A synthesis of cotton agronomy for productive, diverse and sustainable landscapes

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Abstract
This paper specifically addresses the conference theme "Building a productive, diverse and more sustainable landscapes" using the Australian cotton industry of NSW and Queensland as a case study. A meta-analysis of the Australian cotton agronomy research literature was completed. A report was compiled using the Global Reporting Initiative for Sustainability Reporting Framework using economic, environmental and social indicators. In preparing the report, the Australian Cotton Industry considered more than 100 sustainability indicators and consulted stakeholders to report on 45 aspects of sustainability.

The analysis found that agronomy has increased cotton yield productivity from 1200 to 2270 kg/ha between the 1970s and 2014. Cotton fibre length productivity has increased 97 percent. Water productivity, measured using the Gross Production Water Use Index has improved from 0.79 to 1.14 bales/ML over the last decade. In terms of a diversity, landscape data shows crop rotations with legume and cereal crops have increased. Land use data shows cotton farm diversity in Australia is on average 14% cotton, 29% other crops and 42 % is native vegetation. Research has reported biodiversity on farms such as 153 species of birds and 450 species of invertebrates.

The paper discusses how changes in agronomy practices are building a more sustainable landscape. Data and trends over the last 20 years in land management, water use efficiency, integrated pest management, transgenic crop traits, pesticide use, irrigation practices and farm landscape research will be presented.

Key words
Agriculture, sustainability, cotton, water, environment

Introduction

The conference theme "Building a productive, diverse and more sustainable landscape" raises some questions around what is a sustainable landscape, how is this determined, and how to systematically report diversity. Worldwide demand for food and fibre is increasing to service the needs of a growing population and higher standards of living. Consumers are demanding ethical clarity on their food while communities are striving for more sustainable management of natural resources. Agriculture needs to achieve both the demands for increased output of agricultural products and those for sustainability and ethics. For this to be possible, it is important for farming industries to measure and understand their current sustainability trends and adapt farming practices as required.

The concept of sustainability is a widely used expression, but its actual meaning and understanding tends to be aligned to the user's purpose, emotional intelligence and values. There are a considerable range of views in what constitutes sustainability and the conundrums of the definition. It is more pragmatic to understand how farm industries contribute to ecologically sustainable development and what practices can be modified to further improve their sustainability performance. It is generally accepted that the sustainability concept has three distinct, but related environmental, economic and social components.

Measurement of industry sustainability requires consistent approaches across multiple farms, regions and sites, repeated over long periods of time. Despite considerable industry interest, establishing a core set of indicators and gathering the data is challenging. Performance indicators are needed to monitor production systems and report on their trends towards sustainability. Sustainability indicators will also assist with business planning, resource allocation, and provide documented evidence of natural resource stewardship and community impacts. These indicators will need to have attributes that can be applied at the farm, industry, regional or national level.

There are multiple market driven sustainability initiatives around the globe that expect good data to be available, which is not always easy to achieve. Any ongoing review of selected indicators needs to be balanced by the needs of external stakeholders and challenges of long term data sets. The iterative nature of the process, especially with external stakeholder involvement is time consuming and challenging to do properly.

Sustainability reporting is the practice of measuring, disclosing and being accountable for performance towards the goal of sustainable development and is considered synonymous with other terms used to describe for accounting for economic, environmental and social impacts such as triple bottom line or corporate responsibility (Global Reporting Initiative 2006).The paper applies a sustainability reporting framework to show how changes in cotton agronomy practices are building a more productive, diverse and more sustainable landscapes.

Methods

An inventory of potential sustainability indicators was developed which reviewed the material issues of stakeholders and the literature (Roth 2010). This set of potential sustainability indicators was assessed and updated by the cotton industry's environmental assessment working group, taking into account recent developments in international supply chain sustainability initiatives such as the Better Cotton Initiative, Cotton LEADS™, and the Expert Panel on Social, Environmental and Economic Performance of Cotton Production of the International Cotton Advisory Committee (SEEP 2013).

A list of more than 100 potential sustainability indicators was compiled. These indicators were then prioritised using an objective ranking system which scored indicators against six selection criteria. These criteria included; materiality to cotton industry stakeholders, materiality to external stakeholders, cost effectiveness of data collection, technical difficulty of data collection, data integrity and confidence, and accuracy in the data collection.

From a list of more than 100 indicators, 45 were shortlisted as high priority material aspects for the cotton industry to collect, collate and report as shown in Table 1. A meta-analysis of data was then compiled from a range of sources including the agronomy scientific literature. Some examples are presented as results and a full report according to the Global Reporting Initiative Framework is available (Cotton Australia 2014).

Table 1. Material sustainability aspects and indicators for the Australian Cotton Industry

Key aspect	**Environmental Indicator**
Soil health	1.Organic carbon % 2.Practice change. % growers adopting soil health best management practises 3.Soil sodicity (ESP)
On farm water use efficiency and productivity	4.Gross Production Water Use Index 5.Irrigation Water Use Index 6.Practice change 7. Whole farm Water Use efficiency (%)
Groundwater	8.Groundwater levels (rising or falling) 9.Groundwater quality (EC, pH, SAR)
Biodiversity / riparian	10. Area of native vegetation managed under best practice (ha/km) 11. Vegetation condition and connectivity
IPM	12. % growers using Integrated Pest Management practices
Chemical use	13. Herbicide Use (active ingredient kg/ha) 14. Insecticide use (active ingredient kg/ha)
GHG emissions	15. Energy use (kj/kg cotton lint or bale) 16. Nitrogen Use Efficiency (N use/yield)
Key aspect	**Economic Indicator**
Cotton industry production statistics	1. Planted area (ha) - Irrigated 2. Planted area (ha) - Dryland 3. Yield (bales/ha) - Irrigated 4. Yield (bales/ha) - Dryland 5. Fibre Quality 6. Metric tonnes of cotton produced 7. Grower numbers 8. Average/median farm size

