastructure indicators
Research and Development activities

Table 4. *The profitability and some costs of cotton production in Australia (Source: Boyce and Company, 2002).*

Year	Profit	Herbicide cost	Insecticide cost	Fertilizer cost	Fuel /oil cost
1992	1564	106	193	185	121
1993	1285	82	250	151	114
1994	2130	84	252	138	94
1995	2280	104	358	205	79
1996	2086	138	284	185	163
1997	1872	126	376	173	91
1998	1910	114	318	187	107
1999	1076	158	558	182	106
2000	1694	137	409	151	121
2001	1337	116	394	201	194

*All figures are in Australian dollars per hectare.

Table 5. *Accidents types in the Australian Cotton Industry (Source: ACAHS, 2000).*

Activity causing accident	%
Ground preparation	5.9
Planting	4.6
Plant growth	11.4
Picking and carting	11.1
Machinery and equipment maintenance	28.4
Ginning	25
Unknown	13.6

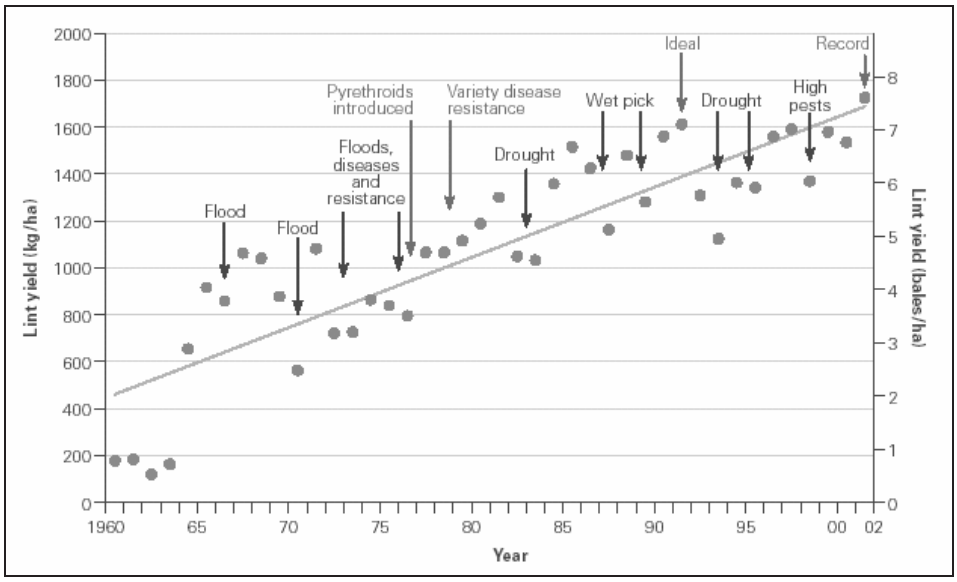

Figure 1. *The lint yield increase of the Australian cotton crop (1960 to 2002).*

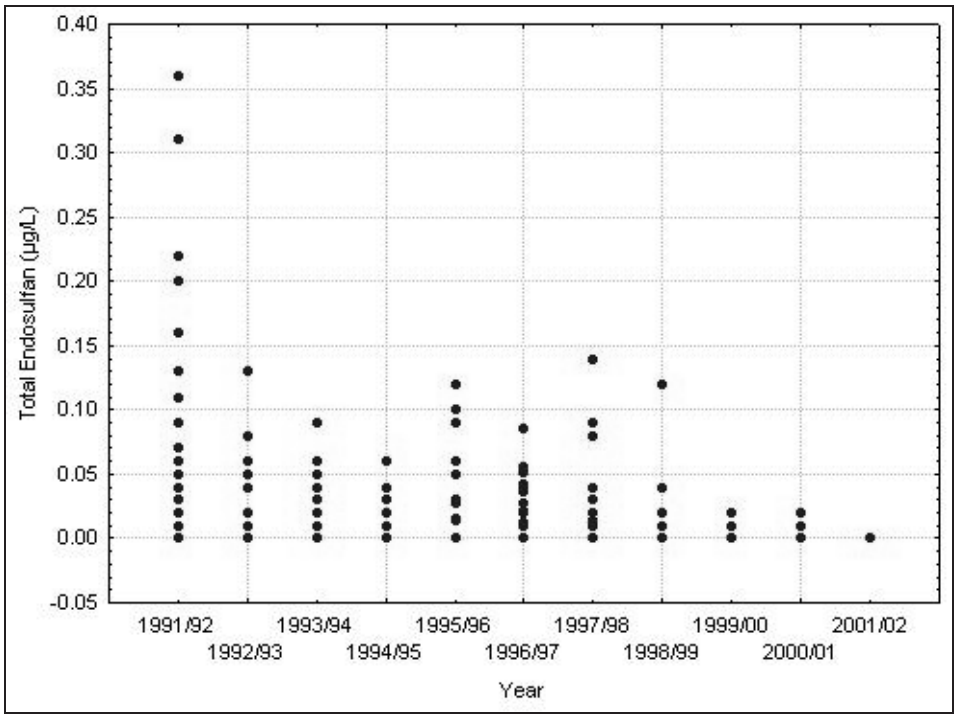

Figure 2. *The endosulfan levels in the Namoi River, Narrabri, 1991 to 2002 (Source: DLWC, 2003).*