Economic value	9. Cotton price/bale ($/bale) 10. Gross value of the cotton produced in Australia ($) 11. Cotton exports % or $ by country (lint and seed) 12. Cotton's % of region gross value 13. Australia's % share of global cotton lint trade 14. Cotton proportion of global textile market
Profitability	15. Gross margin/ha 16. Income/ML water
Key aspect	**Social Indicator**
Education	1. Highest post school qualification of cotton growers
Employment	2.Number of people employed - farms 3.Number of people employed - industry 4.Number of people employed - regional
Workplace health and safety	5.Workers receiving regular health and safety training 6.Workers health & safety programs in place
Demographics	7.Grower age 8.Gender participation in industry
Social capital	9. Australian Cotton Conference delegate numbers 10. Financial membership in regional cotton grower associations
Innovation	11. Investment levels in R&D 12. Growers adoption of technologies
Legal compliance & responsibility	13. Fines imposed upon cotton SMEs by regulatory authorities

Results

Economic Category

The economic aspects considered were cotton production statistics, crop yield and quality, and its economic value. There are up to 1500 cotton farms in Australia with the average area of a cotton farm currently being 495 ha. On average for the last five years (2009-2014); the irrigated crop yield was 9.85 bales/ha (2236 kg/ha) and the dryland crop yield was 4.09 bales/ha (928 kg/ha). Australian yields are high by international standards, almost three times the world average. These yields reached record levels in 2012-13 at 10.73 bales/ha (2436 kg/ha). Production reached a record high in 2011-12 at 1,215,870 metric tonnes (5,356,254 bales) and a low in 2007-08 at 136,831 metric tonnes (602,780 bales) during the millennium drought. Yields have continued to move upwards from 1200kg/ha in the 1970s, through 1400kg/ha in the 1980s to 1600kg/ha in the 1990s and can now be greater than 2270kg /ha (10 bales/ha).

Cotton's contribution to productive landscapes can be measured by its contribution to regional economics. For example, between 1997 and 2011 the value of cotton as a percentage of total agricultural production was 30 to 60 percent in regions where it is grown.

Environmental Category

The environmental aspects considered were soil health, water use, groundwater, biodiversity, riparian land management, integrated pest management, pesticide use and greenhouse gas emissions.

The main changes in management of cotton soils have been an overall reduction in tillage, widespread adoption of controlled traffic, permanent bed farming systems and increased application of nutrients for higher crop yields. Most farmers believe soil health has increased. Improving fertiliser efficiency is a major research and extension priority.

Water is critical to maximise crop yields and fibre quality. Water productivity, measured using the Gross Production Water Use Index has improved from 0.79 to 1.14 bales/ML over the last decade. This has been achieved by both yield increases and more efficient water management systems. The whole farm irrigation efficiency index improved from 57 percent to 70 percent. The crop water use index is above three kg/mm/ha, which is high by international standards (Roth et al 2013).

Examples of landscape or farm diversity include on average cotton farms have approximately 40 percent of their land dedicated to native vegetation. Several studies have investigated wildlife and their habitats on cotton farms and found for example: more than 42,000 birds representing 45 species were found on farm water storages in the Gwydir Valley; 153 bird species were found in natural vegetation in the Namoi Valley, and 450 species of invertebrates have been recorded in one cotton field during the summer.

Comparing the five year averages for the periods 2008-2013 and 1998-2003, the cotton industry has achieved an 89 percent reduction in insecticide use. It has reduced from 5.12 kg to 0.55 kg active ingredient per hectare.

Nitrogen fertilisers and energy consumed are a major source of greenhouse gas emissions, particularly nitrous oxide, and the industry continues to invest in research, demonstration trials and decision support tools focused on improving nitrogen use and energy use efficiency.

Social Category

Key social aspects considered were education levels, demographics, employment, health, social capital, research and development and legal compliance. Education can be used as a measure of human capital. The number of cotton growers with a diploma level or above qualification has risen from 30 percent in 1990 to 50 percent in 2011. The number of growers holding a bachelor degree rose from 13.5 percent to 24.1 percent between 1991 and 2011.

The cotton industry has a strong research and development culture. Over the past 24 years, the Cotton Research and Development Corporation (CRDC) has invested $200 million in research, development and extension on behalf of Australian cotton growers and the Australian Government – delivering an estimated minimum $1.4 billion benefit back to growers on their farms, and twice that value to the wider community (CRDC 2014).

Cotton industry surveys show growers are innovative and adopt new technology readily. For example;
99 percent adoption of transgenic traits for insect and weed management, 82 percent adoption of new round module pickers, 70 percent of farmers use soil moisture probes, 90 percent using satellite navigation systems in tractors, 84 percent use a smart phone or tablet for accessing information about their farming system.
93 percent of farmers use integrated pest management (IPM).

Summary

Cotton agronomy has played an important role in "Building a productive, diverse and more sustainable landscape", (the conference theme). This paper used the cotton industry as a case study using a sustainability reporting process that with some minor modifications would be suitable for most agricultural situations.

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